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# FOREWORD

Presented number of Silesian University of Technology. Scientific Papers. Organization and Management Series. Contemporary management. Presented papers contain result of researches conducted by authors from Poland. The number consists of 42 papers.

The papers presented in the number concentrate on many topics connected with organization and management. There are in the number papers about: production management, Industry 4.0; smart city, human resources management, lean management, impact of COVID-19 pandemic on management, quality management, information management, Corporate Social Responsibility, marketing, public management, environmental management, risk management, innovation management and finance.

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# THE ANALYSIS OF POLISH PATENT APPLICATIONS
# IN THE SOLAR ENERGY TECHNOLOGY
# WITH THE USE OF TEXT MINING METHODOLOGY

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**Purpose:** Knowledge management belongs to the most important elements of organisational management, including manufacturing enterprises. Patent information plays an increasingly important role in this area. Identification of the main directions of invention activity may inspire new product and process ideas, and can help to improve existing solutions. The above is particularly important in the energy sector, which is currently struggling with increasing problems. In this context, solar energy is the subject of interest to inventive communities. The paper discusses patent applications related to solar energy, taking up the task of discovering the main tendencies of technological solutions in this area.

**Design/methodology/approach**: In the work, a pilot study of the research aimed to indicate the directions of technological development in the field in Poland was undertaken. Shortened descriptions of selected patent documents from the Polish Patent Office (PPO) were the subject of the investigation. The descriptions were reduced to the form of a vector space model by using text mining tools. The exploration of such prepared data was done applying unsupervised text mining techniques. Hierarchical cluster analysis enabled the identification of groups of similar inventions. An algorithm to detect outliers within individual patent groups was also developed and applied.

**Findings:** Five patent clusters were identified covering the following thematic areas: PV panel designs, PV panel component designs, the improvement of solar-heat conversion device performance, and solar collector designs. Six patent applications stood out thematically in four of the five clusters.

**Research limitations/implications**: The research is limited to a selected number of patent documents form PPO. However, the presented method and research area are promising. It is planned to extend the analyses to a larger set of patent documents and solve the problem related to the language uniformity of patent applications along with merging data from various sources. In this aspect, a full patent description will be consider as well.

**Originality/value:** In relation to solar energy issues, main patent areas and patent outliers that may be indicators of special interests of inventors were identified. In relation to methodology issues, new solutions within consecutive research steps were proposed.

# 1. Introduction

Knowledge management is one of the most important elements of organisational management, including manufacturing enterprises. Patent information plays an increasingly important role in this area. Patent documents reveal the essence of inventions in a clear, unambiguous and understandable way for a specialist. Data contained in patent databases can be employed for strategic planning purposes and the proper use of these data can contribute to the increase of a company's market value and to achieve competitive advantage of a company. Identification of the main directions of inventive activity in a given area is one of elements supporting the creation and disposal of substantive (intellectual) competences and practical skills, which are intangible assets of the enterprise. Such knowledge may inspire new product and process ideas, and can help to improve existing solutions.

The above is particularly important in the energy sector, which is currently struggling with increasing problems. Climate changes and the devastation of the natural environment caused by the production of dirty energy, on the one hand, and the consequences of geopolitical conditions, also in connection with the war in Ukraine, on the other hand, justify the necessity to support and develop technologies concerning renewable energy sources (RES). One of the most popular RES that are of interest to inventive communities is solar energy. The paper discusses patent applications related to solar energy, taking up the task of identifying the main directions of technological solutions in this area.

A patent is the right to the exclusive use of a technical solution (invention) for a specified period of time, for profit (Journal of Laws, 2000). It is valid only in those countries where patent offices have granted protection for inventions. Patent protection can be obtained in a national, regional or international mode. Such a protection is a signal of an effective inventive activity in a given field. Information on patent documents is made available through free databases, created mainly by national patent offices (for example, Polish Patent Office), international or regional intellectual property organizations (for example, WIPO or ESPACENET). There are also commercial databases containing additional information about inventions, such as legal data (like in PATSTAT). However, there is no repository that includes all patent documents published at any time.

The structure of a patent document depends on the country (or the organization) specificity, but it always contains certain standardized information, which, in addition to the basic data identifying the application, includes technical information, such as International Patent

Classification (IPC) symbols (WIPO, 2015). The IPC symbols are assigned by professional patent attorneys and allow inventions to be classified according to technology domains. Several symbols can be used for one patent document, but it is assumed that the symbol that represents the invention most adequately appears first in the symbol list (WIPO, 2022). In the study, the International Patent Classification was used in order to investigate patent applications within the solar energy technology. The IPC symbols considered in the paper are the result of literature research and analysis of WIPO (2021) indications. The symbols cover the following list: E04D 13/18, F03G 6/06, F24J 2/, F24S, G05F 1/67, H01L 25/00, H01L 31/00, H01L 31/04, H01L 31/05, H01L 31/18, H02J 7/35, H02N 6/00, H02S. The description of the codes is presented in Appendix A.

There were 24,685 patent applications for the solar energy technology identified in the PATSTAT database, which were submitted to patent offices of countries located in Europe, between 01-01-2001 and 28-02-2021 (the data were acquired on 2022-04-24; fall 2021 edition). Among the applications, 16,958 have at least one inventor from a European country – such documents are hereinafter referred to as "European applications". Similarly, if any inventor is a citizen of a particular country, their patent document is assigned to that country (for example, German applications, Polish applications). The ranking of countries according to the number of patent applications of inventors from a given country submitted in the field of solar energy is shown in Figure 1 (first 15 places).
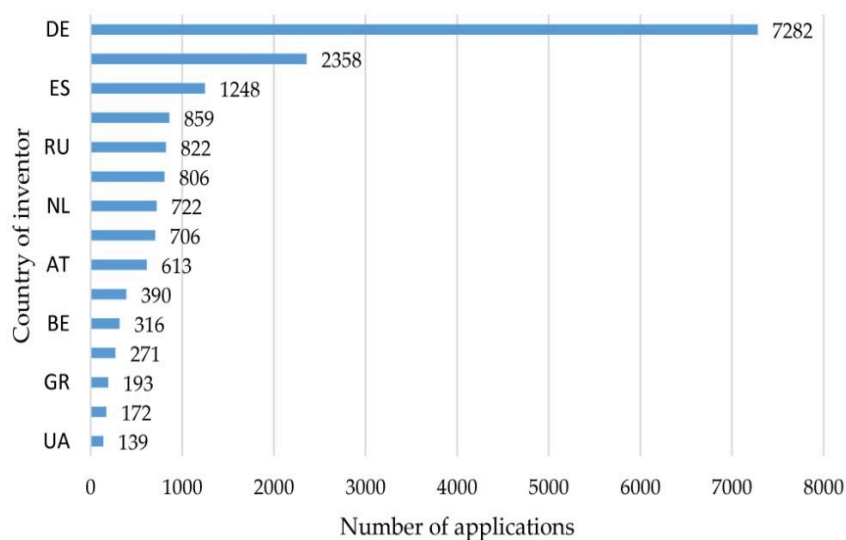


**Figure 1.** European patent applications in the solar energy technology submitted between 01-01-2001 and 28-02-2021 to national patent offices located in Europe, reported in PATSTAT.

Source: authors' own elaboration.

The presented summary should be considered as a picture of the inventive activity of Europeans, since some documents may be counted several times (for several countries), taking into account that several people from different European countries may be inventors assigned to the same application. However, the results presented in the figure confirm, to some extent, the outcome published in other papers, e.g. Binz et al. (2017), Breyer et al. (2013), Sampaio et al. (2018). Germany, France and Spain took the top three places, but the predominance of Germany is significant. The number of applications by German inventors is greater than the sum of applications by inventors from the next six countries in the ranking. The share of documents of Polish inventors in the total number of European inventors' applications amounted to 1.6% (390), yet Poland was ranked tenth out of total 46 countries.

The number of Polish applications against the number of European ones in given years is presented in Figure 2. The year 2020 is not discussed as the data from this year does not include all the applications. The highest activity of Europeans occurs between 2009 and 2011, but the share of Poles in the number of applications does not exceed 2% in this period. A decreasing tendency in the number of European applications has been observed since 2010, while Polish applications increased from 2% to almost 6%.
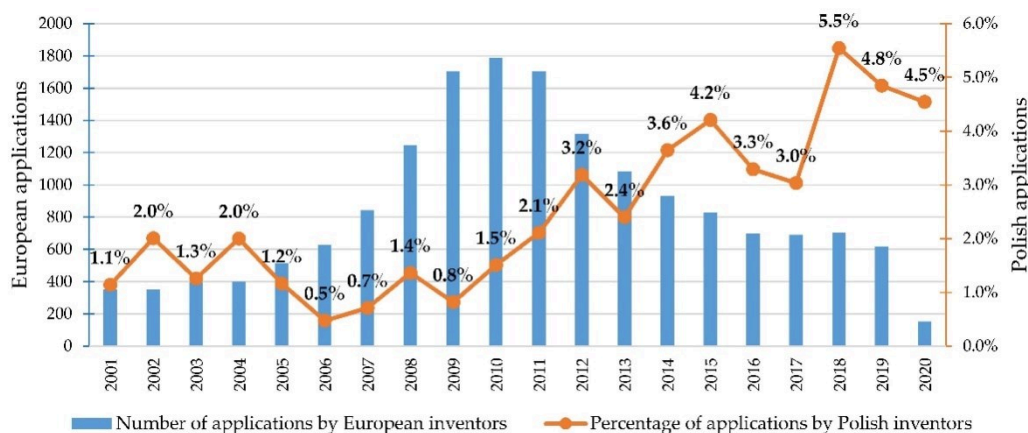


**Figure 2.** European patent applications in the solar energy technology submitted between 01-01-2001 and 28-02-2021 to national patent offices located in Europe, registered in PATSTAT.

Source: authors' own elaboration.

Data in the PATSTAT database do not contain the information necessary for the analyses in the study; in Polish inventors' applications submitted to PATSTAT, short descriptions of inventions are missing in more than one quarter (107 items) of the documents. Therefore the national database of the Polish Patent Office (PPO) was chosen as the data source for the pilot research; on the basis of the analysis of selected patent applications related to solar energy, the characterisation of Polish inventors activity in the area was conducted.

The article consists of six parts. After this introductory section, a literature review discussing patents related to solar energetics is presented. The third section describes the research process, in particular the method of isolating thematic areas of the solar energy technology explored by Polish inventors in Polish conditions, and the method of identifying outliers. Section four shows the obtained results, which are: the patent clusters and outliers detected within them. The fifth section profiles and discusses the clusters and comments on the outlier cases. Finally, a summary and conclusions are presented.

## 2.  Literature review

The literature on patents and solar energy is extensive and, especially in recent years, has grown exponentially. Since the information in all patent databases has a similar structure, research analyses based on it cover two approaches. One can be defined as quantitative, usually supported by frequency analysis as regards selected patent attributes. It is usually devoted to the identification of quantitative trends in the invention landscape. The other approach can be described as qualitative, typically with the use of text mining methods to classify and identify patterns in patents. The two approaches are often combined in the research on patented applications. Green energy, and solar energy in particular, became a common topic in the field of patent research more than a decade ago. A brief literature review on patent analysis for solar energy is presented below. Due to the subject matter of the analyses conducted in the study and the used methodology, the review focuses on the works in which text mining methods in examining patent application descriptions were used.

The work by Liu et al. (2011) examined the photovoltaic technology development from the perspective of patent growth trajectories. The patent data were taken from the database operated by the United States Patent and Trademark Office (USPTO). The research focused mainly on materials used in photovoltaics. Keyword co-occurrence analysis was applied to classify patents into five groups. Three of them, labelled as: Emerging PV, Group III–V, and Silicon, were described as constantly and strongly growing ones. The remaining two, called CdTe and CIS/CIGS were defined as being at the mature stage. Yoon and Kim (2012) proposed a semantic approach method to detect outliers among granted patents, thus indicating potential technology opportunities. The approach was illustrated using organic photovoltaic cells (OPV) related patents retrieved from USPTO database. Nine inventions were indicated as having a strong possibility of being unusual. The following three ones were discussed: (1) a method of fabricating charge-transport structures, (2) an invention concerning "solar networks and power grids", (3) the use of a "poly cross linked phthalocyanine compound". It was outlined that a final review by an expert is necessary to diagnose the selected patents as delivering new technology opportunities. Chi and Ying (2012) discussed the technology evolution of building

integrated photovoltaics (BIPV). In the analysis of patent descriptions, they transformed patent documents into structured data and used patent matrix map analysis to develop R&D strategy of related industries. The technology appeared to be growing with a long-term development potential. The patent text analysis enabled indicating the technology key points in the future as follows: durability, ease of maintenance, customization of PV modules and the BIPV security. Lizin et al. (2013) made a quantitative overview of a global patent activity on the organic photovoltaic (OPV) solar cell types, their substrates and encapsulation materials on the basis of patents retrieved from the FamPat database. The authors found OPV still residing in the fluid technology development phase, following an exponential growth path. Two main technological solutions were identified: (1) a group of semiconductors suitable for energy conversion or control (IPC: H01L-031), and (2) glass, then paper and textiles for photovoltaic cells substrates. Venugopalan and Rai (2015) proposed a hierarchical technique based on natural language processing for classifying patents and for identifying linkage between them. The approach was exemplified on USPTO database issued patents and patent application on PV balance of system technology categories. Topic modelling was used to identify inventions technology areas. Binz et al. (2017) addressed the question about spatial dynamics in new clean technology fields in relation to existing industry lifecycle models and globalization as a creator of new lifecycle patterns. They investigated solar energy technology patents from Thomson Innovation and Derwent World Patent Index global patent databases. The authors discovered that the largest number of patents was related to core technologies and associated with the production of solar cells and modules, while patents related to extraction technology (silicon, ingots and water sawing) made up a small proportion of the knowledge base. However, the authors acknowledged that recently emerging thin-film and organic PV technologies were not the focus of their research. De Paulo et al. (2018) analysed patent data on solar photovoltaics from the Derwent Innovation (DI) database. They filtered out co-ownership patents and use social network analysis to find PV technology development networks. The following patent areas were found as the most frequent ones: "Devices adapted for the conversion of radiation energy into electrical energy", "Assemblies of a plurality of solar cells", and "Silicon; single-crystal growth". Sampaio et al. (2018) used the same data source (DI database) in the discovery of the technological development of photovoltaic cells, applying a frequency analysis. The following areas were indicated as the ones on which predominant patents concentrate: semiconductors for the conversion of solar radiation into electric energy, generators for the direct conversion of light energy into electric energy, and adaptation of solar panels for roof structures. Polymer-based photovoltaic cell technologies, carbon nanostructures, III-V compounds, cadmium telluride and amorphous silicon cells had a predominance of deposited patents as regards the technological issue. Due to the rapid development in the field of photovoltaic technology, Li et al. (2019) selected perovskite solar cell technology as the case study in their work. They used Derwent Innovations database and Twitter data. The evolutionary path of the technology was presented in the form of a map developed on the results of patent topic clustering and

relying on the experts' knowledge in the field. Trappey et al. (2019) analysed WoS scientific literature and DI database patent documents to identify key issues and the patent evolution of the solar power technology. The authors combined multiple, unsupervised machine learning algorithms in their research. The conclusion was that more novel technologies describing integration of renewable energy generation systems and simulation of grid-connected energy storage systems could be found in the literature, while technologies describing solar hydropower storage system with subsystems for indirect solar connection technology were presented in patents.

In the vast majority of cases, solar patent topic investigations focus on photovoltaic technology that has developed considerably fast in the last thirty-plus years. In this aspect, cluster analysis, mapping technology and topic modelling were engaged either in overall PV issue or in its selected subareas. The application of text mining technology to the content analysis of patents that deal not only with the photovoltaic aspect, but take into account the full patent landscape of solar energy technology, is presented less frequently in the scientific literature. To the best of the authors' knowledge, there are no works on this type investigation concerning the invention activity in a selected country, in particular with regard to the EU area. The study proposes a research process in which an enriched approach to text mining of patent data was developed. This is a pilot study of the research aimed to indicate the areas of technological development in the field of solar energy in Poland.

## 3. Materials and methods

The scheme of the research process carried out in the study concerning Polish inventions in the solar energy technology is shown in Figure 3. The proposed approach consists of several steps and includes: acquiring and preparing patent data for the analysis, preprocessing textual data, generating clustering models and selecting the best one, and finally, detecting outliers in the best clustering model. The results obtained in any step constitute data for the next step. The left part of the figure refers to individual steps of the research process, whereas the right part indicates the results of the steps.
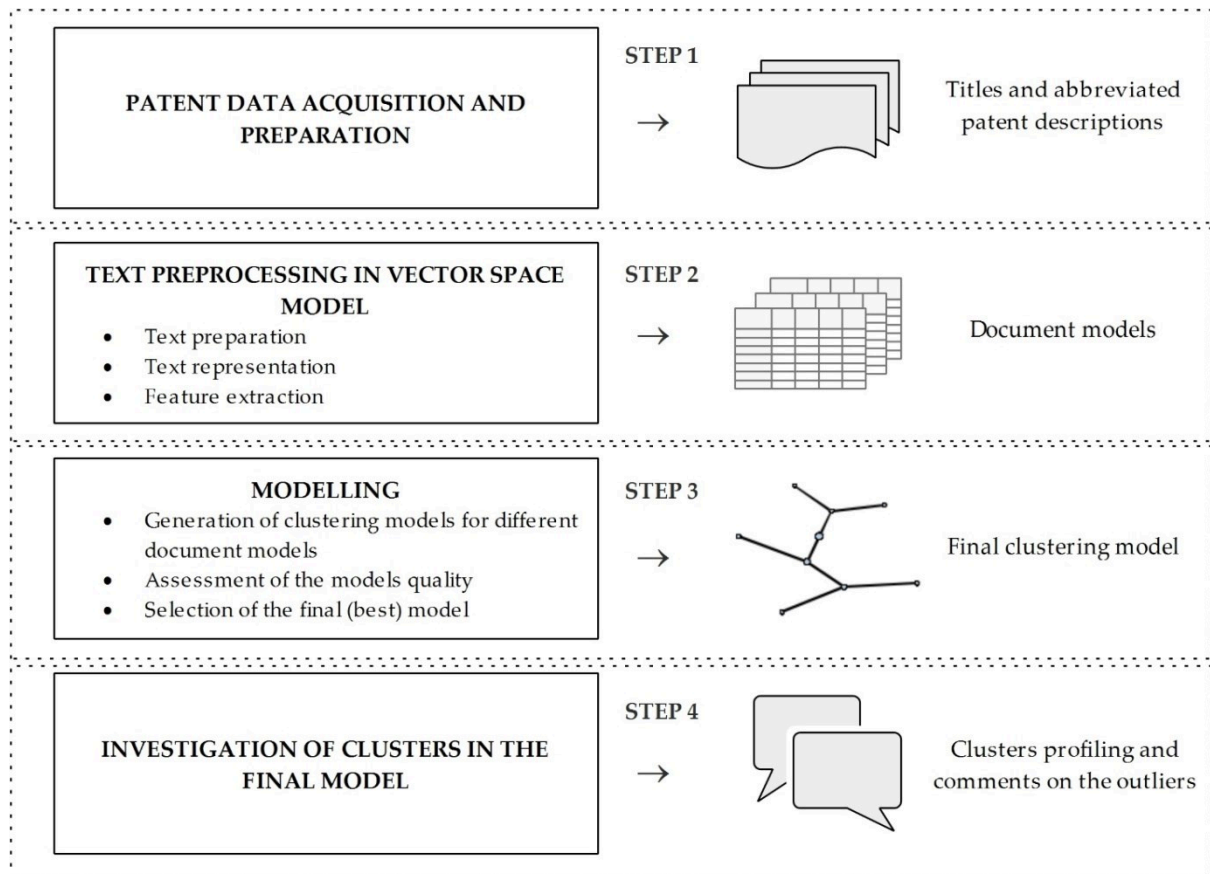
**Figure 3.** The research process for the identification of Polish inventiveness areas in the solar energy technology.

Source: authors' own elaboration.

The following subsections describe the individual steps. The used methodologies and solutions are explained and relevant references are given.

### 3.1. Patent data acquisition and preparation

The Polish patent document structure consists of the following elements:

- a title page containing bibliographical data that identifies the document and a short description of the invention,
- other pages containing a full invention description, patent claims and drawings, if any.

In order to acquire the data, the following bibliographic attributes were used in the definition of search criteria: the inventor's country, the patent application date, International Patent Classification symbols (WIPO, 2021), and keywords. Roots of Polish words related to solar energy have been introduced in the list of keywords, taking into account the fact that the used IPC symbols refer to an area broader than just the technology field under investigation. Table 1 presents the conditions whose logical conjunction was used to search for documents in the PPO repository. The search and retrieval of the resources was performed on 2022-02-17.

**Table 1.**

*Criteria for searching patent documents in the solar energy technology*

| Attribute | Value |
|---|---|
| Inventor's country | PL |
| Application date | ≥ 2001-01-01 |
| IPC symbols | E04D 13/18, F03G 6/06, F24J 2/, F24S, G05F 1/67, H01L 25/00, H01L 31/00, H01L 31/04, H01L 31/05, H01L 31/18, H02J 7/35, H02N 6/00, H02S |
| Words for title and abbreviated patent description search | fotow, solar, słon, słoń, świat, świetl[1] |

[1] full English equivalents: photovoltaic, solar, sunny, sun, light, luminous/illuminated.

Source: authors' own elaboration.

A dataset containing 7 fields and 368 records was obtained, where each record represents a separate patent application. After transforming selected fields, the set of the following variables subjected to further analyses, was obtained:

- a title and abbreviated description of patent application,
- the decision on granting an exclusive right,
- the patent application date,
- the list of IPC symbols assigned to the document.

The primary research process involved the text variables: the title and the abbreviated description. The remaining variables were used in the final step of the analysis of results.

### 3.2.  Text preprocessing in vector space model

In the study, the vector model was chosen for processing text data, in which text documents became the source of "a bag of words" extracted from these documents. Defining "a bag of words" includes lexical processing and the reduction of the word list extracted from patent documents. Due to the fact that the Polish language is inflectional, lemmatization was carried out in terms of lexical processing. Next, nouns and verbs were selected from the obtained parts of speech, a stop-list, and a list of synonyms were used. As a result, a set of words, called terms, was created, on the basis of which the representation of documents in the form of a term – document matrix (TDM, TD matrix) was defined (Kadhim et al., 2014).

TDM is an array in which row headings identify individual patent documents, that is observations, while column headings identify terms, or variables in the multidimensional space, that characterize the observations. The elements of the matrix provide information about the relationship between the term and the document. To specify these elements, weighting functions that transform information about the frequency of terms occurrence are used (Lan et al., 2009). The choice of the weighting function determines the final form of the TD matrix representation. Therefore, the creation of the representation may result in several different representations of the same document collection, depending on a weighting function.

Regardless of the representation, the TD matrix is sparse and has a large dimension, thus implying the need to reduce this dimensionality. The dimension reduction of the TD matrix involves identifying a minimum number of features that best describe the dataset variability. The latent semantic indexing method, which conducts a decomposition of the TD matrix according to its singular values, was applied (Albright, 2004). The matrix decomposition is used to introduce so-called pseudo-terms, which characterize documents and whose number is smaller than the number of original terms. The key task is to determine the degree of reduction in the number of terms. This can be established from a scree plot of the singular values of the TD matrix, ordered in a descending manner. The point on the plot indicating a slowdown in the dynamics of the singular values change defines the degree of reduction. It was proposed to identify this point considering the change in the angle between the horizontal axis and the straight lines connecting the first point of the scree plot to its subsequent points.

The preprocessing stage of textual data is predominantly a decision-making process and may, to some extent, require human involvement. This is particularly visible when thesauri (stop-list, synonyms) are built or when the degree of TDM dimension reduction is determined. The end result is a document model in the form of a reduced TD matrix, where column headings are pseudo-terms and row headings represent documents.

In the study, three different reduced TD matrices were examined – the ones obtained from three different TDM representations in which the matrix elements were defined by the following weighting functions (Bęben, 2020): binary (BIN), log term frequency – inverse document frequency product (LOG-IDF), and term frequency (TF).

### 3.3. Modelling

In the process of identifying thematic areas of the solar energy technology explored by Polish inventors, various data-mining tools were used:

- Hopkins test (Hopkins, Skellam, 1945; Banerjee, Dave, 2004) to check for a clustering tendency in a collection of patent documents,
- cluster analysis to extract thematic groups of inventions,
- a global measure for evaluating the quality of a clustering model to identify the best model relative to other ones created by the same clustering algorithm but using different representations of the TD matrix – the authors' proposal.

A hierarchical grouping algorithm – the Ward method (Vijaya et al., 2019), enabling the identification of clusters of similar documents, was used in the research. In the Ward's algorithm, the number of clusters in the final clustering model is deter-mined automatically with the use of the criterion referring to the pseudo F and pseudo $t^2$ statistics. One can find the method description in the SAS Reference Help (SAS Institute Inc., 2016).

Since clustering was performed for BIN, LOG-IDF, and TF representations of the TD matrix, three clustering models were obtained. To select the best one, the *GQA* global quality assessment measure of the clustering model was proposed.

The *GQA* measure is determined from the following sub-measures: mean silhouette width *MS*, percentage of positive silhouette width values *PPS*, modified Dunn index *MDI*, and clustering effectiveness measure *CEM*.

- Mean silhouette width *MS*:

$$MS = \frac{1}{n} \cdot \sum_{j=1}^{l} \sum_{i=1}^{n_j} S_j(x_i) \tag{1}$$

where:

$S_j(x_i)$ – silhouette width for the $(x_i)$ point (*i*-th observation) in a *j*-th cluster (Rousseeuw, 1987):

$$S_j(x_i) = \frac{b_j(i) - a_j(i)}{\max\{b_j(i), a_j(i)\}}$$

$$a_j(i) = \frac{1}{n_j - 1} \cdot \sum_{\substack{m=1 \\ m \neq i}}^{n_j} d(x_{(j)i}, x_{(j)m}) \tag{2}$$

$$b_j(i) = \min_{\substack{k=1 \cdots l \\ k \neq i}} \frac{1}{n_k} \cdot \sum_{m=1}^{n_k} d(x_{(j)i}, x_{(k)m})$$

$j = 1 \dots l$,

$i = 1 \dots n_j$,

$l$ – number of clusters in the model,

$n_j$ – number of observations in cluster *j*,

$n$ – total number of observations,

$d(x_{(j)i}, x_{(k)m})$ – Euclidean distance between the *i*-th observation in the *j*-th cluster and the *m*-th observation in the *k*-th cluster.

In equation (2), $a(i)$ is the average distance of the $(x_i)$ point from all the other points in the same cluster and $b(i)$ is the mean distance of that point from all the points in the closest cluster to its cluster.

- Percentage of positive silhouette width values *PPS*:

$$PPS = \frac{1}{n} \cdot \sum_{j=1}^{l} \sum_{i=1}^{n_j} P_j(x_i) \tag{3}$$

where:

$$P_j(x_i) = \begin{cases} 1 \text{ for } S_j(x_i) > 0 \\ 0 \text{ for } S_j(x_i) \leq 0 \end{cases} \tag{4}$$

- Modified Dunn index *MDI* (Halkidi, 2001):

$$MDI = \frac{\min_{1 \le j \le l-1} \{ \min_{j+1 \le k \le l} \{AD(j,k)\} \}}{\max_{1 \le j \le l} \{AWCD(j)\}} \tag{5}$$

where:

$$AD(j,k) = \frac{\sum_{i=1}^{n_j} \sum_{m=1}^{n_k} d(x_{(j)i}, x_{(k)m})}{n_j \cdot n_k} \tag{6}$$

$$AWCD(j) = \frac{1}{\frac{(n_j^2 - n_j)}{2}} \cdot \sum_{i=1}^{n_j-1} \sum_{m=1}^{n_j} d(x_{(j)i}, x_{(j)m}) \tag{7}$$

In equations (6) and (7), *AD(j, k)* is the average distance between clusters *j* and *k*, and *AWCD(j)* is the average within cluster distance.

- Clustering effectiveness measure *CEM*:

$$CEM = \frac{ADB}{ADW} \tag{8}$$

where:

$$ADB = \frac{\sum_{j=1}^{l-1} \sum_{k=j+1}^{l} (\sum_{i=1}^{n_j} \sum_{m=1}^{n_k} d(x_{(j)i}, x_{(k)m}))}{\prod_{j=1}^{l} n_j} \tag{9}$$

$$ADW = \frac{\sum_{j=1}^{l} AWCD(j) \cdot n_j}{n} \tag{10}$$

In equations (8) and (9), *ADB* is the average distance between clusters (which is the cluster separation measure) and *ADW* is the average distance within clusters (which is the intra-cluster compactness measure) respectively.

All of the aforementioned sub-measures have an equal interpretation of monotonicity: the larger their values are, the better the clustering quality is. The *GQA* global measure of the quality of the clustering model is given by the following equation:

$$GQA = \frac{1}{2} \cdot (MSI_N + MDI_N) \cdot (CEM_N + PPS_N) \tag{11}$$

where *N* is *min-max* normalization of a measure to the interval <1, 2>, which makes it easier to illustrate *GQA* graphically and to interpret it.

The best clustering model is the one for which the *GQA* measure has the highest value. A graphical illustration of *GQA* is a radar plot, in which the normalized sub-measures are variables and their values for a given model form the vertices of the quadrilateral. The area of the quadrilateral reflects the quality of a clustering model under consideration.

### 3.4. Investigation of clusters in the final model

The final step of the research refers to the definition of the main subject areas in the set of the Polish patent documents, and then to the identification an outlier documents in each of these areas. The main topic area was assumed to be defined by patent documents belonging to the same cluster. Characterization of these areas was carried out using descriptive terms determined by the binomial probability of a given term belonging to a cluster (SAS Institute Inc., 2012) and the IPC symbols assigned to the documents creating the cluster.

According to the information given in the SAS software documentation (SAS Institute Inc., 2012), the following algorithm is used to select descriptive terms for clusters. For specified $m$ descriptive terms for each cluster, the top $2 \cdot m$ most frequently occurring terms in each cluster are used to compute the descriptive terms. For each of the $2 \cdot m$ terms, a binomial probability for each cluster is computed. The probability of assigning a term to cluster $j$ is $prob = \mathrm{F}(k|N, p)$, where:

- F is the binomial cumulative distribution function,
- $k$ is the number of times when the documents containing the term appear in cluster $j$,
- $N$ is the number of documents in cluster $j$,
- $p$ is equal to $(sum-k)/(total-N)$; $sum$ is the total number of times when the documents containing the term appear in all the clusters, and $total$ is the total number of documents.

The $m$ descriptive terms are those with the highest binomial probabilities.

In order to identify documents that do not match the nature of the cluster, an outlier patent detection procedure was proposed. An outlier patent is represented by points in multidimensional space (after dimension reduction) whose location is significantly away from the main clustering tendency. The main tendency is determined by the centre of gravity, whose coordinates are the average of the coordinates of the documents for which the expert positioned the IPC code relating to solar energy (see Table 1) as the first in the list of codes classifying the invention. The Mahalanobis distance was used in diagnosing outlier documents (De Maesschalck, 2000). The following algorithm was proposed for the identification of outlier patent documents.

**The outlier patent document search algorithm**
- Calculate the gravity centre of points in the reduced multidimensional space.
- Sort the set of document distances from the centre of gravity in a non-decreasing order.
- Calculate the mean value of the first 95% of the distances in this set as the cut-off point for outliers, the point is denoted as *TO* (threshold for outlier).

- Compare the difference between two consecutive distances (points on the distance axis) with the *TO* value.
- If the difference between a given distance and the distance preceding it is greater than *TO*, then this distance (point on the axis) defines the critical distance value *CDV*. The *CDV* and all distances (points on the axis) greater than that identify documents in the cluster which can be treated as potential outliers.

## 4. Results

Preprocessing 368 pieces of text data on patents (titles and abbreviated patent descriptions) was performed in *SAS Enterprise Miner* using the tools of the *Text Miner* package. As a result, a set of 1746 terms was obtained, on the basis of which three forms of TD matrix were created: BIN, LOG-IDF and TF. The dynamics of changes in the ordered descendingly singular values (SV) of the TD matrix were examined so as to determine the degree of reduction in the number of terms. Figure 4 presents the scree plots of the singular values (large plot) and the change in the angle between the horizontal axis and the straight lines connecting the first point of the plot to its subsequent points in the scree plot (small one) for each representation of the TD matrix. The plots indicate the number of singular values equal to 5, 7 and 8, implying the reduction degree of TD matrices for the BIN, LOG-IDF and TF representations respectively. Their reduced TD matrices are denoted by the *BIN_5SV*, *LOG-IDF_7SV* and *TF_8SV* symbols further on.

For the analysed set of text patent data represented by full-size and reduced TD matrices, it was checked whether there is a tendency to form clusters. A Hopkins test was conducted in which the null hypothesis that the dataset follows a multivariate uniform distribution (i.e., there are no distinct clusters) is verified. It is assumed that if the test statistic is greater than (aprox.) 0.5 then the data tends to cluster (Hopkins, Skellam, 1954).

In the study, for the full-size (original) TD matrices, the test statistic values are greater than 0.83 and for the reduced TD matrices greater than 0.71, indicating a statistically significant tendency to cluster, which means that the data are significantly clusterable.
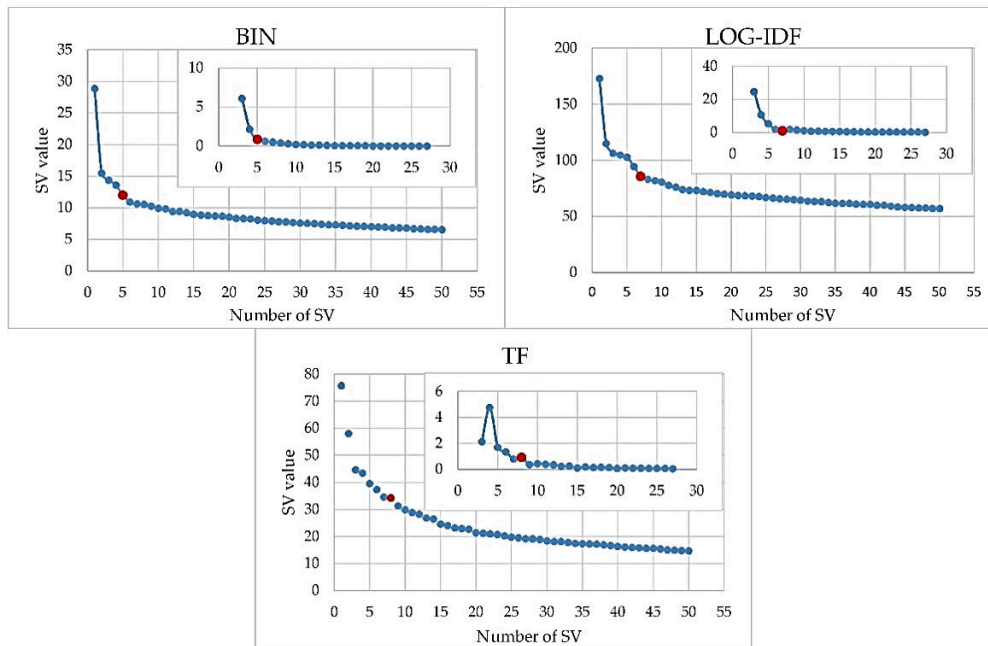
**Figure 4.** Dynamics of changes in singular values depending on the TD matrix representation.

Source: authors' own elaboration.

The *BIN_5SV*, *LOG-IDF_7SV*, and *TF_8SV* matrices were subjected to the cluster analysis resulting in three clustering models. Global measures of clustering quality (*GQA*) were calculated for them. Figure 5 shows a radar plot in which the variables are the normalized sub-measures of the model quality. The model created from the *BIN_5SV* TD matrix, which has the largest *GQA* value equal to 6.47, was selected for further analysis; the model is denoted as *BIN_5SV*.
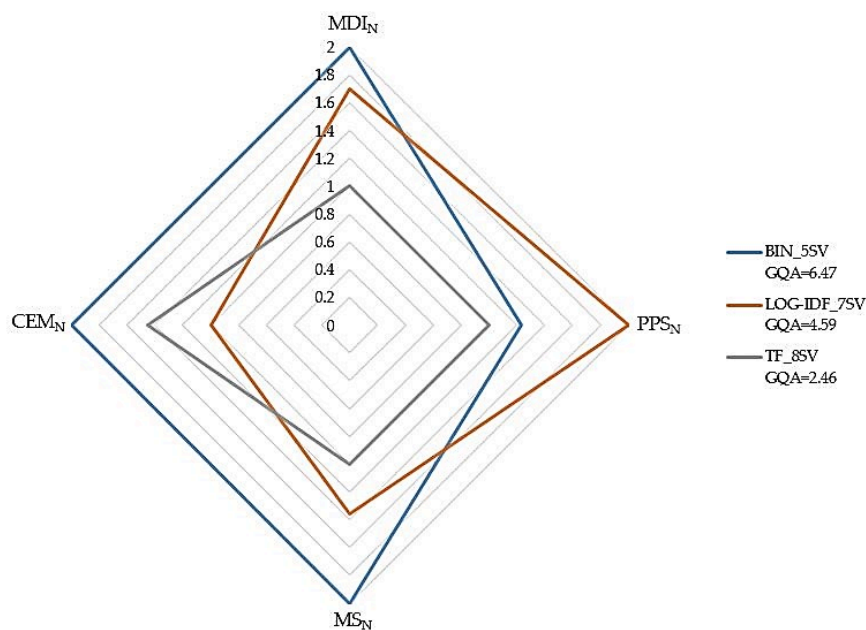


**Figure 5.** Graphical illustration of the *GQA* measure for different clustering models.

Source: authors' own elaboration.

The Ward's algorithm determined five clusters in the *BIN_5SV*-model, which are further identified by the symbols: *C1-C5*. They allowed the identification of leading thematic areas in the field under investigation. The areas are typically characterized by a set of most important terms extracted from documents assigned to individual clusters. In the study, the *m* parameter (determining the number of the terms) was set apriori as equal to 15. The terms are listed in Table 2, where certain statistics characterizing the clusters are also given. The "+" sign indicates that the term includes multiple grammatical forms of the word.

**Table 2.**
*Description of the patent clusters BIN_5SV model*

| Cluster | Cluster size (# patents granted) | Extracted terms | Total number of IPC codes (per document) | Number of solar code / first-positioned IPC code |
|---|---|---|---|---|
| C1 | 94 (35) | +cell, +substrate, +time, +semiconductor, +dye, +generator, +voltage, +foil, +photoelectrode, +contact, +material, +layer, +current, +form, +cover | 320 (3.4) | 142 / 57 (44% / 18%) |
| C2 | 29 (13) | +photodiode, +bend, +shape, +centre, +hole, +meander, +element, +mechanism, +area, aluminium, +thickness, +frame, +lens, +layer, +part | 102 (3.5) | 46 /18 (45% / 18%) |
| C3 | 77 (27) | +battery, +valve, +mechanism, +installation, +hole, +water, +net, +clutch, +container, +construction., +heat, +sensor, +device, +engine, +panel | 223 (2.9) | 102 / 44 (48% / 20%) |
| C4 | 62 (25) | +evaporator, +exchanger, +valve, +pump, +layout, +circulation, +heat, +outfall, +controller, +water, +container, +installation, +collector, +meander, +application | 167 (2.7) | 79 / 41 (47% / 25%) |
| C5 | 106 (47) | +collector, +absorber, +pipe, +wall, +divider, +radiation, +medium, +canal, +space, +coverage, +chamber/compartment, +air, +plate, +application, +surface | 253 (2.4) | 124 / 89 (49% / 35%) |

Source: authors' own elaboration.

In addition to the extracted terms characterizing the clusters, the IPC solar-related codes were taken into account to profile the main subject areas of Polish inventiveness. The codes are presented in Figure 6.
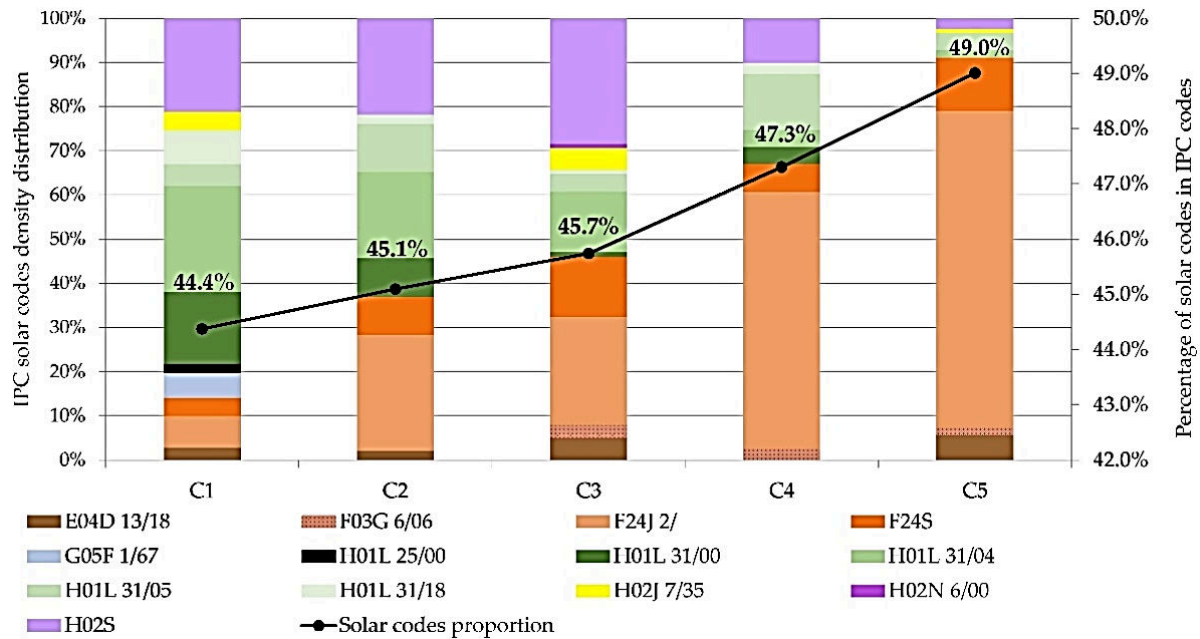
**Figure 6.** Information on IPC solar related codes in the *BIN_5SV* model clusters.

Source: authors' own elaboration.

Bar charts and the corresponding left-hand axis in the figure show the distribution of the IPC solar related codes in individual clusters of the *BIN_5SV* model. The green group refers to codes related to photovoltaics, while the orange group refers to codes related to solar thermal energy. The line plot and the corresponding right-hand axis illustrate the percentage of solar energy related codes in the total number of IPC codes as regards the documents of a given cluster. In each cluster there are IPC codes not assigned to the solar thematic area; patent applications cover a wider area than just solar energy – the percentage of non-solar codes ranges from 51% in cluster *C*5 to 56% in cluster *C*1.

Additional information on the frequency of IPC codes occurrence in documents of particular clusters is presented in Table 3; non-solar related IPC codes form the *Other codes* separate category. For each cluster, two values are given for each code: the first is the number of occurrences of the code in the cluster documents, and the second one (enclosed in parentheses) is the number of those occurrences in the first position of the IPC classification. Due to the very rare occurrence, the information about the H01L 25/00 and H02N 6/00 codes has been moved to the end of the table.

**Table 3.**
*IPC codes frequency distribution by the clusters of the BIN_5SV model*

| Cluster | E04D 13/18 | F03G 6/06 | F24J 2/ | F24S | G05F 1/67 | H01L 31/00 | H01L 31/04 | H01L 31/05 | H01L 31/18 | H02J 7/35 | H02S | Total solar codes | Other codes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C1 | 4 (1) | 0 (0) | 10 (5) | 6 (2) | 8 (5) | 23 (15) | 34 (11) | 7 (2) | 11 (2) | 6 (1) | 30 (13) | **142** (57) | 178 (37) |
| C2 | 1 (1) | 0 (0) | 12 (5) | 4 (3) | 0 (0) | 4 (3) | 9 (1) | 5 (1) | 1 (0) | 0 (0) | 10 (4) | **46** (18) | 56 (11) |
| C3 | 5 (0) | 3 (1) | 25 (12) | 14 (8) | 0 (0) | 1 (1) | 14 (4) | 4 (0) | 1 (1) | 5 (1) | 29 (16) | **102** (44) | 121 (33) |
| C4 | 0 (0) | 2 (0) | 46 (31) | 5 (4) | 0 (0) | 3 (1) | 3 (0) | 10 (1) | 2 (0) | 0 (0) | 8 (4) | **79** (41) | 88 (21) |
| C5 | 7 (3) | 2 (0) | 89 (71) | 15 (12) | 0 (0) | 0 (0) | 2 (1) | 5 (0) | 0 (0) | 1 (0) | 3 (2) | **124** (89) | 129 (17) |
| **Total** | **17 (5)** | **7 (1)** | **182 (124)** | **44 (29)** | **8 (5)** | **31 (20)** | **62 (17)** | **31 (4)** | **15 (3)** | **12 (2)** | **80 (39)** | **493 (57)** | **572 (119)** |

H01L 25/00 is not the first-positioned IPC code; it appeared 3 times, only in cluster *C1*.
H02N 6/00 is not the first-positioned IPC code; it appeared once, only in cluster *C3*.

Source: authors' own elaboration.

For each cluster, the proposed outlier search algorithm was applied. The results are summarized in Table 4 and illustrated in Figure 7 consisting of two parts. One part, in the form of a numerical axis, is an illustration of how the algorithm for detecting outlier points in a cluster works. Individual points on the numerical axis correspond to the distances of cluster documents from the centre of gravity. Red colour indicates the distances that identify outliers. The second part of the figure is an illustration on a plane of the clustering results showing the location of documents in each cluster. The figure is an approximate visualization as points (documents) in 5-dimensional space were dropped into 2-dimensional space. The centre of gravity is marked with a green circle, while outlier points are marked with red circles.

**Table 4.**
*Outliers detection results*

| Cluster | TO | CDV | Identifiers of potential outlier documents |
|---|---|---|---|
| C1 | 4.34 | 9.19 | 361, 363, 354 |
| C2 | 4.6 | 7.5 | 38 |
| C3 | 4.6 | 11.73 | 360 |
| C4 | 4.35 | 9.79 | 267 |
| C5 | 4.51 | - | - |

Source: authors' own elaboration.
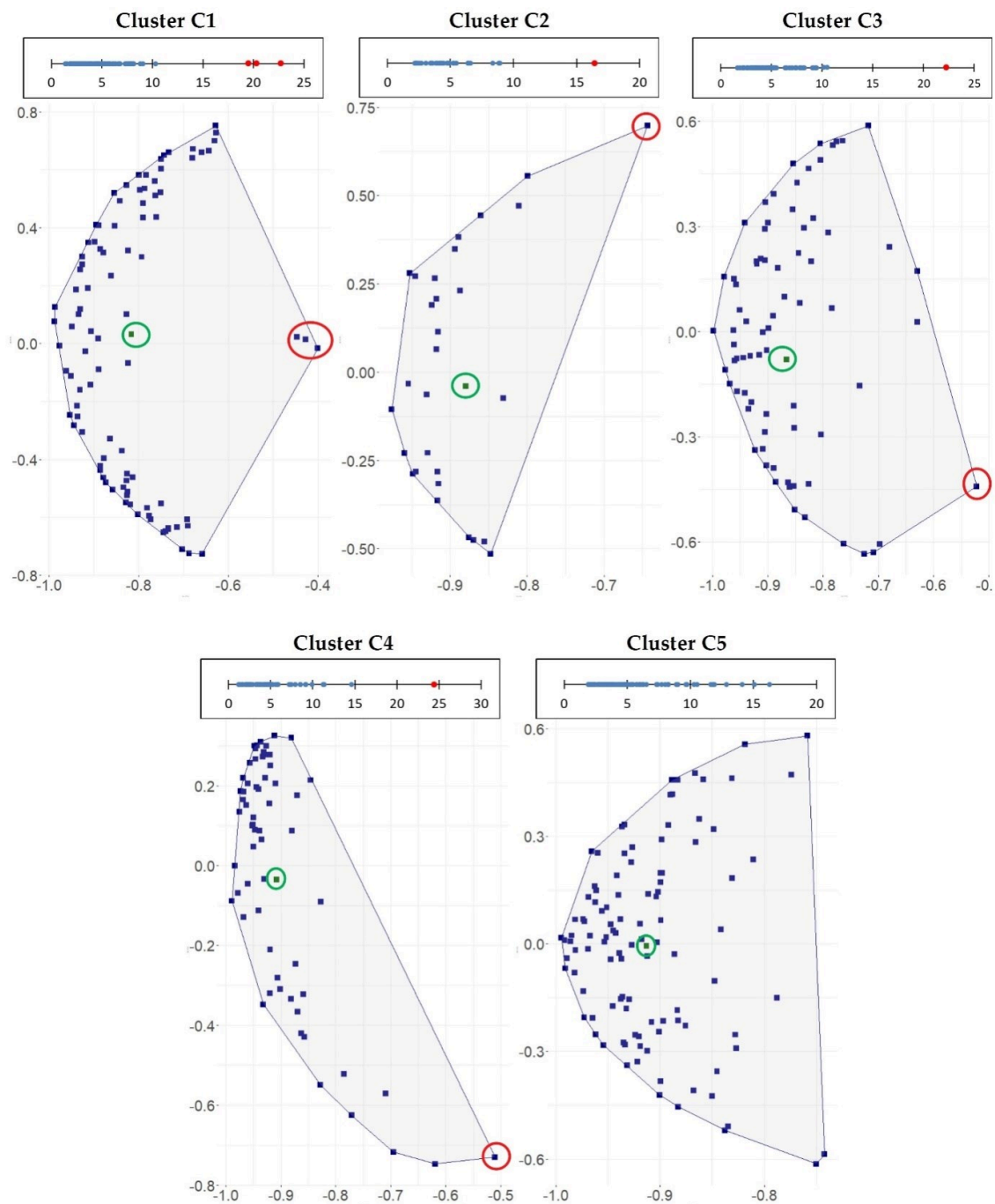
**Figure 7.** Distances of the documents from the cluster gravity point and the illustration of the documents location in each cluster in the BIN_5SV model – up and down graph respectively.

Source: authors' own elaboration.


## 5. Discussion


By observing the cluster characteristics shown in Table 2, Figure 6 and Table 3, the following profiles can be derived from the Polish patents related to solar energy in the period 01/2001-03/2021.

Cluster *C*1 is the most heterogeneous one as regards both all and the first-positioned IPC solar-related codes. The number of the codes assigned to the patent documents belonging to this cluster is greater than in the other clusters (see Table 3). Three out of them: H01L 31/00, H01L 31/04, and H02S, account for over 61% of solar classification (68% in the case of first-positioned codes). Considering the description of these IPC codes and the extracted terms (such as *cell*, *generator*, *voltage*, *current*, *form*, *cover*) it can be assumed that cluster *C*1 is devoted to technical solutions for the design of photovoltaic cells and the use of photovoltaic cells in dedicated technical solutions. The cluster generally refers to the conversion of the solar radiation energy, mainly captured by PV devices, into electrical energy or for the control of electrical energy by such radiation.

In cluster C1, three potential outliers with a high mutual similarity were identified. They concern technical solutions for 3D spatial photovoltaic panels. They describe projects the purpose of which is the improvement of photoelectric efficiency. 3D spatial panels make a better use of the same base area than fixed flat solar panels, capturing more amount of light by the light-absorbing material. There are no other 3D photovoltaic panel solutions in the cluster.

In cluster *C*2, the subject of patent applications according to the IPC classification, regardless of the *Other codes* category, is divided into two types of inventions – those concerning solar heat utilization (F24J 2/, F24S) and the ones regarding solar electricity utilization (all the codes starting with H01L). The cluster refers to the design solutions for solar devices or their components (*photodiode*, *bend*, *shape*, *centre*, *hole*, *meander*, *aluminium*, *lens*).

There is one potential outlier identified in cluster *C*2 and it concerns the solution that can have an application in photovoltaic panels. That is a silicon diode in which the active layer has a thickness greater than the visible radiation penetration layer, and the substrate layer has the same type of conductivity as the active layer. There is another application as regards a photodiode in the cluster, but its description concerns the reception of infrared radiation.

In cluster *C*3, more than 42% of the solar-related codes (45% first-positioned codes) refer to photovoltaic devices (H01L 31/04, H02S), nearly 40% (45% respectively) to solar heat devices (F24J 2/, F24S). The cluster concerns inventions relating to improvements in the operation of solar solutions and the accumulation and collection of energy generated from solar radiation (*battery*, *valve*, *mechanism*, *installation*, *sensor*, *clutch*, *engine*, *container*, *heat*). In terms of the type of a solar device, heterogeneity is a feature of the cluster.

There is one potential outlier identified in cluster *C3* and describing the hybrid design of a 3D spatial photovoltaic panel with cooling and heating for enhancing its performance. The panel is cooled by receiving thermal energy and using it to heat domestic water. In contrast, heating is used to remove snow and ice from the panel. In cluster *C3* there are no other applications with such a solution.

Cluster *C*4 refers to solar thermal radiation utilization systems for dedicated solutions. It contains proposals to improve the operation of solar heat receivers (*evaporator*, *exchanger*, *pump*, *controller*, *water*, *meander*, *collector*). Among all solar-related codes, 65% are direct references to solar collectors (F24J 2/, F24S).

The only potential outlier in cluster *C*4 describes composite zinc oxide nanowires for the production of electrodes in dye-sensitized photovoltaic cells and the production method. There are no other applications that contain such a solution.

Cluster *C*5 is the clearest one as regards both all and the first-positioned IPC solar-related codes. Its documents contain design solutions devoted to devices or their components connected with the conversion of solar radiation into heat, or for heat accumulation (*collector*, *absorber*, *pipe*, *divider*, *radiation*). Nearly 84% of all the solar-related codes are direct references to solar collectors (F24J 2/, F24S).

No potential outliers were identified in cluster 5. The distances of the documents from the cluster centre of gravity are evenly distributed, which is the consequence of the homogeneity of the cluster.

After reviewing the applications, a comment can be added that clusters *C*2, *C*3 and *C*4 contain also inventions relating to hybrid solar energy solutions.

# 6. Conclusions

In the period 01/2001-03/2021, 368 applications in the field of solar energy by Polish inventors were submitted to the Polish Patent Office. The number of the applications increased gradually over the years; at the end of the period, there were more than three times as many applications annually as at the beginning. The research on patent activity and the search for correlations within patent classes and groups allowed identifying the directions of technological solutions in the field of solar energy in Poland.

Most of the patent applications relate to solutions for converting solar energy into electricity, slightly fewer relate to converting solar energy into thermal energy, and there are also hybrid solutions. The clustering analysis made it possible to distinguish among them thematic areas including: PV panel designs, PV panel component designs, the improvement of solar-heat conversion device performance, and solar collector designs. In the collection of the analysed patent applications, there were sporadic references to increasingly common technologies focusing on solar cell materials that would have both high efficiency and low cost.

Seeking for outliers in the analysed sets of documents may be beneficial for research and development departments in various organizations or for individual inventors. The proposed outlier patent document search algorithm allowed the identification of six patent applications that stood out thematically in four out of the total number of five clusters. None have been

rejected in the patent granting process; 4 applications are pending (2022/05/22) and 2 have received patent protection. It seems that the direction of development in the solar energy technology may be 3D spatial panels and material technologies for photovoltaics. All outliers concern photovoltaic solutions and none of them refer to the technology of converting solar radiation into thermal energy. The proposed algorithm for identifying outliers seems to work well, but it was applied to a limited study topic and should be verified for other cases. It is also advisable to seek expert opinion in this respect.

In the research process, new solutions regarding the research methodology were proposed in the consecutive steps (see Figure 3). They constitute the authors' methodology contribution as follows:

- the development of the method for selecting the degree of the Term Document Matrix dimensionality reduction (step 2),
- the proposition of the *GQA* global measure of clustering quality assessment (step 3),
- the elaboration of the outlier patent detection algorithm (step 4).

There is the following substantive contribution (as regards the research subject):

- the characterization of the main tendencies of inventiveness in the Polish solar energy technology,
- the detection of outliers in the Polish patent applications, indicating potential directions of technology development in the field of solar energy in Poland.

The presented research is a pilot study and it discusses the issue of solar energy patents for one country, that is Poland. However, the results may be interesting as a country case study and can be referred to in the context of analogous studies for other countries. The developed research methodology is also very promising.

It is planned to extend the analyses to a larger set of patent documents and at the same time solve the problem related to the language of the patent applications (the necessity of having all the analyzed documents in one language) along with merging data from various sources. The data extension concerns a wider range of the inventors' nationality and a wider range of patent databases (such as USPTO and EPO). Considering the fact that patent titles and patent abstracts can be insufficient for the analysis, full patent descriptions are planned to be considered as well. In this aspect, patent claims should also be taken into account.

A properly edited dictionary plays a key role in cluster identification. Therefore, it will also be the subject of the further work, in which parts of speech other than nouns and verbs should be taken into account.

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# Appendix A

**Table 1a.**
*The description of selected IPC codes*

| IPC Code | Description[1] |
|---|---|
| E04D 13/18 | Roof covering aspects of energy collecting devices, e.g. including solar panels |
| F03G 6/06 | Devices for producing mechanical power from solar energy with solar energy concentrating means |
| F24J 2/ | Use of solar heat, e.g. solar heat collectors |
| F24S | Solar heat collectors; solar heat systems |
| G05F 1/67 | Automatic systems in which deviations of an electric quantity from one or more predetermined values are detected at the output of the system and fed back to a device within the system to restore the detected quantity to its predetermined value or values, regulating electric power to the maximum power available from a generator, e.g. from solar cell |
| H01L 25/00 | Assemblies consisting of a plurality of an individual semiconductor or other solid state devices |
| H01L 31/00 | Semiconductor devices sensitive to infra-red radiation, light, electromagnetic radiation of shorter wavelength, or corpuscular radiation and specially adapted either for the conversion of the energy of such radiation into electrical energy or for the control of electrical energy by such radiation; Processes or apparatus specially adapted for the manufacture or treatment thereof or of parts thereof; Details thereof |
| H01L 31/04 | * Adapted as photovoltaic [PV] conversion devices |
| H01L 31/05 | *** Electrical interconnection means between PV cells inside the PV module, e.g. series connection of PV cells |
| H01L 31/18 | * Processes or apparatus specially adapted for the manufacture or treatment of these devices or of parts thereof |
| H02J 7/35 | Parallel operation in networks using both storage and other dc sources, (e.g. providing buffering) with light sensitive cells |
| H02N 6/00 | Generators in which light radiation is directly converted into electrical energy |
| H02S | Generation of electric power by conversion of infra-red radiation, visible light or ultraviolet light, e.g. using photovoltaic [pv] modules |

[1] The code description was taken from https://onscope.com/ipowner/en/ipc.html (accessed on 01 March 2022).

Source: authors' own elaboration.

# DESCRIPTION OF THE COMPANY'S MISSION IN THE PLASTICS PROCESSING INDUSTRY

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**Purpose:** The article is a response to the needs of a specific company for help in writing a mission based on the Japanese management philosophy, especially Toyota, which is based on elements of the Toyota House roof. The content of the mission is supposed to emphasize the importance of these elements in the interpretation of employees (respondents).

**Design/methodology:** To achieve the stated goal of the article, the BOST questionnaire, the main research tool in toyo-tority, was used. The respondents assessed the importance of such elements of mission (factors) as: quality, work safety, costs, execution time, and attitude of the crew. A statistical analysis of the obtained sets of scores was carried out. An importance series was built, the preferences of the analyzed factors were assessed, the average scores were compared, the influence of the re-spondents' characteristics on the scores of the examined factors was determined.

**Findings:** The analysis of the research results allowed to obtain interesting information: quality, according to the respondents, is the most important, two factors - costs and work safety show similarity (for the 10% criterion) in terms of preferences, the average of these factors did not show any significant differentiation of the average scores. On the evaluation of the quality factor three respondents' characteristics are influenced, the cost - two, work safety - none.

**Originality:** This article presents: Make the Toyota House roof from the set of five elements a research tool and signing it into the BOST survey structure. These elements were referred to industries other than the automotive industry. Confirmation of the equivalence of the comparative scale and the range scale in the assessment of the similarity of the preference factors. The article is addressed mainly to the management staff and students of management and production engineering.

**Keywords:** mission, toyotarity BOST method, preference.

**Category of the paper:** research paper.

# 1. Introduction. The concept of mission

Mission is a precise word, expressed in a language understandable to employees and the organizational environment outlining its far-reaching goals and aspirations. Mission is the statement of vision employed by organization for strategic purposes (Griffin, 2005). Vision, on the other hand, is the image of the future that organizations want to create. The word "vision" comes from the Latin word *videre*, meaning "vision". According to the most natural definition vision is the concept of the company's future, the most fundamental aspiration that in order to be effective should be shared by both the management and other employees.

It is difficult to develop a good mission statement, as two contradictions have to be accommodated. First of all the mission should be lapidary but at the same time broad. Secondly, the mission should contain the element of a dream and indicate the operational way of its implementation.

## 1.1. Mission in the structure of toyotarity

TOYOTARITY is a concept invented by the author of the chapter and is a proprietary name (Borkowski, 2012a).

**Toyotarity is defined as a scientific study of human-machine and human-human interactions with regard to process-based approach and Japanese culture, especially that of Toyota, aimed at continuous improvement with the use of knowledge.**

The basic model of TOYOTARITY is shown in Figure 1.
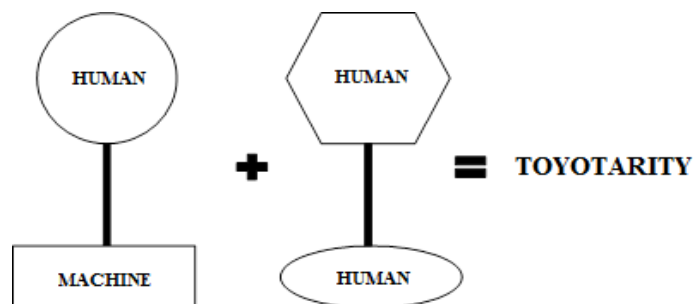


**Figure 1.** The basic model of TOYOTARITY.
Source: Borkowski, 2012b.

## 1.2. Mission in Toyota's house structure

The production system is a purpose-designed and structured subsystem that includes electrical power, materials and information used by a human to produce certain goods or services to satisfy the diverse needs of consumers (Lewandowski, Skołud, Plinta, 2014). The production system is the configuration of the com-ponents, the relationships between them and the conversion processes (converting the system's input vector into an output vector) (Durlik, 2007).

The Toyota Production System is based on the assumption that all individual elements work for the cause of a whole (Ohno, 2008). Its goal is also to support and encourage employees to continually strive for improvement in every sphere of company's activity (Liker, 2005).

In literature, several models of Toyota production system are described. One of them is shown in Figure 2. In general, the TPS (Toyota production System) is based on the philosophy of the Toyota Way (Liker, Meier, 2011).

The Toyota Way means much more than tools and techniques (Liker, Hoseus, 2016):

- It is a set of tools and techniques engaging all employees in continual improvement of their work (Kaczmarska, Gierulski, 2022).
- It depends on people who have the ability to detect invisible problems and try to solve them.
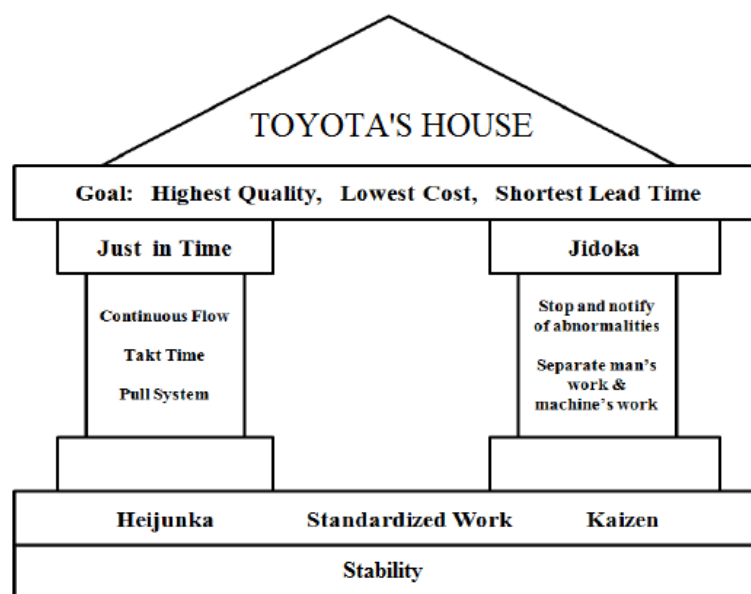
**Figure 2.** Toyota Production System. Toyota House.
Source: Liker, 2005.

### 1.3. Mission in the BOST questionnaire

The BOST questionnaire, that is Toyota's management principles in questions, was created by Stanisław Borkowski, Prof. of Technical and Economic Sciences. The name comes from the two initial letters of the author's first name and surname and is a proprietary name, (Borkowski, 2012a, 2012b, 2012c). Each of Toyota's principles is described by a set of factors called areas (Borkowski, 2021). The survey has two versions: for supervisors and for employees (Silwerman, 2009).

The BOST survey is universal and can be used both in manufacturing and service-providing enterprises (e.g., banks, hospitals, schools and shops) (Apanowicz, 2005; Babbie, 2007). The survey for manufacturing enterprises (one version for employees and the other for supervisors) consists of 12 sets of factors (areas). The version for the employees includes a set of factors describing the elements of the Toyota house roof and principles 1, 2, 3, 4, 6, 7 and

14, whereas the version for the supervisors includes a set of factors describing all the principles of management in Toyota and the elements of the Toyota house roof. The survey contains a rank scale and the respondents use it to evaluate the importance of each factor (Nowak, 11).

In the author's publications (Borkowski, 2022) the elements of mission (the roof of Toyota House are presented as follows:

**Area E1. What is most important in your enterprise? Arrange the factors in the priority order inserting 1; 2; 3; 4; or 5 (5 is the most important factor) into the box:**

| JA | | Quality |
| KO | | Costs |
| CR | | Lead time |
| BP | | Occupational safety |
| MZ | | Staff morale |

The manufacturer of PVC pipes and fittings (Kaczmarska, Gierulski, Zajac, Bittner, 2021). The products include sewer pipes of different diameter, length and wall thickness, connectors, wells and inspection openings. The main customers are construction companies and supermarkets. The enterprise runs three shops including one located on its premises, the second within the distance of 20 and the third 50 km. Construction materials produced by other companies are also sold there.

## 2. Basic of the statistical analysis of evaluation sets – analysis of the structure of the respondents' characteristics

### 2.1. Characteristics of selected statistical measures

In the BOST method the following statistical measures are used to analyze the sets of responses:

- arithmetic mean,
- standard deviation,
- quartile deviation,
- coefficient of variation,
- coefficient of skewness,
- coefficient of excess,
- similarity according to the comparative scale and the range scale,
- differentiation of average ratings,
- correlation analysis.

The most intuitive measure of position is the arithmetic mean. For data in a detailed series, it is calculated by adding all the values assigned to the feature, and dividing the sum is by the number of features (Ostasiewicz, Rusnak, Siedlecka, 2006).

Standard deviation is an absolute measure of the differentiation in the distribution of features; it indicates the average deviation from the arithmetic mean (Pułaska-Turyna, 2008).

Quartile deviation is one half of the difference obtained by subtracting the first quartile from the third quartile. The quartile deviation is, therefore, an absolute measure and indicates the average deviation from the median for a half of middle values in the data set (Pułaska-Turyna, 2008).

The coefficient of variation is the ratio of the standard deviation to the arithmetic mean expressed as a percentage.

The coefficient of skewness (asymmetry) is used to determine the strength and direction of asymmetry; it does not normally exceed the interval from -2 to +2. The sign indicates the direction of the asymmetry; the positive sign (histograms over the zero axis) indicates the right-sided and the negative the left-sided skewness (Rabiej, 2012).

The coefficient of excess (We) is a measure of the extent to which the units concentrate around the mean. A small concentration of units around the mean is expressed by a relatively flat distribution and vice versa. The excess coefficient indicates the degree of flattening of the set with respect to the flattening of the normal set (Piłatowska, 2009).

## 2.2. Assessment of respondents' characteristics

The BOST survey comprises the following characteristic of independent variable (respondents' features):

- gender (MK) - 1 - man, 2 - woman,
- education (WE) - 1 - < secondary, 2 - secondary, 3 - higher I, 4 - higher II,
- age (WI) - 1 - to 25 years, 2 - 26-35 years, 3 - 36-45 years, 4 - 46-50 years, 5 - 51-55 years, 6 - 56-60 years, 7 - 61-65 years, 8 - over 66 years,
- work experience (SC) - 1 - to 5 years, 2 - 6-15 years, 3 - 16-25 years, 4 - 26-30 years, 5 - 31-35years , 6 - 36-40 years, 7 - 41-45 years, 8-– over 45years,
- current employment is your place of work (MR):
  1 – first      □ , 2 – second□ , 3 – third    □ ,
  4 – fourth   □ , 5 – fifth    □ , 6 – further□ .
- in the present company I was employed in the mode: (two answers may be marked) (TR):
  1 – regular   □ ,        2 – transfer □ ,
  3 – on account of better financial conditions   □ .

In the company manufacturing PVC pipes and fittings, the BOST questionnaire was filled in by 32 respondents, including 21 men and 11 women (Figure 3a).
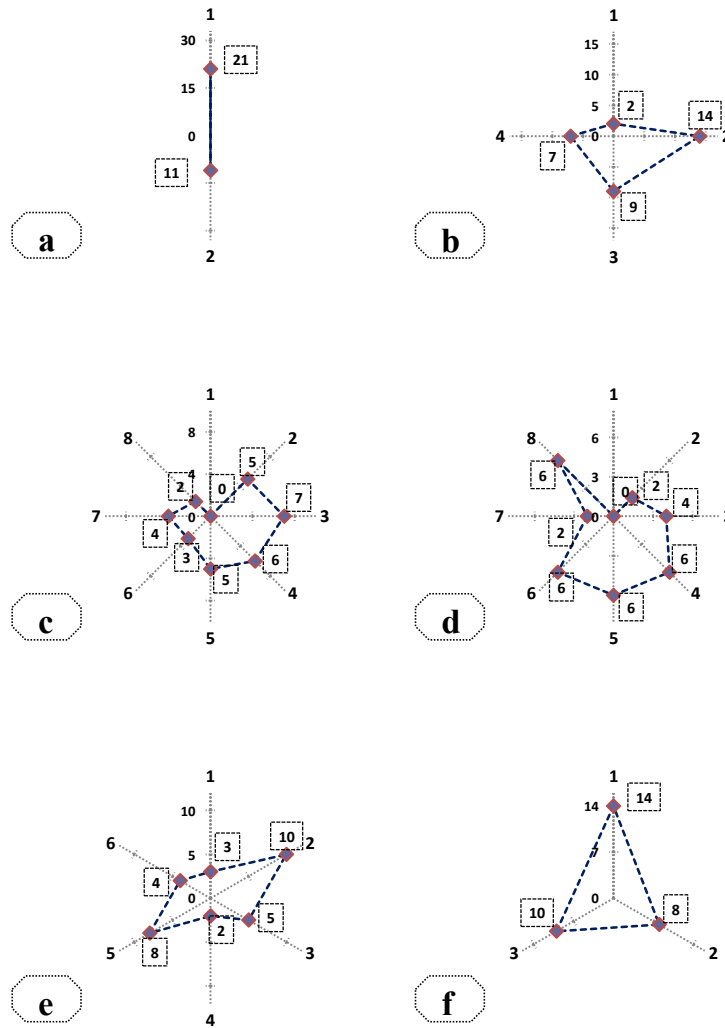
**Figure 3.** Radar graphs. Respondents characteristic with consideration of: a) gender, b) education, c) age, d) job seniority, e) mobility, f) way of recruitment.

Source: own study.

Figure 3b shows that 14 people (44%, Table 1, WE column) have a secondary education and a total of 16 respondents out of 31 have higher education. The biggest group of respondents (7 persons) is aged between 36 and 45, (Figure 3c; taking into account the next two variants of age we obtain 18 people (57% of respondents) aged between 36 and 55. This group of respondents, being the most efficient, constitutes human capital of the company. Figure 3d shows that four variants of work experience have the same number of respondents, 6 each. For 62% of respondents a long-term employment is also a company capital. Respondents are very mobile (Figure 3e), as only 3 of them (9%) have not worked before in any other company. Figure 3f shows that the high rotation of the staff was associated with low salaries. The owner stabilized the staff by basing the mode of recruitment on two procedures: transfer to another post and good salary.

**Table 1.**

*Features of respondents. Percentage characteristic*

| Symbol | Features' marking and their rate characteristic | | | | | |
|---|---|---|---|---|---|---|
| | MK | WE | WI | SC | MR | TR |
| 1 | 66 | 6 | 0 | 0 | 9 | 44 |
| 2 | 34 | 44 | 16 | 6 | 31 | 25 |
| 3 | | 28 | 22 | 13 | 16 | 31 |
| 4 | | 22 | 19 | 19 | 6 | |
| 5 | | | 16 | 19 | 25 | |
| 6 | | | 9 | 19 | 13 | |
| 7 | | | 13 | 6 | | |
| 8 | 32 | | 6 | 19 | | |

Source: own study.

In conclusion, most of the respondents, the employees of company producing PVC pipes and fittings, are men. The majority of respondents are at the age of highest productivity. Most have work experience of 26-45 years, more than 90% have previously worked in at least one company. A significant number of the respondents considered the amount of salary as the most important factor when accepting the job (Pocztowski, 2003).

As noted above, in the BOST method, the correlation between the respondents' features is analyzed. The results are presented as bubble charts, taking the form of a matrix. When analyzing the matrix data the following should be kept in mind: the maximum number of possible correlations is 5, the general number of correlations is 15, the correlation applies to three levels of $\alpha$: 0.05; 0.1; 0.2 (Figure 4). The correlations of features obtained for the respondents employed by the manufacturer of PCV pipes and fittings are shown in Figure 4. A preliminary analysis shows that in 4 cases no correlation exists. The mode of recruitment (TR) does not show a statistically significant correlation with the mobility. The correlations with respondents' gender ($\alpha = 0.05$) and education ($\alpha = 0.2$) are negative. In the next two cases correlations are positive: with age at $\alpha = 0.2$ and with work experience at $\alpha = 0.1$. Women are more likely than men to be recruited on a standard basis while less educated respondents are more interested in the amount of salary; older employees and those with longer work experience show more interest in the amount of salary. The respondents' gender (MK) is correlated with the mode of recruitment, work experience and age (Figure 4). The correlations are negative at the $\alpha$ level of 0.05. That means that women are more likely than men to be recruited on a standard basis, they are younger and have shorter work experience. The education of respondents (WE) showed a statistically significant correlation with the same features as gender, the direction of the relationship is also negative, but the level of $\alpha$ is 0.2. During recruitment procedure less educated respondents show interest in the amount of salary, are older and have long work experience.

The age of respondents (WI) showed statistically significant correlation with other features. These correlations are as follows: with the mode of recruitment - positive correlation, $\alpha = 0.2$, with mobility - positive correlation, $\alpha = 0.2$, with work experience - positive correlation,

α = 0.05, with education - negative correlation, α = 0.2, with gender - negative correlation, α = 0.05. This indicates that older respondents show more interest in the amount of their future salaries, are mobile, have long work experience, are less educated and are mainly men.
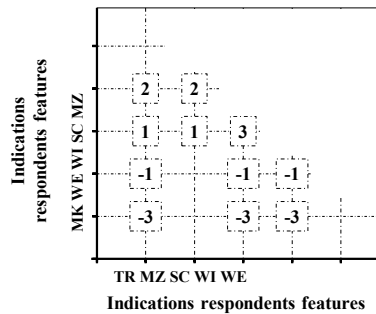


**Figure 4.** Results' map of correlation analysis between respondents' features. 1 for α = 0.2; 2 for α = 0.1; 3 for α = 0.05. (-) negative.

Source: own study.

The respondents' work experience (SC) also shows statistically significant correlation with other features. The correlations indicate that persons with a long work experience are interested in the amount of future salaries, have worked in other companies, are older, do not have higher education and are men.

The respondents' mobility (MZ) showed statistically significant correlation with work experience (positive correlation, α = 0.1) and age (positive correlation, α = 0.2). The respondents who frequently change jobs are older and have long work experience.

## 3.  Presentation of the results of teh BOST survery and their analysis

### 3.1. Analysis of the structure of assessmments of the importance of factors describing the mission of enterprises according to Toyota

The analysis of the respondents' features (explanatory variables) and the evaluation of factors describing Toyota mission are followed by the statistical analysis. Figure 5 shows the selected statistical measures of the sets of results obtained in T enterprise. The ratings of factors describing Toyota mission obtained from the respondents employed by the company producing PVC pipes and fittings (T4) are presented in Figure 5. The rating for *quality* (JA) is "4" (9 occurrences) and for *staff morale* (MZ) "1" (17 occurrences). The set of ratings for *costs* (KO) has the maximum number of occurrences for "3" (13 occurrences), lead *time* (CR) for "2" (10 occurrences) and *occupational safety* (BP) for "4" (10 occurrences).
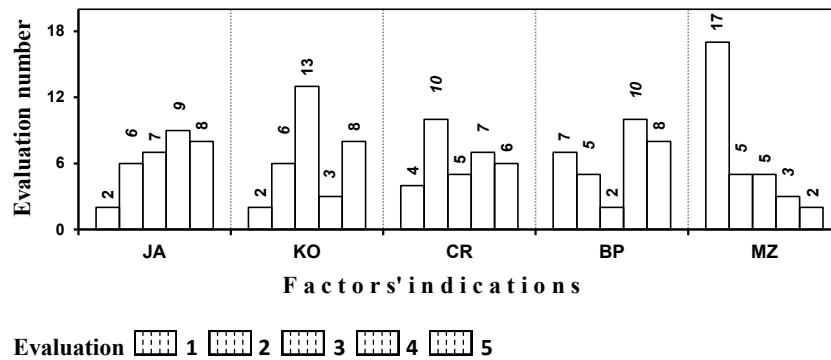
**Figure 5.** Roof of the Toyota house. Distribution analysis of evaluations E1 area factors.

Source: own study.

## 3.2. Statistical analysis of sets of ratings

The analysis of the respondents' features (explanatory variables) and the evaluation of factors describing Toyota mission are followed by the statistical analysis. The results of a statistical analysis of factors describing Toyota mission obtained in the enterprise manufacturing PVC pipes and fittings are shown in Figure 6.
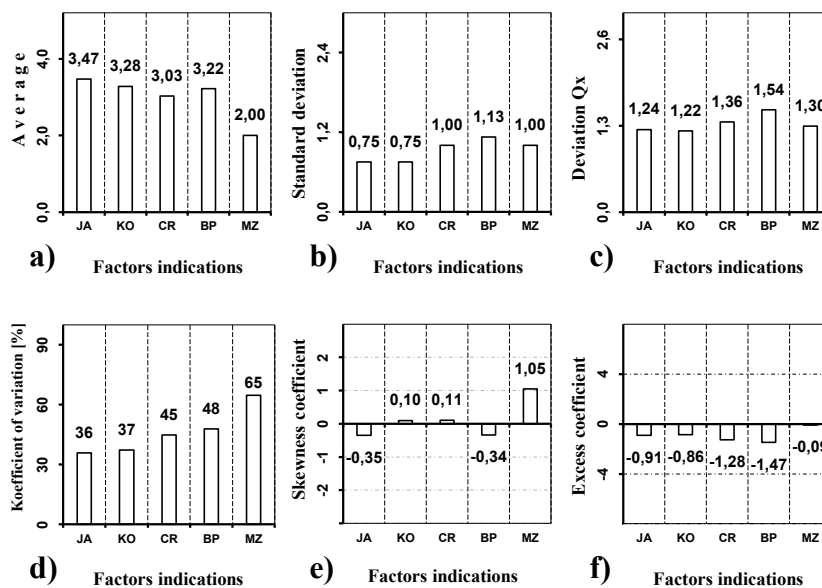


**Figure 6.** Roof of the Toyota house. Comparison: a) average, b) standard deviation, c) Qx deviation, d) coefficient of variation, e) skewness, f) kurtosis for E1 area factors.

Source: own study.

The respondents think that the most significant factor of the mission in their enterprise is *quality* (JA) (Figure 6a). They were unanimous as the set of ratings obtained (Figure 6b) has the smallest standard deviation. As regards the distribution of 50% of central values (Figure 6c) the largest deviation from the median exists in the set of ratings for *occupational safety* factor. (BP). The factor is scattered in the interval between 36 – 65%, and includes three scale ranges. In the range from 20 to 40% covering moderate differentiation of feature the sets of ratings for

*quality* (JA) and *costs* (KO) exist; in the range from 40 to 60% covering a strong differentiation of features the sets of ratings for *lead time* (CR) and *occupational safety* are present. The set of ratings for *staff morale* factor has a very strong differentiation of feature as the coefficient of variation is greater than 60%. The distributions of ratings for *quality* (JA) and *occupational safety* (BP) have negative coefficients of skewness which means that they are skewed to the left. The coefficient of skewness for the ratings of factors denoted as KO, CR, BP is positive; the ratings are grouped around lower values.

On the basis of the degree of asymmetry expressed by asymmetry coefficient the distributions of ratings fall within two scale ranges. A very weak asymmetry of distribution (range from 0.0 to 0.4) applies to the distribution of ratings for the factors denoted as: JA, KO, CR, BP. The distribution of *staff morale* (MZ) factor has the skewness coefficient of 1,05 which means that its asymmetry is moderate. The excess coefficient of ratings obtained for all factors is negative which implies that they are less flattened than normal ones.

### 3.3. Development of the series of factors arranged by the degree of importance (The Roof of Toyota House)

One of the aims of the BOST survey is to examine the relationships between ratings obtained for the factors. For that purpose the series of factors (describing the Toyota mission) arranged by the degree of importance, the preferences for each factor, and the differentiation of average ratings are presented. To develop the series of factors by the degree of importance, the rating scale is used. It is calculated on the basis of the average rating. For a five-point scale it is five. The extent to which the scale is used is expressed as the average rating divided by the maximum rating (resulting from the scale) multiplied by a hundred (expressed as a percentage). Figure 7 shows the application of the ranking scale in five enterprises.
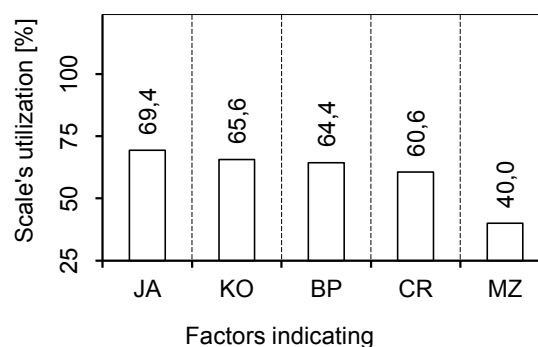


**Figure 7.** The usage of measurement scale for evaluating the importance of factors which describe the mission.

Source: own study.

Basing upon the data the following series of factors (describing the Roof of Toyota House) arranged by the degree of importance were obtained:

$$JA > KO > BP > CR > MZ \tag{1}$$

The respondents think the enterprise manufacturing PVC pipes and fittings (T4) focuses on *quality* (JA) as the most important element of its mission. Quality is understood as compliance with technical requirements such as length, diameter, tightness and chamfering.

Since pipes are usually joined at an angle, the quality of fittings consists in maintaining the required angles, and diameters. Customers want the exposed pipes and fittings to be white. This preference is taken into account and the color of pipes and fittings is included in quality factors. *Costs* factor (KO) occupies the second place. Defective pipes are cut into shorter ones in order to eliminate the defect. Some are milled and so are defective fittings. The respondents think that occupational safety can take the third place (series 1). Since the moving parts of the machines are separated from the respondents by curtains, the number of accidents at work is negligible. The majority of accidents are caused during transport and assembly of pipes. The fourth place in the order of significance is taken by *lead-time* factor (CR). As the manufacturing of PVC pipes and fittings is based upon rigid technologies the introduction of any modification results in an increased number of defective products.

## 3.4. Interpretation of series of importance

The interpretation of series of importance describing Toyota mission will be conducted on the basis of preferences expressed by the respondents while ranking the significance of factors. Two scales will be used to compare preferences: Thurstone scale and the scale of range developed by the author (Sagan, 2003). The purpose of using two scales is to demonstrate their equivalence. The figures include: the comparative scale and the scale of range: (a) showing the factors studied, (b) illustrating the distance between adjacent factors, (c) showing the distance (%) between adjacent pairs of factors on a selected scale (Borkowski, Knop, 2014).

Figure 8 and Figure 9 are used to determine respondents' preferences regarding factors describing Toyota mission, (series 1) in the enterprise manufacturing PVC pipes and fittings. The relationship 1 and the distribution of factors on the comparative scale (Figure 8a) and on the scale of range (Figure 9a) indicate that the order of factors is the same on both scales.

Analyzing the distances between pairs of factors we obtain the following relationships: for the comparative scale:

$$CRMZ(0.57) > JAKO(0.10) > BPCR(0.08) > KOBP(0.04) \tag{2}$$

for the scale of range:

$$CRMZ(1.03) > JAKO(0.19) = BPCR(0.19) > KOBP(0.06) \tag{3}$$

Thus we can conclude that:
- the distances between factors are bigger on the scale of range than on the comparative scale,
- two pairs with the same distance between factors are present on the percentage scale of range.
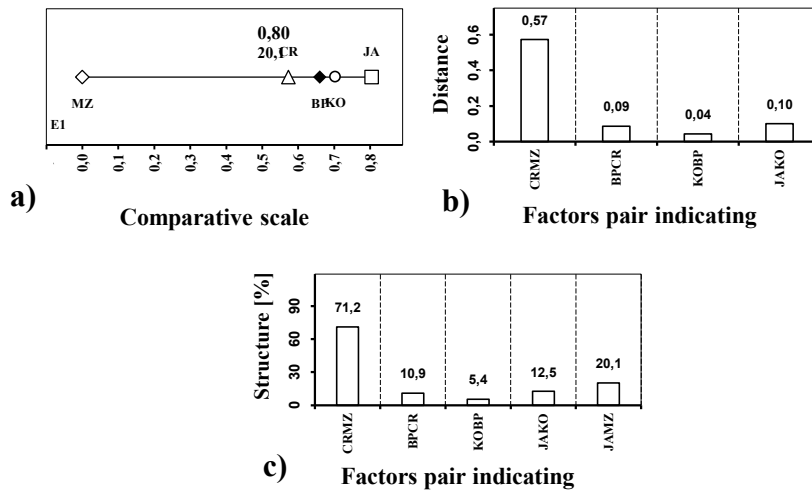
**Figure 8.** Characteristics of comparative evaluations' scale for importance factors in E1 area: a) distribution of factors on the scale, b) distance between pairs of factors, c) scale structure (%).

Source: own study.

While analyzing the preferences (Figure "a" and Figure "c") we notice some peculiarity in the distribution of factors on the scales; four factors are distributed in the range of 70-100%. We find that *quality* (JA) unlike other factors is most strongly preferred (Hamrol, 2013). The *costs* factor (KO) shows a similarity in preference to the o*ccupational safety* (BP) because the distance between them is less than 10%. Both factors are in the strong preference area (80-100%). The *lead time* factor (CR) does not show similarity in preference to other factors. It is located in the area of strong preference (60-80%). S*taff morale* (MZ) is the least preferred factor.
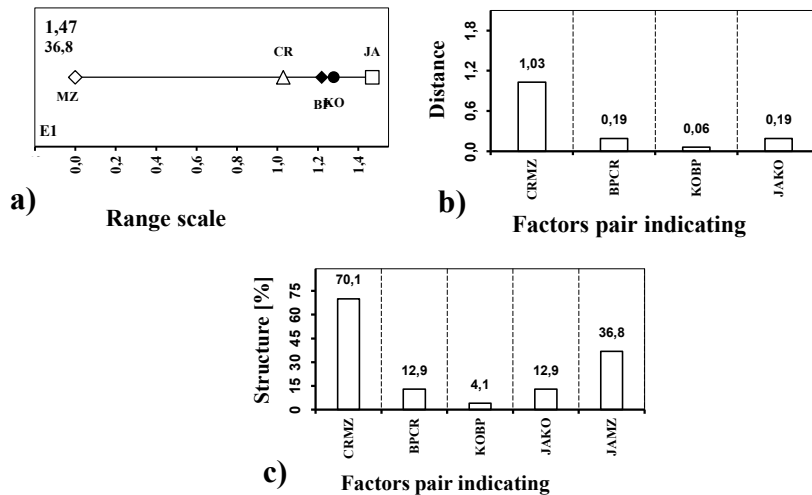


**Figure 9.** Characteristics of range' scale for average importance evaluations' for factors in E1 area: a) distribution of factors on the scale, b) distances between pairs of factors, c) structure (%) of scale.

Source: own study.

### 3.5. Differentiation of average ratings of factors describing the enterprise mission

Table 2 presents the results concerning the differentiation of the average ratings of factors located in E1 area for the enterprise manufacturing PVC pipes and fittings. The pairs with *quality* (JA) factor have the differentiation of average ratings written as: JA: KO – (0; 0; 0), JA: CR – (0; 0; 1), JA: BP – (0; 0; 0), JA: MZ – (1; 1; 1). It can be concluded that the average rating of *quality* factor differs from those of *lead time* factor (CR) only at α = 0.2 and *staff morale* factor (MZ) at α = 0.05; 0,1 and 0.2. From the Table 2 it follows that the average ratings of the pairs of factors KO: JA, KO:CR and KO:BP do not show significant differentiation. Therefore, they can be written as (0; 0; 0). The average ratings of KO: MZ pair show significant differentiation at all α levels. The differentiation of average ratings for two pairs containing *lead time* factor (CR), namely, CR:KO, CR:BP are also written as (0; 0; 0). This means that their average ratings do not differ significantly at α = 0.05; 0.1 and 0.2. The average ratings of CR: MZ show significant differentiation at all assumed levels of α, which is written as (1; 1; 1). The differentiation of the average ratings of CR: JA exists only at α = 0.2.

**Table 2.**
*Roof of the Toyota house. The results of importance difference analysis average evaluations factors for E1 area*

| Indications | | KO | CR | BP | MZ |
|---|---|---|---|---|---|
| **JA** | test | *0,61* | *1,35* | *0,71* | *4,63* |
| | α = 0,05 | *no* | *no* | *no* | *yes* |
| | α = 0,1 | *no* | *no* | *no* | *yes* |
| | α = 0,2 | *no* | *yes* | *no* | *yes* |
| **KO** | test | *E1* | *0,77* | *0,18* | *4,07* |
| | α = 0,05 | *1,9600* | *no* | *no* | *yes* |
| | α = 0,1 | *1,6449* | *no* | *no* | *yes* |
| | α = 0,2 | *1,2816* | *no* | *no* | *yes* |
| **CR** | test | | | *0,52* | *3,11* |
| | α = 0,05 | *yes - significant diversification* | | *no* | *yes* |
| | α = 0,1 | | | *no* | *yes* |
| | α = 0,2 | | | *no* | *yes* |
| **BP** | test | | | | *3,43* |
| | α = 0,05 | *no - insignificant diversification* | | | *yes* |
| | α = 0,1 | | | | *yes* |
| | α = 0,2 | | | | *yes* |

Source own study.

From the column PB in Table 2 we conclude that the average ratings of: BP: JA, BP: KO, BP: CR do not show significant differentiation and can be written as (0; 0; 0). The average rating of *occupational safety* factor (BP) differs significantly from that of *staff morale* (MZ) at the assumed levels of α. The differentiation is written as BP: MZ – (1; 1; 1). The relationships in the pairs of factors containing *staff morale* factor (MZ) in all cases (MZ column in Table 2) are written as (1; 1; 1), owing to a significant differentiation at α = 0.05; 0.1 and 0.2. It should be stressed that the significant differentiation of average ratings is observed only for JA: CR (CR: JA) and four pairs in which *staff morale* factor (MZ) is present.

On the basis of relationship (1) we obtain the pairs with the following differentiation of average ratings: JA: KO - (0; 0; 0), KO: BP - (0; 0; 0), BP:CR - (0; 0; 0), CR:MZ - (1; 1; 1). Hence we can conclude that in the relationship 1 the statistical differentiation of the average ratings exists only for the factors taking the fourth (*occupational safety* – BP) and fifth place (*staff-morale* – MZ).

To sum up, the biggest number of differentiated average ratings is observed for the manufacturer of concrete products while the smallest one for the manufacturer of PVC pipes and fittings. The average ratings show the least differentiation for pairs with *costs* factor (KO). In five enterprises all pairs with *staff morale* factor (MZ) show significant differentiation of the average ratings at the assumed α levels.

### 3.6. Correlation analysis

The results of correlation analysis for the enterprise manufacturing PVC pipes and fittings are shown in Figure 10. Two respondents' features: gender (Figure10a) and education (Figure 10b) do not influence the ratings. The respondents' age (Figure 10c) influences the rating of three factors: *quality* (JA), positive correlation at $\alpha = 0.2; 0.1$; *lead time* (CR), positive correlation at $\alpha = 0.2$; occupational *safety* (BP), negative correlation at $\alpha = 0.05; 0.1; 0.2$. The respondents' work experience (Figure 10d) also influences three factors: *quality* (JA), positive correlation at $\alpha = 0.2$; *lead time* (CR), positive correlation at $\alpha = 0.2;01$; occupational *safety* (BP), negative correlation at $\alpha = 0.05; 0.1; 0.2$. This indicates that respondents' age and work experience are equally active in affecting the ratings of the analyzed factors. The respondents' mobility (Figure 10e) influences the rating of *quality* factor (JA), positive correlation at $\alpha = 0,2$. The ratings of *quality* (JA) with positive correlation at $\alpha = 0,2$ and *staff morale* (MZ) with negative correlation at $\alpha = 0.2$ are affected by the recruitment procedure (Figure 10f). The most sensitive factor is *quality* (JA), which is affected by four respondents' features.
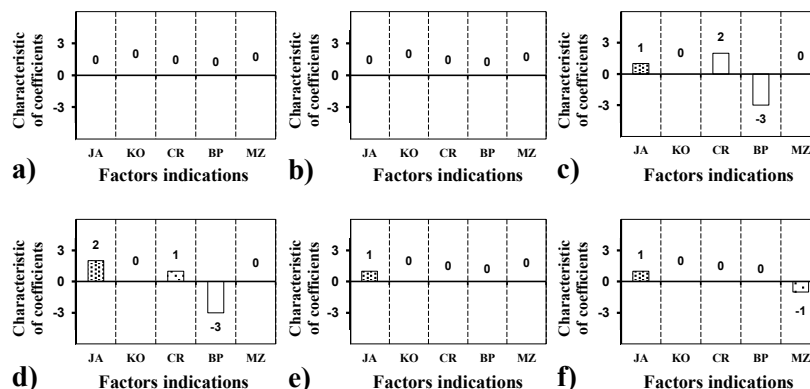


**Figure 10.** Roof of the Toyota house. Number of statistically significant coefficients for importance evaluations factors in E1 area depending on the respondents' features: a) gender, b) education, c) age, d) job seniority, e) mobility, f) way of recruitment. (+) positive correlation, (-) negative correlation.

Source: own study.

## Summary and conclusions

It was shown that employees regard quality as the most important element in company. Next in line is cost and work safety (the average values are almost the same, as the only ones similar to each other in terms of preferences), less recognition was given to the implementation time and the lowest is staff morale. Standard deviation has the sets of assessments for the work safety factor, also this set has the highest quarter deviation. The coefficient of variation indicates that the most distributed assessment is in the set of factors staff morale. The sets of factors ratings: quality, work safety have left-hand skewness, sets of ratings of all factors are characterized by flattening less than normal. This means that the analysed sets of scores do not raise any objections in terms of statistics. During the analysis of the significance of the differentiation of average scores, the following information was obtained: out of 10 cases, there are five, of which four concern the staff morale factor.

The structure of the respondents' characteristics is following: in the plastics processing industry works mainly men, half of the respondents have higher education, 57% of respondents are at the age of the highest productivity, 62% of respondents have over 26 years of work, 91% of respondents have previously worked in at least one other enterprise. It has been shown that two features: age and seniority are statistically significantly correlated with the other five features.

No influence of gender and education on the evaluation of the importance of the analysed factors was identified. The evaluation of the quality factor is influenced by the remaining four characteristics of the respondents, age and seniority are similarly created by the evaluation of three factors. The evaluation of the cost and quality factor is not influenced by any of the respondents' characteristics. Considering the analysis of the obtained assessments of the importance factors describing the roof of the Toyota's House and the structure of the respondents' characteristics and relations between them, the content of the company's mission in the plastics processing industry can be formulated.

The mission of our company is mainly the highest and constant quality of manufactured plastic products. The products are manufactured considering high work safety and costs and production time and staff. Managers of the enterprise achieve the mission by human resource management so that the employees are mainly men, with higher education, in the productive age, with the longest possible work experience and with experience in other enterprises. In order to maintain the appropriate structure of human resources, candidates with specific personal characteristics are recruited, with the possibility of wage negotiating.

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# COMPETENCES 4.0 IN THE LOGISTICS SECTOR AGAINST THE CHALLENGES OF SUSTAINABLE DIGITAL TRANSFORMATION OF THE ECONOMY IN THE POLISH PERSPECTIVE

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**Purpose:** The aim of the paper was the identification of 4.0 competences that should be characterized by logistics workers in the era of the fourth industrial revolution.

**Design/methodology/approach:** First step was the desk research analysis of source material (monographic studies, publications and reports). The second step were primary (fragmentary) explanatory, descriptive and explanatory, focused on the implementation of one research goal. The method used in the course of the study was the "user-centric" CAWI (Computer Assisted Web Interview).

**Findings:** Technologization and robotization require from employees to acquire new digital competences. Studies show that logistics workers are aware of the needed change. There is a need to acquire competences 4.0 which can consist of cognitive, informative and technical competences.

**Research limitations/implications:** The main limitation of the research was the availability of employees in logistics companies and the precise division of enterprises in which the respondents were employed. In the available statistical summaries and address databases, there is no division taking into account the place of logistics as an element of business activities in enterprises.

**Practical implications:** Research can be also a signpost for employers of what kind of competences should be developed in the future in the face of upcoming economy 5.0 and society 5.0.

**Originality/value:** The article can be a road-map for sustainable digital transformation taking into account not only machines but also human beings.

**Keywords:** digitization, competences 4.0, sustainable economy, logistics.

**Category of the paper:** research paper.

## 1. Introduction

The basis of the functioning of modern societies is the digital revolution. The wealth of information and knowledge of generations stimulates development, signaling the enthronement of Society 5.0 and Economy 5.0. The boundary between what is digital and what is biological is already blurring, interfering with the way companies and economies operate. Big data, cloud computing technologies, mobile connectivity possibilities, automation and robotization result in transformation and integration of vertical and horizontal value chains with the progressive role of the client as an inducer of digital transformation of enterprises.

In view of such a digitized image of reality, there is a growing demand for employees who have the skills to tune enterprises to the pulse of digital beats and bits. This aspect inspired the authors to undertake an in-depth analysis of both secondary and primary sources. Among the existing industries, the authors decided to study the adaptation of employees' competences to the requirements of the digital economy in the logistics industry. The reason for the choice was the fact that the logistics industry, dealing with the integration and coordination of processes, is highly dependent on innovative technical solutions. Moreover, logistics companies, being the closest to customers representing the digital economy, integrally follow the digital transformations of the business environment.

Today, logisticians very often participate in the processes of recalibration of structures and methods of operation of enterprises in which logistic processes are carried out. Employees dealing with logistics, having hard technical competences and embedded in them soft social competences determining creativity, effectiveness and efficiency, can flexibly adapt to changing conditions, improve existing solutions and generate new ideas, as well as learn new competences. What is important in this process is how employees perceive themselves and to what extent they assess their scope of competences, and whether they see the need to strengthen it.

The authors of this article undertook the challenge of diagnosing the current state of the competence assessment of employees dealing with logistics, which includes both employees of the TSL industry and employees performing logistic tasks in enterprises whose logistics is not the domain of activity. For this purpose, the authors focused on the identification of 4.0 competences that should be characterized by logistics workers in the era of the fourth industrial revolution. Consistently, the considerations undertaken in the study were aimed at obtaining arguments to verify the hypothesis: "In the era of economy 4.0 and the upcoming economy 5.0, a logistics employee should be distinguished by competences 4.0 identified with the emanation of cognitive, social and technical competences, which enable him to be open, flexible, effective and efficient acting in the context of social and economic development and networking".

On the basis of the results of the desk research analysis of the existing Polish and foreign-language source material (monographic studies, publications and reports), the authors presented the results of analyzes of the collected primary material, including the self-assessment of logistics employees in the area of competences 4.0. An important and innovative element of the study is the self-assessment approach made by logistics employees. In the literature on the subject, such an employee perspective in terms of the desired competences in the context of Economy 4.0 is presented to a small extent and in individual publications. Therefore, according to the authors, it was worth adopting such a perspective.

## 2. Sustainable changes in the economy in the context of digital transformation

The third decade of the 21st century is a time of sudden, abrupt changes in the economy spreading on a global scale. They are referred to as digital disruption (Hill, 2017), because their key feature is discontinuity in the face of traditional legal, social and business conditions and being rooted in the digital environment, on the one hand serving as an incubator of changes, and on the other – simultaneously or separately – a strong factor transformation of economic processes. One of the main changes required is digitization and the use of information technology (Ingaldia, Klimecka-Tatara, 2022, pp. 237-246). The dynamics of changes brought about by the digital revolution creates the need to educate and improve the competences of the future, which will enable openness to changes. The rapidly growing amount of data and the convergence of different technologies that have emerged with the definitive introduction of information and communication technologies are transforming all areas of the economy. These technologies offer enormous potential for economic growth. The constant convergence of the real and virtual worlds is the main driver of digitization and change in all sectors of the economy. These changes, which all companies have to deal with, can affect entire industries, changing the way goods are designed, manufactured, delivered and paid for, or the process of providing services. Advances in digitization have led to wide and varied questions about the future of society (Dufva, Dufva, 2019, pp. 17-28). Digital solutions that put people first, create new business opportunities, encourage the development of credible technology, foster an open and democratic society, create space for a dynamic and sustainable economy, and help combat climate change (Transformacja cyfrowa, 2022). Meanwhile, Poland – from the European and global perspective – is one of the countries affected by the crisis of digital competences necessary for the country's development, including in the field of Industry 4.0. In most competency rankings, it has been in the top five countries of the European Union for years (Agencja Rozwoju Przemysłu S.A., 2020).

Digitization is often referred to as one of the mega-trends shaping the future, which refers to the activities of transforming various previously physical or analog activities into digital data systems. The concept of the digital economy first appeared in the mid-1990s. According to Don Tapscott, we are entering an "era of networked intelligence" where intelligent machines and people connect through technology. A similar definition was proposed by Erik Brynjolfsson and Brian Kahin, according to whom the digital economy is "the last and still largely unrealized transformation of all sectors of the economy thanks to the computer digitization of information" (Brynjolfsson, Kahin, 2000, pp. 295-324).

The European Commission, which presented the vision and direction of digital transformation in Europe by 2030, proposed the compass of the digital decade in the European Union, pointing to four most important directions (Europes digital, 2021):

- digital skills,
- secure and sustainable digital infrastructure,
- digital transformation of enterprises,
- digitization of public service.

The European Union promotes a digital agenda focused on human needs and adherence to EU norms and standards. It cares about the security and resilience of its digital supply chains and provides global solutions in this area. These goals are achieved through the implementation of digital economy packages funded through initiatives combining funds from the EU's Member States, companies and partners with similar goals, and the development of a toolkit linking regulatory cooperation, capacity and skills building, and investment in international cooperation and research partnerships. In this way, Europe is preparing businesses and all Europeans for a human-centered, sustainable and prosperous digital future. Digital rights and rules provide a reference framework for citizens in terms of their digital competences, and guide EU Member States and businesses with regard to new technologies. They are designed to help all EU citizens to get the most out of the digital transformation (figure 1).



| Human rights as the most important element of digital transformation | Supporting solidarity and social integration | Providing freedom of choice on the Internet |
|---|---|---|
| | **Digital rights and rules** | |
| Supporting participation in digital public space | Increasing human safety, security and empowerment | Promoting the sustainability of the digital future |

**Figure 1.** Digital rights and rules.

Source:   https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_pl.

The research of the Economic and Social Research Council (ESRC) shows that most of the definitions in the literature on the subject define the digital economy through the prism of the use of new technologies. It includes the physical infrastructure on which digital technologies are based (broadband lines, routers), devices used for access (computers, smartphones), applications that power it and the functions that provide it (Internet of Things, data analytics, cloud computing) (Dahlman, Mealy, Wermelinger, 2016). It consists of goods or services the development, production, sale or provision of which depend entirely on digital technologies (Kling, Lamb, 2000, pp. 295-324). It is a combination of several general purpose technologies and many economic and social activities carried out by humans via the Internet and related technologies, and functions thanks to digital technology, in particular electronic transactions carried out over the Internet (OUP, Digital Economy, 2017). The digital economy can also be characterized as a global web of economic activities, functioning thanks to the existence of information and communication technologies (ICT) (Rouse, 2016). The pillar of the digital economy is hyper-connectivity, meaning the growing interconnection of people, organizations and machines, enabled by the Internet, mobile technologies and the Internet of Things (IoT)" (Dahlman, Mealy, Wermelinger, 2016). In 2017, the UN agency UNCTAD recognized that the new digital economy is developing thanks to the implementation of advanced cyber-physical systems (combining machines, employees and IT systems). Includes technologies and processes based "in one way or another" on advanced information and communication solutions, such as: robotization and production automation, new data sources from mobile and ubiquitous Internet connectivity, cloud computing, big data analytics and artificial intelligence. UNCTAD experts noted that "these technologies will radically reduce the need for routine tasks and change the location, organization and content of mental work" (UNCTAD, 2017). To sum up, in the vast majority of the above-mentioned definitions, the digital economy is equated with the fact of using new technologies.

The current business environment is characterized by an unprecedented degree of volatility, uncertainty, complexity and ambiguity (VUCA) (Szalavetz, 2022, pp. 332-343). Digitization is certainly the main driver of change in most sectors of the economy, but also of profound social change. According to J. Pieregud (2016), the key factors driving the development of the digital economy are currently:

- Internet of Things (IoT) and Internet of Everything (IoE),
- hyperconnectivity,
- cloud-based applications and services (*cloud computing*),
- Big Data Analytics (BDA) and Big-Data-as-a-Service (BDaaS),
- automation and robotization,
- multi-channel and omni-channel distribution models of producst and services.

In March 2021, the European Commission adopted a new development strategy in the socio-economic sphere – Digital Compass 2030. It defined the main directions of digital transformation of Europe. In the field of basic digital skills, the European Union's goal for 2030 is to have them at least 80% of society. According to the The Digital Economy and Society Index 2021 (DESI, 2021), Poland ranks 24th among the 27 EU countries when it comes to digital skills of the society. Only 44% of Poles aged 16-74 have basic digital skills, although most jobs require such skills (Digital Economy and Society Index, 2021). Digital competences of employees are one of the main determinants of the development of companies from an increasing number of industries, including the logistics industry. They are characterized by reference to skills, knowledge, behavior, attitudes, abilities and character traits (Kispeter, 2018).

The logistics industry plays a key role in the economy and society, pooling available resources to increase the efficiency and effectiveness of logistics companies (Grubmuller, Duerkop, Huth, 2021, pp. 313-325). Logistics companies are interested in digitization because they perform better in a competitive market (Psomas, Kafetzopoulos, Gotzamani, 2018, pp. 54-73). Digitization in the logistics industry offers many opportunities and challenges in the context of the environment and climate or job creation. A strategic and sustainable development approach to identifying various aspects of the impact of technology on the economy is necessary for the responsible management of enterprises, for the benefit of enterprises, as well as the entire socio-economic and natural environment. The use of digitization in logistics contributes even more to the implementation of intelligent devices, distributed intelligent hierarchical systems, various management and control solutions, automatic identification systems, network communication systems or standardized ICT networks and internet cloud solutions (Illés, Varga, Czap, 2018). These changes significantly affect the functioning of the economy and the labor market. New technologies influence today's work and change the social attitude towards the organization and design of work (Terhoeven, Tegtmeier, Wischniewski, 2022, pp. 302-307). Against this background, the question arises, what does human-oriented work design have to look like in the digital age? In order to define the indications for the design of a job, you first need to find out what working conditions actually exist for each task and what is their level of digitization. Numerous studies in this area indicate the acceleration of technology and industry convergence and highlight the role that digitization gives these processes further momentum. Research shows that the development of new ICT technologies has enormous potential to support employees.

## 3. Competences in Industry 4.0

Industry 4.0 is a technological, process and organizational transformation of enterprises. Its condition is the advanced use of digital solutions and data resources, and its goal – mass

personalization of the production of goods and services in response to the individual needs of customers. (Śledziewska, Włoch 2020) The fourth industrial revolution introduces a number of technological changes, also for the functioning of enterprises. But regardless of the size of the enterprise, its structure and other attributes, employees are its most valuable, strategic capital: the capital of qualifications, knowledge, skills, experience, personality and values. Human capital is treated as the most important part of intellectual capital, which, in cooperation with structural capital (capital of processes), is in the modern economy based on knowledge, the basic sources of competitive advantage and the value of each company (Gorustowicz, 2019, pp. 75-85) Therefore, in the labor market, competences that distinguish human work from the work of IT systems, robots or artificial intelligence are of particular importance today.

C. Levy-Leboyer (1997) pointed out that competences refer to the integrated use of abilities, personality traits as well as acquired knowledge and skills, which guarantee the possibility of achieving the assumed goals and strategy of the enterprise. He treated competences as a specific category of individual features that are closely related to value systems and the acquired knowledge. M. Butkiewicz (1995) distinguishes between the concept of competence and qualifications. The first is defined as the scope of knowledge, skills and responsibilities, powers of attorney and authority to act. On the other hand, he describes the latter as professional and defines it as a system of knowledge, skills and attitudes conditioning the performance of the tasks entrusted to an employee. According to this author, qualifications include such factors as: education, professional knowledge, professional skills, psychophysical skills and professional ethics. T. Oleksyn (2010, p. 18) points out that competences are formal powers to make decisions, deal with matters and represent an organization. And these powers to act are the main element that distinguishes competences from qualifications that do not contain this element.

Regardless of the conceptual construct adopted, it should be pointed out that competence is the ability to use effectively the knowledge and abilities at work. On the other hand, qualifications can be equated with education and professional experience.

There are many divisions of competences in the literature on the subject. You can talk about the so-called core competences (corporate), which are related to the vision of the company and constitute a description of behaviors, values and attitudes important for its implementation. Having them by all employees is crucial for the organization, but they do not reflect the full set of skills, knowledge and attitudes needed for a given position. Therefore, they are complemented by executive competences (Oleksyn, 2010, p. 33).

Competencies can be divided into soft, relating to character traits, and hard, indicating skills that can be called technical (e.g. language skills, computer literacy, knowledge about management processes or building a specific device). Another division is the so-called key competences allowing the employee to effectively perform work in a specific position (Oleksyn, 2010, p. 20). We can talk about threshold competences, i.e. the minimum ones required to work in a given position. There are also optimal competences that lead to the achievement of the assumed desired results. When starting work, the employee is required to

cope with basic tasks and all other competences that go beyond this level are highly rated (Armstrong, 2002, p. 245).

Among the lists of key competences (Janowska, Skrzek-Lubasińska, 2019), the most common ones are: knowledge and its application, understanding, critical thinking, problem solving, adaptive learning, as well as group work, controlling emotions, commitment, reliability, honesty, punctuality, independence and creativity. Many of them are classified as competences of the future, although the importance given to them varies depending on the approach and methodology adopted. According to the report of the World Economic Forum, where you can find a list of the main professional skills based on the O * NET platform and its Content Model10, the most desirable competences are: comprehensive problem solving, social skills, such as cooperation with others and process skills, which include critical thinking or active listening (World Economic Forum, 2016). Due to the new paradigm of work in the digital economy, which is flexibility, the most important skills will be those related to the constant adaptation to new conditions. This applies, inter alia, to changes in qualifications in line with market expectations, i.e. the ability to continuously learn, the ability to adapt to work in new teams, with constantly different people.

Industry 4.0 is not only a technological change and the related need for a different dimension of human-machine cooperation, but also new competences required from employees who, as participants in the 4.0 revolution, must develop the ability to constantly learn and constantly self-develop. The competences of the future can be divided into three main groups: cognitive, social and functional (Debowski, Stechly, 2019). Bearing in mind that the concept of functional competences should be understood as the ability to perform specific work, specific professional tasks, they can be identified in the context of Industry 4.0 with digital and technical competences. Social competences include, among others: effective cooperation in a group, leadership and entrepreneurship, emotional intelligence, people management. These are key competences when it comes to dealing with change, building openness in the face of uncertainty. Emotional intelligence is especially important, as it is responsible for successful cooperation with others, for the manner of expressing emotions. Developed interpersonal skills are equally important as companies undergoing digital transformation will look for employees who can work well with others and support the company together. On the other hand, cognitive competences (commonly known as thinking competences) include: critical thinking – the ability to think in a rational and orderly manner, aimed at understanding the relationship between facts or concepts. It should be noted that the development of the Internet has led to an "overload" of information, and therefore the skills to assess the quality of the collected information and to identify reliable information are of key importance. Creativity – no matter how much digitized is (will there be) the work environment, how much artificial intelligence enters professional activity, a person is still more effective in proposing non-standard solutions to problems. Future labor market challenges and the jobs created will require employees to be highly creative, new ways of thinking and going beyond the usual patterns; cognitive

adaptability and flexibility – the ability to adapt to a changing environment. We are not able to fully predict what competences the future employers will need, therefore it is important to focus on lifelong learning and openness to new challenges; reasoning and solving complex problems. The third group includes digital and technical competences (equated with hard skills), among which digital competences are particularly important, which are not limited only to programming or data analysis, but cover a wide range of skills: from digital problem solving to knowledge of privacy or cybersecurity. As digital tools will become commonplace and the logistics industry will be affected by the fourth industrial revolution, all employees (in almost every workplace) will need technical skills. IoT (Internet of Things), virtual and augmented reality, artificial intelligence, robotics, automation and other modern technologies will become an inseparable part of the everyday experience of every employee (Barwińska-Małajowicz 2020, p. 19). It should be noted that competences will change through the progressive automation and servicisation of economies, diffusion of technological progress, internationalization of organizations, globalization and demographic changes (Szukalski, 2017, p. 260). The Competency Impact highlights the need to develop both transversal skills (from execution to entrepreneurship) and digital interactions between people and machines. The impact of the digital revolution is particularly relevant to companies seeking to maintain their business competitiveness by becoming part of this new paradigm. The players of the Fourth Industrial Revolution are companies deeply committed to the transformation process, which is both a powerful opportunity and a difficult challenge (Fregnan et al., 2020). While digital technologies offer many opportunities to lower costs, accelerate operational processes, and enhance collaboration between HR stakeholders, there are also downsides such as the digital divide, hyper-connectivity, reduced face-to-face contact and the loss of relevance faced by tech professionals.

It is worth emphasizing that the logistics industry, operating in the modern dimensions of the Industry 4.0, must also adapt to the implementation of innovative technologies, modern work process organization systems, and task implementation systems. Organizational success and building competitiveness force a redefinition of the needs of human capital, in particular its qualifications and competences. Manpower conducted research in 2021 (Raport Logistyka w Polsce, 2021), pointing to the shortages of experienced and appropriately qualified staff, among others in such positions as: warehouse manager, logistics process engineer, logistics expert, freight forwarder, quality management expert, export specialist, freight forwarder, warehouse management employee, etc. This situation results mainly from the necessity to introduce changes concerning, inter alia, new trends in the organization and management of logistics activities, the need to implement new technological, ICT (*information and communication technologies*) and product solutions, etc.

Research carried out by Manpower shows that employers in the area of logistics are looking for both hard and soft skills. The most desirable hard competences include: the ability to plan continuity in the supply chain, technical inspection qualifications, knowledge of foreign languages, forecasting skills, operation of WMS (*warehouse management system*) systems, competence in process optimization or knowledge of issues in the field of artificial intelligence and automation. Key soft skills include: responsibility, cooperation, openness to permanent learning and development, mobility, the ability to adapt quickly, the ability to recalibrate to changing working conditions, independence in action, transparency and the ability to multitasking.

The indicated exemplary competences are a response to the modernization of the Industry 4.0, which profoundly changes the operating environment in the field of logistics and requires it to adapt to broadly understood innovations. In the document 2009 Interim Report on the OECD Innovation Strategy (OECD Annual Report 2009), key assumptions were identified, which are based on the following assumptions:

- innovation is a "necessity" to meet global challenges,
- the world economy is undergoing many transformations which have a profound impact on the way innovations occur,
- non-technological, organizational and social innovations gain importance,
- the innovation process often requires the introduction of a new business model, entrepreneurs play an important role in creating innovation,
- innovative processes implemented by entities connected in the network help to engage resources from various areas (institutions, enterprises), which helps to satisfy scarce resources (including knowledge and skills),
- a broader understanding of innovation poses new challenges to policy,
- it also requires better tools to shape it,
- the innovation process is burdened with risk (as well as costs) and it is an element that has not changed over the years,
- innovation leads to specialization along the value chain, increased cooperation and partnership, and the development of the knowledge economy;
- research combined with public investment play a key role in shaping the innovation of the economy.

This situation forces the logistics industry to transform in the trend of digitized economy 4.0.

## 4. Changing needs and expectations on the labor market – employers' requirements

The 21st century brought a number of changes concerning the specificity of the organization's functioning, its management system, including the organization of work processes (Kurt, 2019). In the environment in which modern business entities operate, there are many determinants that affect the way of shaping success and competitiveness, leading organizations to increase readiness to change and reduce mismatch by increasing their innovation (Todt et al., 2019). The key variables include changes in the structure of the population of employees belonging to different generations, representing different attitudes, morale, skills, experience and competences. As a consequence of the transformation of the approach to work, employees expect the crystallization of different expectations from employers, professional work and the shaping of career development paths (Jerman et al., 2019).

Of course, managers do not remain passive to the changes taking place in their environment. They monitor transformations in the area of modern solutions implemented in organizations that give them a chance to build organizational success, analyze the business and organizational side as well as the quality and quantity of human resources. They must be correlated with each other, adjusted to the company's strategy, increasing its chance to adapt to the changing environment (Behling, Lenzi, 2019). The fact that employees are always the most valuable organizational capital shows that managers must, on the one hand, respond to the changing expectations of the staff, and on the other, they are determined to look for employees who best fit their organization and the adopted management concept. Such a situation makes it necessary to look for solutions that will help to face contemporary economic, ecological and social challenges (Wygnański, 2009, p. 4).

Organizations see the possibility of shaping conscious, responsible relations between economic development, care for the environment in which they operate and satisfying diverse needs in the concept of sustainable development (Petrişor, Petrişor, 2013). In the Our Common Future report, this approach was defined as development that meets the needs of the modern generation without compromising the ability of future generations to meet their own needs (Brundtland, 1987). Therefore, today, employees more and more often no longer constitute the cost of the organization, but are a profitable investment that largely determines the market value of a modern company.

Currently, the development of the enterprise is often spontaneous and difficult to predict, and the employee-employer relationship is increasingly changing its direction from subordination to partnership-based cooperation and more and more often cooperation identified as "a manifestation of cooperation for a common goal with which the cooperating parties identify" (Polak, 2016, p. 286; Lipka, 2004, p. 17). Collaboration is a more advanced type of cooperation, meaning "coordinated action aimed at the implementation of partial tasks resulting from the division of labor or inter-organizational links resulting from concluded contracts and agreements that facilitate or enable the implementation of specific tasks" (Kaczmarek, 2000, p. 5).

Managers today expect much greater innovation in work processes, openness to training and development, professional experience, commitment, pro-ecological attitude to work processes, language competences, time management skills, modern leadership, flexibility, which is a condition for effective functioning on the market (Wilsz, 2016). Organizations using this approach clearly indicate that such a situation brings with it both many opportunities and threats for employees. On the one hand, employees are treated as internal stakeholders who have a real impact on organizational processes, they are given the opportunity to increase their attractiveness, and on the other hand, they are expected to be ready to constantly change, to be agile and to adapt to evolving processes.

The development of new ICT technologies (Information and Communication Technology) means that modern employers, creating new jobs, are increasingly looking for employees on the market with developed skills to work with modern technologies, processes correlated with modern technology, network work and multi-processing (Evans, 2016). Employers expect agility from employees and skillful "changing over" between the tasks carried out in such a way that it does not adversely affect the effectiveness of their implementation. The phenomenon of multitasking has become today a determinant of the effective implementation of business goals and tasks, both in the individual and organizational dimensions. The very nature of work is also changing, taking more and more virtual and flexible forms (Alvesson, 2016; Lauda et al., 2015). This situation results in the formation of new professions and the marginalization of others. This situation leads to the employee competency gap. This, in turn, makes it necessary to identify competences and professions that are in demand on the labor market in the near future (Delia et al., 2016). Knowledge in this area will help to better prepare future employees to function on the labor market.

Many organizations aware of the importance of competences, qualifications and skills possessed by human capital indicate that the use of effective ones has become important and effective business models. They are designed to help the organization function in precarious conditions and bring it closer to achieving success. This model should be treated more as a specific way of thinking, directed at unique or non-standard ways of solving organizational problems through which the organization can change and develop in a creative way (Sobińska, 2015). The company, guided by this type of model approach, shapes specific expectations for

the staff. These requirements, defined as key, are to create added value for the groups of stakeholders, which are the employer and the employee (Doligalski, 2013). Importantly, modern organizations place more and more requirements on suppliers of human capital. It is assumed that the world of education should prepare an appropriate offer in order to equip potential employees with the knowledge needed for the needs of the future labor market or to shape attitudes aimed at releasing dormant layers of competences (Bencsik et al., 2016).

Organizations striving for organizational effectiveness, while building a competitive advantage, should be aware of what potential they are looking for – what competences, know-how and to which they have access (Mahmood et al., 2018).

For this reason, they should constantly monitor the variables included in people management systems so that the model they choose helps them to guarantee the best possible staff creating and contributing to the success. Shortened decision-making processes, flattening structures, delegating powers, participatory management model are the attributes of flexibility and the perspective of advantage (Brilman, 2002, p. 391). Moreover, the sensitivity of a contemporary and modernly managed organization is correlated with the ability to build the capability to flexibly respond to emerging threats and opportunities in the organization's environment.

## 5. The specificity of the logistics industry - transformation in the trend of digitization

Digital transformation requires implementation, speed and response from various enterprises. The logistics industry was also not indifferent to these changes. There is even a certain synergy between technology development and the boom in the logistics industry. On the one hand, it is thanks to innovative, digital technologies that the logistics industry can function better, respond faster to customer needs, and have greater opportunities to make its processes more flexible. On the other hand, it is the needs of the logistics industry that influenced the digital world, forcing the search for new solutions that will enable this faster response to the needs of a changing market. The important point is that both of these worlds pursue a common goal of responding to a turbulent environment.

In the current situation, most enterprises and industries operate in the so-called VUCA (ambiguity, uncertainty, complexity, volatility) environment. This theory is not a novelty in the world of considerations, especially in relation to personnel management (Horstmeyer, 2020), supply chain (Saikouk et al., 2021), selected industries (Hoeft, 2021), or in the context of challenges related to the use of modern technologies (Kaivo-oja, Lauraeus, 2018). According to this theory, the environment is characterized by: ambiguity, because it influences the entities functioning in it in various ways; uncertainty due to constant changes in conditions resulting

from various economic, social, legal and political phenomena; complexity as it is influenced by many interrelated factors; variability, which results in a way from the previous factors, but is also an expression of interdependencies taking place in the environment.

The current situation in the world was caused by the Covid-19 pandemic, as well as by geo-political conditions. Unfortunately, this causes many problems in various industries around the world, including Poland. Therefore, it can be concluded that the challenges of the turbulent environment mean that enterprises and supply chains have to face many problems.

These problems do not bypass the logistics industry, which is a link for various industries, provides services supporting basic production and commercial activities, and may also contribute to increasing market share and gaining a competitive advantage. The situation of the logistics industry in recent years can be characterized by three elements: growing customer requirements and expectations, sustainable development with the use of ecological solutions in logistics processes, the use of innovative technologies supporting the organization and implementation of tasks. The logistics industry operates in very specific conditions, because it serves both industry, acting as a link in supply chains in various parts of the economy, it must meet the requirements of individual customers, which it serves on behalf of commercial enterprises, and is responsible for its own actions towards society and the economy by adapting to legal requirements, ecological and social trends. The logistics industry consists of many different entities that provide services for both industry and individual clients. Logistics services provided by logistics operators relate to transport, warehousing, material and packaging manipulation, inventory management, reverse logistics management, as well as ensuring an appropriate flow of information. (Bozarth, Handfield, 2019). Logistics operators usually offer services tailored to the needs of industrial customers by providing contractual services. Flexibility in the approach to logistics services is a challenge, but it has also become a necessary element (an order winner).

Recent years have seen the growing importance of the logistics industry in Poland. According to the report of 7R and Colliers (Logistyka wolniej, 2022), in the first quarter of 2022, the total supply of warehouse space in Poland amounted to 25 million sq m, and thus increased by another 1.3 million sq m. The demand for logistics services has certainly increased due to the pandemic and online sales support. It has been estimated that in 2020 in Poland, sales on the e-commerce market increased by 30%. Currently, e-commerce already accounts for 10% of all trade in Poland (Kopańko, 2021). At the same time, it is estimated that in Europe, turnover in online cross-border trade will increase by 51% in 2022. However, without the participation of logistic support, these results would not be possible. Logistics support certainly played a key role due to the growing needs of e-commerce customers. On the one hand, the service of online sellers as principals, and on the other hand also online buyers as individual recipients, meant that the logistics industry, especially CEP (courier-express-parcel), had to adapt to various expectations. Hence the growing demand for warehouse space. On the other hand, from the perspective of clients/individual recipients, appropriate service of the so-called last mile

service. The KEP market around the world handles over 200 million parcels per day. The world network consists of over 2.5 million cars, 1000 airplanes, several hundred thousand trucks connecting hundreds of central sorting plants and thousands of branches around the world (Miliardowe przychody kurierów, 2020). Such a situation requires proper coordination and the use of innovative solutions in the field of quick response to customer needs. Therefore, the logistics industry focuses primarily on modern technology. The last decade was marked by the fourth industrial revolution, which in logistics received its own name Logistics 4.0. On the one hand, researchers claimed that this term covers real-time data analysis, innovative manufacturing technologies, robots and autonomous vehicles, and real-time data exchange (Strandhagen et al., 2017). Others noted that it was mainly about the transparency and flexibility of supply chains, as well as the ability to track materials and products in real time (Hofmann, Ruesch, 2017). However, no single, unambiguous definition of this term has been presented (Dallasega et al., 2022).

These technological changes are primarily the use of IT systems that allow for real-time tracking of all operations. Pfohl (2016) mentioned as significant, first of all, communication systems between machines/robots, the use of the Internet of Things, especially in industry (e.g. in factories, smart factories), robots and autonomous vehicles, or augmented reality.

The use of such innovative technologies was not only to meet the needs of the market in terms of speed of response, but also to meet the needs related to the growing demand for services, with simultaneous staff shortages. (Cichosz et al., 2020). However, despite the automation of processes in logistics 4.0 through the use of robotics in warehouses (Nantee, Sureeyatanapas, 2021) or innovation in transport (Dong et al., 2021), it is inevitable to employ specialists or develop new digital competences that will enable the effective use of such inventions (Singh et al., 2022).

An appropriate approach to sustainable development is also important for the logistics industry, which in this case may mean the use of modern technologies, while developing human capital and caring for its well-being.

Sustainable development in logistics is primarily the application of innovation to reduce the negative impact on the natural environment (Javaid et al., 2022). The tasks of information systems are, above all, optimization of the course of processes in order to increase efficiency with less use of warehouse or transport resources (Ali, Phan, 2022; Gerhátová et al., 2021; Thaller et al., 2021). Support for information systems can also be useful in the context of building closed-loop chains that will aim for a zero environmental impact. Such possibilities are provided by simulations of material circulation systems or systems tracking the flow of materials and products in the supply chain (Bag, Pretorius, 2022). Another aspect may also be the impact on shaping the marketing potential and responding to the expectations of customers in the logistics industry, especially individual customers. It is mainly about the use of technology in pro-ecological activities, and thus increasing the competitiveness of the offer (Fallahpour et al., 2021).

Moreover, a very important task of innovative technologies is to facilitate work and reduce the burden on employees (Aloini et al., 2022). Taking care of employees' well-being should also be a response to new social challenges. From the perspective of the Covid-19 pandemic, it is certainly one of the factors that allows for increased efficiency and loyalty among employees.

Considering the growing importance of innovative technologies, it should be noted that the logistics industry is facing a new challenge. On the one hand, it is important to take care of the natural environment and, in the context of sustainable development, reduce energy consumption and the negative impact on the environment. On the other hand, you should take care of employees who will operate innovative technologies. Digital competences will become an essential element for these IT systems, robots and autonomous vehicles to be fully utilized and used efficiently.

## 6. Competences 4.0 in the logistics industry in research representation

Research covering the measurement of the competences of employees in the logistics industry was carried out among employees of enterprises at the turn of April and May 2022. Due to the source of measurement, these studies can be described as primary (fragmentary) explanatory, descriptive and explanatory, focused on the implementation of one research goal. The subject of the measurement was to define the digital skills and competences necessary for employees of the logistics industry in the era of the challenges of the economy 4.0. The method used in the course of the study was the "user-centric" CAWI (Computer Assisted Web Interview). Questionnaire consisting of 17 closed questions, including 10 based on the scaling of attitudes according to Rensis Likert, placed on the Google platform. Due to the scope of the measurement, the study can be described as fragmentary and deterministic.

The study covered not the entire population of people working in logistics at the turn of April and May 2022 in enterprises operating in Poland, but only a part in the form of a research sample. The minimum size of the sample was quantified assuming the representativeness of the sample for the working population of Poland in working age, i.e. men aged 15-64 and women aged 15-59, whose number as at December 31, 2020 was 16 555 000 people. Important information for calculating the fraction is the number of employees employed in logistics enterprises (Central Statistical Office in Poland: classification of enterprises Transport and Warehouse Management Department) operating in Poland, the number of which as at December 31, 2020 was 933 500 people and the number of people working in the logistics departments of companies whose logistics is not the dominant feature. With this approach, it was difficult to determine the actual number of employees due to the unknown number of employees employed in logistics in enterprises whose logistics is not a dominant. Therefore,

for the purpose of calculating the minimum sample size, the fraction size was assumed at the level of 0.5 both for people potentially working in logistics and 0.5 for people not working in logistics among people working in Poland as of December 31, 2020 with a random error of 5% and a confidence level of 0.95.

The formula (1) was used to calculate the minimum sample size:

$$n_{min}=NP(\alpha^2 \cdot f(1-f))/NP \cdot e^2+\alpha^2 \cdot f(1-f) \tag{1}$$

where:

$n_{min}$ – is the minimum sample size,

NP – the size of the study population,

$\alpha$ – the confidence level for the results,

f – fraction size,

e – assumed maximum error.


After making the calculations, the minimum sample size was $n_{min} = 384$ units. The recruitment of study participants was carried out on the basis of the non-random selection of units typical for the snowball test, which means that the request to participate in the study was sent via social networking sites on logistics to all persons meeting the conditions of the study participant: age over 15 years and employment and work performed in the scope identified with logistics. In the selection of individual participants of the study, non-random sampling was used, therefore it is difficult to fully assess the representativeness of the samples in a statistical sense due to the lack of randomness. However, due to the size of the received sample, it is possible to infer.

The collected research material in the form of raw data was coded and statistically analyzed using the SPSS program (Statistical Package for Social Sciences). The result of the work is the presentation of the profile of the studied sample and substantive data presenting, according to the respondents, the scope of digital skills and competences necessary for employees of the logistics industry in the era of the challenges of the economy 4.0.

625 participants took part in the study, which is more than the calculated necessary minimum number. The studied sample was dominated by men (55.2% of the respondents) compared to women (44.8% of the respondents). Taking into account the age of the respondents, the largest group (40.6%) are people aged 21-30. The remaining respondents were aged 31-40 (33.1%), 41-50 (16.3%), 15-20 (7.7%) and over 50-64 (2.2%). In turn, taking into account education, more than half of the respondents (55.4%) have secondary education, and every fifth respondent (21.4%) has secondary or higher education (21.0%). The smallest number of people had primary education (2.2%).

Taking into account the size of the enterprise, the vast majority of respondents (42.4%) are employed in enterprises employing over 250 people. Every third respondent (31.2%) works in an enterprise employing up to 50 people and almost every fourth respondent (26.4%) in an enterprise employing between 50 and 250 people. The enterprises in which the respondents

are employed are mainly enterprises operating on an international scale (53.6%). Every third (32.8%) respondent declares that the company in which he works operates on a national scale, slightly more than tenth (13.6%) is employed in a company operating on a local scale. With regard to the place of logistics in the formula of the company's operation, every third respondent (32.8%) represents a company in which logistics is important (the company has a Logistics Department). Almost every third respondent (28.0%) works in a company where logistics is key (represents the TSL industry). Every fifth respondent (21.6%) admitted that logistics performs a secondary function (a single employee is responsible for logistics activities) and every fifth (17.6%) that logistics supports the company's core activities (logistics unit).
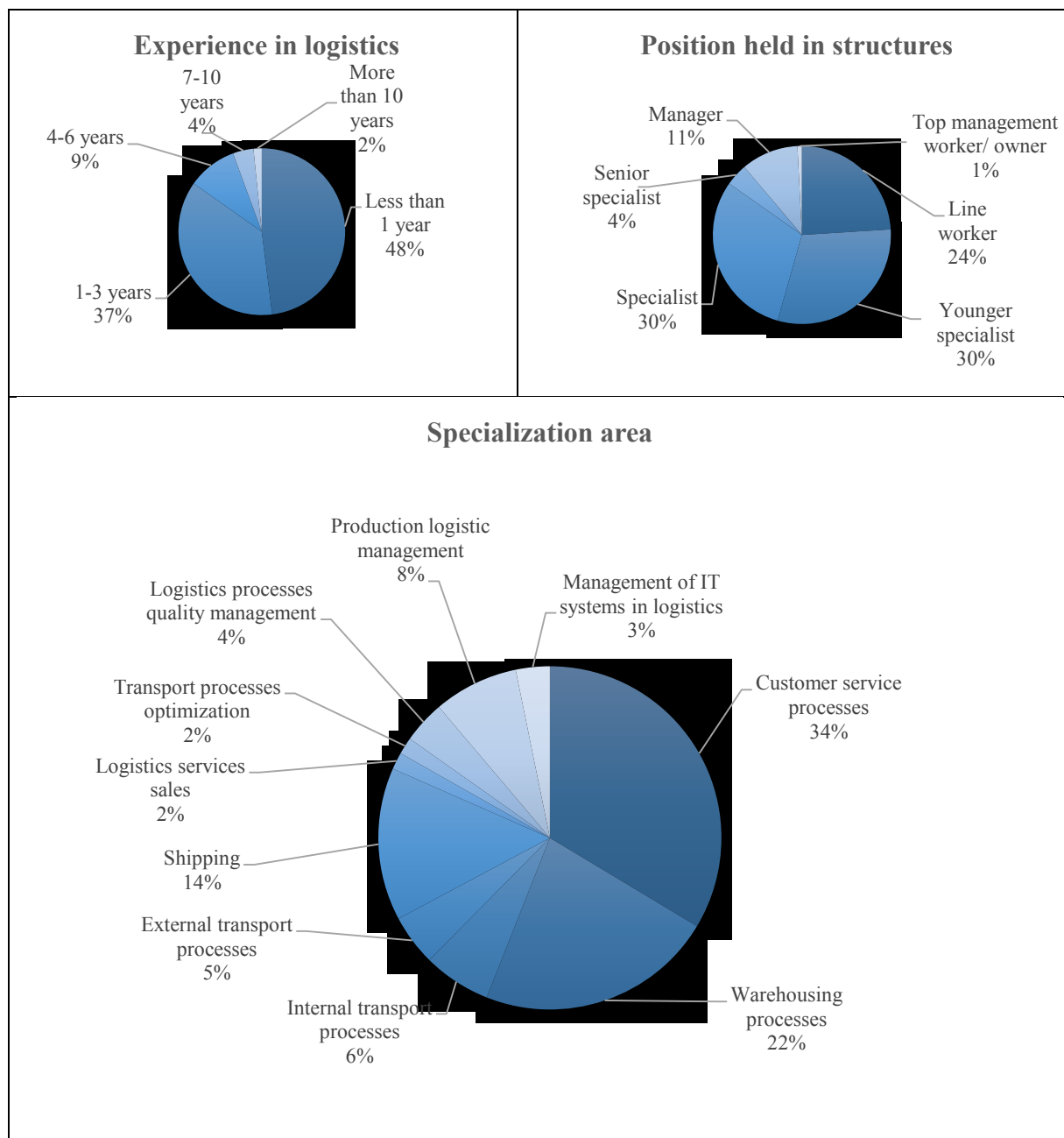


**Figure 2.** Profile of the respondent as a logistics employee.

Source: own research.

The respondents participating in the survey admit that the majority of them have little experience of working for less than 1 year (48.0%) or from 1 to 3 years (37.0%). The vast majority of the respondents are employed in positions such as: junior specialist (30.4%), specialist (30.4%) or line worker (24.0%). Few of the respondents are employed as a manager (10.4%), senior specialist (4.0%) or represent top management employees (0.8%). With regard to the area of logistics activity, the respondents admit that it is most often the area of customer service (33.6%), warehousing (22.4%), shipping (14.4%), production logistics (8.0%) or internal transport processes. (6.4%).

The respondents, when asked about having 4.0 competences necessary in the era of the digital economy, admit that among cognitive competences, they can definitely solve problems quickly (86.4%), take steps towards self-improvement (83.2%), are focused on critical thinking (73.6%), analytical thinking (72.0%) and complex problem solving (70.4%). On the other hand, when it comes to social competences, employees are definitely oriented towards good relations and creating bonds in the team (85.6%), good organization of working time (84.8%), and attention to constant flow of information in the team (82 , 4%), ethics and high work standards (81.6%), motivating colleagues (75.2%) and supporting innovation (73.6%). In terms of the third component, i.e. technical competences, the respondents admit that they have substantive knowledge in their area of specialization (71.2%), have specialized education (66.4%), use at least one foreign language (61.6%) and operate machinery and technical devices (56.8%).

**Competences 4.0 of logistics worker**

| Competence | Definitely yes | Rather yes |
|---|---|---|
| Use of at least one foreign language fluently in speech and writing | 23,20% | 38,40% |
| Operation of machinery and technical devices used in the implementation of logistics processes | 23,20% | 33,60% |
| Having substantive knowledge in a given area | 28,00% | 43,20% |
| Having a specific education | 24,80% | 41,60% |
| TECHNICAL | | |
| Crisis and conflict management | 18,40% | 45,60% |
| Work in the design system | 23,20% | 38,40% |
| Motivating colleagues | 31,20% | 44,00% |
| Focus on constant changes | 24,00% | 40,80% |
| Supporting innovation | 29,60% | 46,40% |
| Taking care of good relations and creating ties in the team | 35,20% | 50,40% |
| Dbałość o stały przepływ informacji w zespole | 36,00% | 46,40% |
| Supporting the development of other team members | 30,40% | 43,20% |
| Focus on achieving long-term goals | 31,20% | 42,40% |
| Initiating events and processes | 28,80% | 40,80% |
| Good organization of working time | 39,20% | 45,60% |
| Ethics and high work standards | 32,80% | 48,80% |
| SOCIAL | | |
| Solving complex problems | 23,20% | 47,20% |
| Speed of problem solving | 30,40% | 56,00% |
| Critical thinking | 31,20% | 42,40% |
| Constant self-improvement | 34,40% | 48,80% |
| Analytical thinking | 30,40% | 41,60% |
| COGNITIVE | | |

■ Definitely yes   ■ Rather yes

**Figure 3.** Competences 4.0 of a logistics worker ready for the challenges of the digital economy.

Source: own research.

After analyzing the structure of the distribution of responses, a cross-analysis was carried out to determine the possibility of a relationship between the selected variables. The basis at this stage was the contingency table each time, allowing for the juxtaposition of two features at the same time. The table consisted of r rows and s columns each time. Each row and column corresponded to particular variants of the feature X and Y. The content of the contingency table consists of the $n_{ij}$ numbers of sample elements that have the i-th variant of the feature X (i = 1, 2, …, R) and the j-th variant of the feature Y (j = 1, 2, …, s). Each time the contingency table was the basis for the verification of the null hypothesis (H0) of the existence of the potential stochastic independence of random variables X and Y and the alternative hypothesis (H1), adopted in the case of rejecting the null hypothesis (H0) according to the formula (2):

$$H_0: \quad P\{X = x_i \wedge Y = y_j\} = P\{X = x_i\} \quad P\{Y = y_j\}$$
$$H_1: \quad P\{X = x_i \wedge Y = y_j\} \neq P\{X = x_i\} \quad P\{Y = y_j\}$$

(2)

The basis for the verification of the H0 hypothesis about the stochastic independence of the variables was the value of the statistics obtained from the formula (3):

$$\chi^2 = \sum_i^r \sum_j^s \frac{(n_{ij} - \tilde{n}_{ij})^2}{\tilde{n}_{ij}} : \chi^2_{(r-1)\cdot(s-1)}$$

(3)

where:

$n_{ij}$ – conditional empirical numbers resulting from the contingency table,

$\tilde{n}_{ij}$ – theoretical conditional counts that could appear in the table if the features were independent.

Hypothetical numbers are determined according to the formula (4):

$$\tilde{n}_{ij} = \frac{n_{i\cdot} \cdot n_{\cdot j}}{N}$$

(4)

The H0 rejection area is always right-handed. Its size depends on the adopted significance level α. It gets bigger the bigger it is α. It is generally assumed to α <= 0,05. Critical values of the χ2 distribution with (r-1)*(s-1) degrees of freedom. If only $\chi^2$emp > $\chi^2$α than H0 is rejected in favor of the H1 hypothesis, which means that the pair of features is mutually dependent on each other. Using the above methodology, the process of testing the statistical significance of the relationship between the selected variables was carried out on the basis of the SPSS computer program.

When analyzing competences 4.0, broken down into cognitive, social and technical in terms of experience, position held and the area of logistic specialization of the employee, the obtained contingency tables indicated the existence of potential relationships between the selected variables. The verification of the indicated relationships was confirmed by the $\chi^2$ independence

test at the strength of the relationship determined by V-Cramer (Table 1). The analysis shows that the existing dependencies are in most cases weak, but in a few cases they are significant.

Particular characteristics of cognitive competences indicate connections between experience, the position held and the area of specialization. In terms of experience, the most important thing is continuous improvement and analytical thinking. On the other hand, continuous improvement and the speed of problem solving are strongly related to the position held. Likewise, continuous improvement and speed of solving with the area of specialization.

**Table 1.**
*Competence 4.0 of a logistics worker ready for the challenges of the digital economy in terms of experience, position and area of specialization – the $\chi^2$ independence test at the strength of the relationship determined by V-Cramer*

| | Experience | | | Position | | | Specialization area | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\chi^{2a}$ | $p^b$ | $V^c$ | $\chi^{2a}$ | $p^b$ | $V^c$ | $\chi^{2a}$ | $p^b$ | $V^c$ |
| **Cognitive** | | | | | | | | | |
| Analytical thinking | 87,882 | 0,001 | 0,216 | 130,858 | 0,001 | 0,264 | 136,835 | 0,001 | 0,270 |
| Constant self-improvement | 120,944 | 0,001 | 0,220 | 695,297 | 0,001 | 0,527 | 454,766 | 0,001 | 0,427 |
| Critical thinking | 72,130 | 0,001 | 0,170 | 140,722 | 0,001 | 0,237 | 200,340 | 0,001 | 0,283 |
| Speed of problem solving | 39,174 | 0,001 | 0,125 | 677,757 | 0,001 | 0,521 | 377,792 | 0,001 | 0,389 |
| Solving complex problems | 45,468 | 0,001 | 0,156 | 154,011 | 0,001 | 0,287 | 163,313 | 0,001 | 0,295 |
| **Social** | | | | | | | | | |
| Ethics and high work standards | 39,134 | 0,001 | 0,125 | 656,467 | 0,001 | 0,512 | 436,116 | 0,001 | 0,418 |
| Good organization of working time | 110,114 | 0,001 | 0,210 | 262,567 | 0,001 | 0,324 | 264,534 | 0,001 | 0,325 |
| Initiating events and processes | 55,717 | 0,001 | 0,149 | 674,323 | 0,001 | 0,519 | 387,936 | 0,001 | 0,394 |
| Focus on achieving long-term goals | 79,577 | 0,001 | 0,206 | 189,981 | 0,001 | 0,318 | 156,199 | 0,001 | 0,289 |
| Supporting the development of other team members | 70,136 | 0,001 | 0,167 | 680,612 | 0,001 | 0,522 | 381,290 | 0,001 | 0,391 |
| Ensuring a constant flow of information within the team | 65,792 | 0,001 | 0,162 | 667, 099 | 0,001 | 0,517 | 381,989 | 0,001 | 0,391 |
| Taking care of good relations and creating ties in the team | 34,835 | 0,001 | 0,137 | 172,530 | 0,001 | 0,303 | 138,897 | 0,001 | 0,272 |
| Supporting innovation | 87,983 | 0,001 | 0,188 | 691,022 | 0,001 | 0,526 | 424,702 | 0,001 | 0,412 |
| Focus on constant changes | 81,665 | 0,001 | 0,181 | 129,090 | 0,001 | 0,227 | 112,000 | 0,001 | 0,212 |
| Motivating colleagues | 46,988 | 0,001 | 0,137 | 338,465 | 0,001 | 0,368 | 289,166 | 0,001 | 0,340 |
| Work in the design system | 94,608 | 0,001 | 0,195 | 281,991 | 0,001 | 0,336 | 262,826 | 0,001 | 0,324 |
| Crisis and conflict management | 37,917 | 0,001 | 0,123 | 416,242 | 0,001 | 0,408 | 295,741 | 0,001 | 0,344 |
| **Technical** | | | | | | | | | |
| Having a specific education | 161, 006 | 0,001 | 0,254 | 119,358 | 0,001 | 0,219 | 168,026 | 0,001 | 0,259 |
| Having substantive knowledge in a given area | 148,697 | 0,001 | 0,244 | 700,785 | 0,001 | 0,529 | 392,769 | 0,001 | 0,396 |
| Operation of machinery and technical devices used in the implementation of logistics processes | 63,350 | 0,001 | 0,159 | 137,026 | 0,001 | 0,234 | 258,008 | 0,001 | 0,321 |
| Use of at least one foreign language fluently in speech and writing | 76,920 | 0,001 | 0,175 | 300,133 | 0,001 | 0,346 | 299,179 | 0,001 | 0,346 |

[a] $\chi^2$ – test value; [b] p – asymptotic significance; [c] Relationship strength calculated using V-Cramer.

The links between social competences and experience are especially strong in the case of good organization of working time, focus on long-term goals, working in a project system, supporting innovation and focus on constant changes. On the other hand, supporting innovation, supporting the development of other team members, initiating events and processes, taking care of the constant flow of information in the team as well as ethics and high work standards are more closely related to the position held. In the case of logistics specialization, however, there is a connection with ethics and high standards of work, supporting innovation, initiating events and processes, supporting the development of other team members and taking care of the constant flow of information in the team.

The last group of 4.0 competencies that are important in the case of logistics employees are technical competences. The strongest relationship exists between having directional experience and having substantive knowledge in a given area, and experience. Moreover, having substantive knowledge in a given area, using at least one foreign language fluently in speech and writing is related to the position. On the other hand, having substantive knowledge in a given area and using at least one foreign language fluently in speech and writing is related to the area of specialization.

A special group of competences that should be characterized by employees in the 21st century are digital competences, which include IT, informative and functional competences. The respondents state that among IT competences, they can definitely use a computer and other electronic devices (switching on, off, using a mouse and a touch screen) (89.6%), use applications and various software (installation and use of functionalities: downloading the application, installing the application on a mobile device, tracking usage costs, creating files, developing content, saving, searching and organizing) (89.6%) and using the Internet (connecting to a Wi-Fi network, opening a browser, reloading pages , using hotkeys, adding a bookmark, downloading files, privacy settings, file transfer, virus protection, form filling) (88.0%). The smallest number of respondents (65.6%) admitted that they can create digital content (using the right software).

On the other hand, when analyzing the indications in the area of digital competences identified with informative competences, the respondents most often indicated yes and rather yes to searching for information in digital space (82.4%), the assessment of the credibility and usefulness of digital information (82.4%) and the understanding of the content obtained digital information (81.6%).
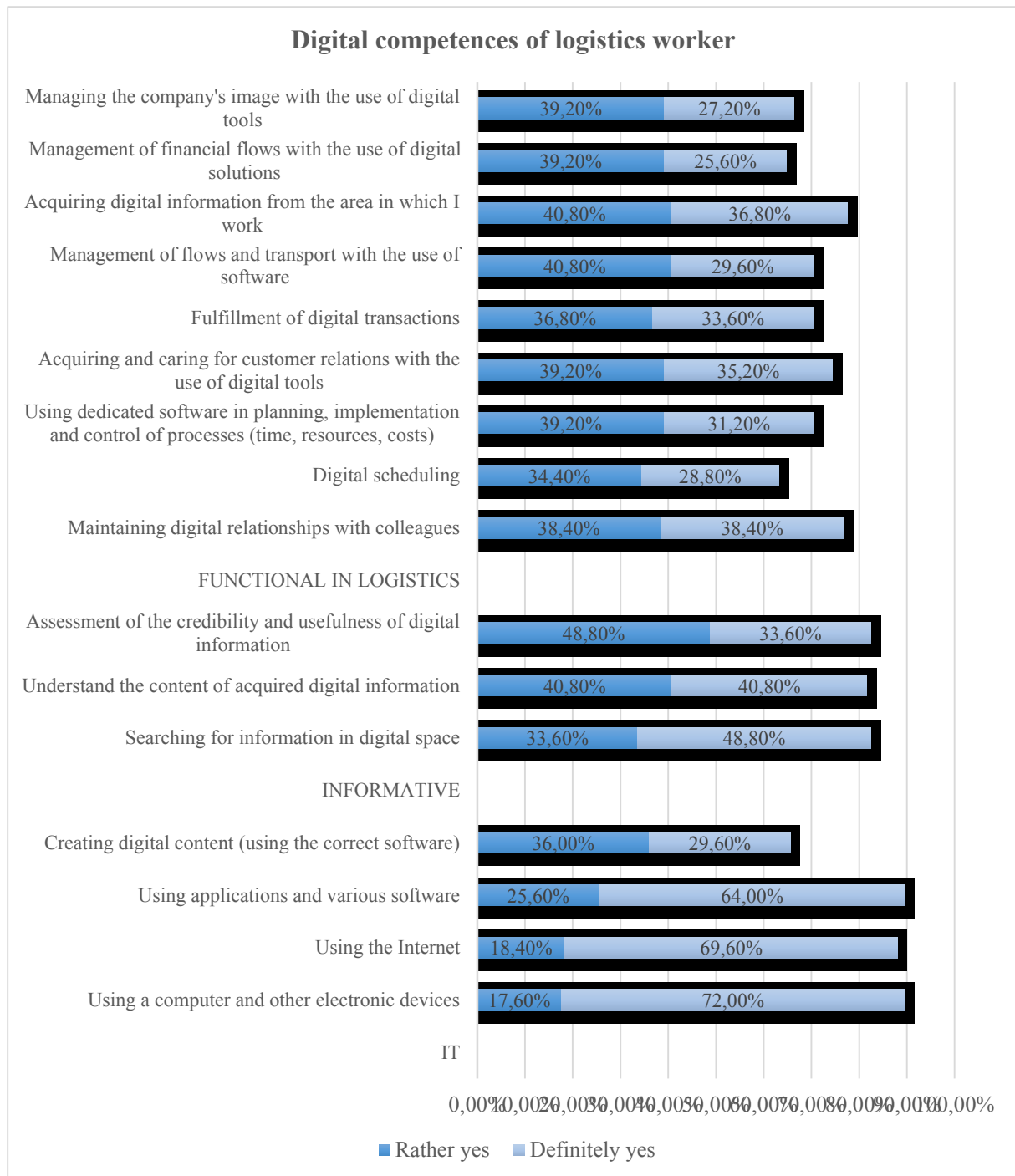
**Figure 3.** Digital competences of a logistics worker ready for the challenges of the digital economy. Source: own research.

On the other hand, in the group of digital competences in the functional area, the respondents definitely so and rather so admitted that they can maintain digital relationships with colleagues (76.8%) and are able to obtain digital information from the area in which they work (77.6%). In addition, they take care of acquiring and maintaining relationships with customers using digital tools (74.4%), managing flows and transport using software (70.4%), carrying out digital transactions (70.4%) and using dedicated software in planning, implementation and control of processes (time, resources, costs) (70.4%).

Competences such as corporate image management with the use of digital tools (66.4%), financial flow management with the use of digital solutions (64.8%) and digital scheduling (63.2%) are at a slightly lower level.

After analyzing the structure of the distribution of responses, a cross-analysis was carried out to determine the possibility of a relationship between the selected variables. Similarly to competencies 4.0, the $\chi^2$ test of independence was used with the strength of the relationship determined by V-Cramer (Table 2).

Particular characteristics of IT competences indicate connections between experience, position held and the area of specialization. In terms of experience, the most important is the creation of digital content and the use of applications and various types of software. In turn, the use of a computer and other electronic devices as well as the use of applications and various types of software are strongly related to the position held. On the other hand, the use of the Internet and the use of applications and various types of software are related to the area of specialization.

**Table 2.**
*Competence 4.0 of a logistics worker ready for the challenges of the digital economy in terms of experience, position and area of specialization – the $\chi^2$ independence test at the strength of the relationship determined by V-Cramer*

| | Experience | | | Position | | | Specialization area | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\chi^{2a}$ | $p^b$ | $V^c$ | $\chi^{2a}$ | $p^b$ | $V^c$ | $\chi^{2a}$ | $p^b$ | $V^c$ |
| **IT** | | | | | | | | | |
| Using a computer and other electronic devices | 38,278 | 0,001 | 0,124 | 448,080 | 0,001 | 0,423 | 257,171 | 0,001 | 0,321 |
| Using the Internet | 27,556 | 0,036 | 0,105 | 306, 219 | 0,001 | 0,350 | 202,809 | 0,001 | 0,285 |
| Using applications and various software | 66,291 | 0,001 | 0,163 | 370,080 | 0,001 | 0,385 | 244,398 | 0,001 | 0,313 |
| Creating digital content (using the correct software) | 80,776 | 0,001 | 0,180 | 177,587 | 0,001 | 0,267 | 168,178 | 0,001 | 0,259 |
| **Informative** | | | | | | | | | |
| Searching for information in digital space | 33,196 | 0,007 | 0,115 | 237,044 | 0,001 | 0,308 | 212,484 | 0,001 | 0,292 |
| Understand the content of acquired digital information | 75,338 | 0,001 | 0,174 | 288,790 | 0,001 | 0,340 | 231,036 | 0,001 | 0,304 |
| Assessment of the credibility and usefulness of digital information | 60,664 | 0,001 | 0,156 | 283,298 | 0,001 | 0,337 | 175,998 | 0,001 | 0,265 |
| **Functional in logistics** | | | | | | | | | |
| Maintaining digital relationships with colleagues | 15,118 | 0,516 | 0,780 | 279,631 | 0,001 | 0,334 | 186,630 | 0,001 | 0,273 |
| Digital scheduling | 45,076 | 0,001 | 0,134 | 145,334 | 0,001 | 0,241 | 158,150 | 0,001 | 0,252 |
| Using dedicated software in planning, implementation and control of processes (time, resources, costs) | 142,420 | 0,001 | 0,239 | 183,962 | 0,001 | 0,271 | 126,651 | 0,001 | 0,225 |
| Acquiring and caring for customer relations with the use of digital tools | 70,460 | 0,001 | 0,168 | 180,529 | 0,001 | 0,269 | 214,287 | 0,001 | 0,293 |

Cont. table 2.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Fulfillment of digital transactions | 57,874 | 0,001 | 0,152 | 229,813 | 0,001 | 0,303 | 144,080 | 0,001 | 0,240 |
| Management of flows and transport with the use of software | 118,892 | 0,001 | 0,218 | 185,262 | 0,001 | 0,272 | 131, 477 | 0,001 | 0,229 |
| Acquiring digital information from the area in which I work | 89,171 | 0,001 | 0,189 | 195,318 | 0,001 | 0,280 | 122,844 | 0,001 | 0,222 |
| Management of financial flows with the use of digital solutions | 80,598 | 0,001 | 0,180 | 87,598 | 0,001 | 0,187 | 187,272 | 0,001 | 0,274 |
| Managing the company's image with the use of digital tools | 69,589 | 0,001 | 0,167 | 277,888 | 0,001 | 0,333 | 242,677 | 0,001 | 0,312 |

[a] $\chi^2$ – test value; [b] p – asymptotic significance; [c] Relationship strength calculated using V-Cramer.

The links between information competences and experience are especially strong when it comes to understanding the content of the acquired digital information. Similarly, the understanding of the content of the acquired digital information is related to the position held and the area of specialization.

The last group of digital competences that are important in the case of logistics employees are functional competences in logistics. The strongest dependence exists between the employee's use of dedicated software in planning, implementation and control of processes (time, resources, costs), management of flows and transport with the use of software, as well as obtaining digital information in the area in which I work, and experience. In turn, maintaining digital relationships with colleagues, managing the company's image with the use of digital tools, carrying out digital transactions, acquiring digital information in the area in which I work and using dedicated software in planning, implementation and control of processes (time, resources, costs) is related to the position held. On the other hand, acquiring and caring for customer relationships with the use of digital tools, managing financial flows with the use of digital solutions, maintaining digital relationships with colleagues and digital scheduling related to the specialization area in which the employee performs their tasks.

The respondents admit that they are aware that the current competences should be strengthened. Definitely yes and rather yes (84.8%) declare that they are ready to acquire new competences or complete retraining due to the change of the nature of work due to the influence of new technologies. Only every tenth respondent (12.8%) is undecided on this issue. The respondents most often pointed to the improvement of competences in the field of solving technical problems with the use of software (80.8%), handling new software (79.2%), using IT tools in teamwork (76.8%), searching for information and analyzing data ( 76.0%), data visualization (69.6%), and programming (60.0%).

In summary, the computer revolution in recent years has transformed the world in which the company and its employees exist. The changes affected the functioning of economies, industries, individual enterprises and citizens. The emanation of these changes is the necessity for employees to have competences referred to as competences 4.0. It is these cognitive, social, technical and digital competences, especially IT, informative and functionally related to

logistics, that will allow employees to follow the current of changes and find themselves in the future. The analysis shows that employees declare that they have competences from the 4.0 trend. This state of affairs is a derivative of the experience, position and area of expertise in the field of logistics in which the respondents work. These links could be strengthened. The respondents are aware of this and express their willingness to strengthen them.

## 7. Summary

The intensity of digitization accelerates the "pulse" of multiplicative socio-economic changes, including logistics. Business models are being reconfigured. Customerization, networking and technologization are becoming a trigger that signals changes in logistics. In line with the new trend, the demand for logistics employees with the desired amount of knowledge and experience as well as competences referred to as 4.0 competences is growing. The relationship between the possible business success of logistics companies and the functioning of their employees is visible as never before. Currently, an employee in logistics is not only a passive contractor of commissioned tasks, but becomes a co-creator responsible for the development of the company.

Due to the fact that digitization contributes to the creation of a new type of interaction between people and machines, the necessary condition is to have 4.0 competences. Especially those that distinguish human work from the work of information systems, robots or artificial intelligence. As human will still be difficult to replace in these areas, they have been referred to as the competences of the future. There has never been a better moment for employees with the right competencies, i.e. competencies 4.0.

Therefore, as the results of the research conducted by the authors show, it is important that the employee is substantive, able to work in a team and efficiently use the technical infrastructure and software. Self-improvement, problem-solving speed and critical thinking are extremely useful in the case of logistics employees, which determine the speed and efficiency of receiving and analyzing information by employees. On the other hand, caring for good relationships and creating ties in the team, good organization of working time and attention to the constant flow of information in the team make collaborative employees more effective. By adding a component of technical competences in the form of substantive knowledge in the field of logistics, the use of devices, including computers, applications and the Internet, we can submit a full competency profile of an employee 4.0. An employee who can search for information in digital space, evaluate it in terms of credibility and usefulness, and can acquire and maintain relationships with other employees and customers, manage flows, and plan, implement and control processes using digital instruments for this purpose.

The above arguments allowed to positively verify the hypothesis: "In the era of economy 4.0 and the upcoming economy 5.0, a logistics employee should be distinguished by competences 4.0 identified with the emanation of cognitive, social and technical competences, which enable him to act openly, flexible, efficient and effective in the context of social and economic networking".

Summing up, digital revolutionizes, remodeluces and recalibrates the present day. In the labor market shaped by the processes of automation and platformization, there will be such employees who, based on advanced cognitive, social and technical competences (including digital ones), will be able to adjust the profile of their skills to the rapidly changing expectations of employers. On the other hand, the time is coming for those companies that will appreciate and care for their logistics employees. It is their knowledge, experience, skills and competences 4.0 that will allow in the future to increase competitiveness, develop and achieve business success, in line with the motto: "Primo – people, secundo – processes and tertio – technology". That could be the effect of sustainable digital transformation.

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# ESSENTIAL COMPETENCIES FOR GEN Z REMOTE WORKERS – RESEARCH RESULTS

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**Purpose:** The article's primary goal is to identify the most important values in the life of representatives of Generation Z after their experience of remote work in an uncertain time of COVID-19 pandemic and critical competencies essentials at home-office.

**Design/methodology/approach**: The authors conducted a diagnostic survey with a survey questionnaire. The questionnaire was carried out using the CAWI method. It was filled in by 310 respondents who represent Generation Z, are professionally active and worked remotely during the pandemic. Frequency and percentage statistics and descriptive parametric were applied in the statistical evaluation.

**Findings:** The research results showed that, in Gen Z-ers' opinion, they need specific competencies to be effective in remote work. They indicated the most important ones: the ability to use remote technologies and manage their own time, independent problem solving, self-motivation and commitment.

**Research limitations/implications**: The authors intend to continue the research carried out in the discussed topic, as well as in the field of adaptability to remote work of other three generations, i.e., Y, X and BB. Due to the limitations of the research sample, it is important to underline that generalizing the research results must be done with caution.

**Practical implications:** Human resource managers are challenged to develop the competencies necessary for effective work in a virtual environment. It is also a guideline for which areas employees need support and appropriate training policy.

**Originality/value**: Our paper contributes to the latest insight into essential competencies for Gen Z in remote work. Managers need this knowledge to manage young employees from the Z generation best and ensure their effectiveness while working remotely.

**Keywords:** Generation Z, remote work, competencies, life value.

**Category of the paper:** Research paper.

# 1. Introduction

The outbreak of the COVID-19 pandemic initiated a revolution in work systems in most companies. Due to lockdown and restrictions, many were forced into remote working arrangements, which created many challenges and opportunities (Eurofound, 2020). Consequently, remote work is expected to continue at a higher percentage than before the pandemic, although lower than the numbers at its peak (Shifrin, Michel, 2022). Research from McKinsey Global Institute (Lund et al., 2021) estimates that 20-25% of the workforce could work remotely three to five days a week in countries with advanced economies. Other studies suggest more significant numbers will engage in a hybrid model, averaging two remote workdays per week (Lund et al., 2020). There is an urgent need to understand better how to influence the effectiveness and efficiency of the work provided under these conditions. It is necessary to consider both positive and negative experiences from this period. A fundamental issue in this context would be identifying the competencies necessary to succeed when working outside a traditional office environment. It is worth emphasizing that the primary and executive competencies needed in stationary work are insufficient to effectively provide remote work (Sawatzky, R., Sawatzky, N.J., 2019). Additional competencies are necessary to enable effective work performed remotely (Wang, Haggerty, 2009). As emphasized by Jeran (2016) and Ślązak (2012), traditional forms of work differ significantly from remote work, including heterogeneous workplace, multidimensional flexibility related mainly to the way of performing tasks, or constant contact of employees via ICT with the enterprise and other team members.

It is hard to define the concept of competence (Page, Wilson, 1994). Sajkiewicz (2002) perceives competencies as a set of knowledge, skills, value system, personality, and interests that, developed in the work process, lead to the results desired by the organization. Figure 1 shows the main components of the construct, which are competencies. The employee's value system occupies a special place among the indicated components. It is the foundation for creating and describing the competencies expected by employers. It creates employees' views and ways of thinking, shaping their attitudes and habits and, consequently, more or less desirable behaviors and work results.
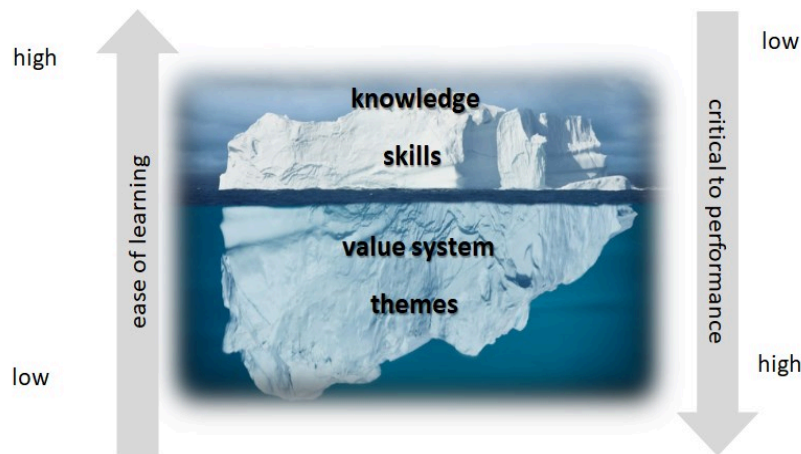
**Figure 1.** Competency Ice-berg model.

Source: own work based on Baron-Puda, M. (2012). Projektowanie strategii rozwoju kompetencji pracowników przedsiębiorstw produkcyjnych. *Zarządzanie Przedsiębiorstwem, Vol. 4*, p. 2.

Concerning remote work, virtual competencies are of particular importance. Wang and Haggerty (2011) theorize that individual virtual competence (IVC) is a new and distinct capability that individuals require to perform effectively in their organizations. They also suggest that IVC is vital and stands in contrast to those necessary in a co-located setting. Specifically noted were competencies that relate to technology, motivation, and self-efficacy. Virtual competencies were the subject of research even before the pandemic. The growing interest in remote work after its outbreak has intensified this tendency (e.g., Tsareva, Omelyanenko, 2020; Krasnova, 2021).

The article's authors refer to the value and problem of the competencies necessary for success as a remote worker from the perspective of the youngest employees, born between 1990 and 2000 - referred to in the literature as the Z generation (Tulgan, 2016). They are entering the workforce with higher numbers every year[1]. According to the authors, such an orientation of considerations is justified. It can provide valuable information to employers and employees who face challenges in managing remote work for employees of various ages. The more so because the knowledge on this subject is quite limited.

Gen Z was born in the digital age, grew up during the technological explosion, and has never experienced a world without the internet or social media. They are the first truly digital native generation (Lanier, 2017). It significantly influences their value system, life experiences, and outlook. Z-ers appreciate work-life balance and flexibility in the workplace. They expect flexible solutions from employers in the field of forms of work organization, including enabling them to provide work in the form of remote work (Kantar TNS, 2018; Kopertyńska, 2020). Many young Z-ers were forced into remote work just as they started their professional lives (Bruner, 2021). They began their professional careers in purely remote work environments and had no chance to live the working life they dreamt of during college. They do not experience the in-person onboarding, networking, and training they typically expect when working in a company (Kantar TNS, 2018; Chillakuri et al., 2018). The article's primary goal is to identify

the most important values in the life of representatives of Generation Z after their experience of remote work in an uncertain time of COVID 19 pandemic and critical competencies essentials at home-office.

## 2. Methods

For the purpose of this article, the following research questions were formulated:

RQ1. Which of the analyzed values are the most important for Generation Z, and which are relatively less critical?

RQ2. Which employee competencies are the most important and relatively less necessary in remote work in the opinion of the Z Generation?

RQ3. Which of the analyzed values and competencies are consistent and interrelated?

The presented goal and research questions implied the need to select appropriate methods, techniques, and research tools. For the purposes of this article, an empirical, quantitative research method was used, which was a diagnostic survey using the surveying technique. The research tool was a questionnaire. It contained closed questions in the form of a disjunctive cafeteria and a 5-point interval ordinal scale. The survey ended with a metric that enabled carrying out the socio-demographic characteristics of the studied population. Then, the two data analysis method was used as part of the adopted research methodology. Due to the nominal nature of the variables, frequency and percentage statistics and descriptive parametric were applied in the statistical evaluation. In addition, as part of the conducted research, one of the statistical methods of factor analysis was used, namely principal component analysis (PCA) and variable correlation analysis. The survey was conducted in the 1st quarter of 2022. It was filled in by 334 respondents who represent Generation Z, are professionally active and worked remotely during the pandemic. As many as 310 questionnaires were selected for the final analysis (n = 310). Participation in the study was voluntary and anonymous. Data shown in the article is based on the responses/declarations of the surveyed. The sample was differentiated according to gender - 71.6% were women. Additionally, every third of the representatives of the youngest generation works in the service sector (32.9%). Most of the surveyed people live in a large city (61.3%), and the majority do not have children (88.4%) (Table 1).

**Table 1.**
*Descriptive statistics pertaining to the research sample*

| Sample differentiation criterion | | n | % |
|---|---|---|---|
| Gender | Female | 222 | 71.6 |
| | Male | 88 | 28.4 |
| Business sector | Commerce | 20 | 6.5 |
| | Production | 26 | 8.4 |
| | IT | 38 | 12.3 |
| | Service | 102 | 32.9 |
| | Education | 14 | 4.5 |
| | Medicine | 12 | 3.9 |
| | Other | 98 | 31.6 |
| Residence | Country | 54 | 17.4 |
| | Small town (population below 20k) | 30 | 9.7 |
| | Mid-size town (population between 20k – 100k) | 36 | 11.6 |
| | Big city (population over 100k) | 190 | 61.3 |
| Children | Yes | 36 | 11.6 |
| | No | 274 | 88.4 |

Source: own work based on conducted research.

## 3. Results

The first question addressed to respondents concerned their values and life priorities. Twenty of them were analyzed. The respondents assessed them on a 5-point ordinal scale, from 1 to 5, where 1 is an unimportant meaning, and 5 is a very important meaning. Table 2 presents the main descriptive statistics: mean, standard deviation, and median.

**Table 2.**
*Descriptive statistics of the importance of values and life priorities – ranking of importance*

| Place in the ranking | Values/life priorities | Mean | Standard deviation | Median |
|---|---|---|---|---|
| 1. | Family | 4.66 | 0.68 | 5.00 |
| 2. | Happiness | 4.62 | 0.69 | 5.00 |
| 3. | Health | 4.55 | 0.70 | 5.00 |
| 4. | Freedom | 4.52 | 0.71 | 5.00 |
| 5. | Friends | 4.47 | 0.75 | 5.00 |
| 6. | Free time | 4.35 | 0.74 | 4.00 |
| 7. | Development | 4.26 | 0.75 | 4.00 |
| 8. | Responsibility | 4.25 | 0.78 | 4.00 |
| 9. | Commitment | 4.20 | 0.78 | 4.00 |
| 10. | Relationships with other people | 4.20 | 0.89 | 4.00 |
| 11. | Tolerance | 4.19 | 0.91 | 4.00 |
| 12. | Persistence | 4.10 | 0.85 | 4.00 |
| 13. | Empathy | 4.08 | 0.93 | 4.00 |
| 14. | Work-life balance | 4.04 | 0.91 | 4.00 |
| 15. | Cooperation | 3.94 | 0.85 | 4.00 |
| 16. | Care for the environment | 3.65 | 1.01 | 4.00 |
| 17. | Compassion | 3.59 | 0.98 | 4.00 |
| 18. | Work | 3.43 | 0.87 | 3.00 |
| 19. | Spirituality | 2.57 | 1.34 | 2.00 |
| 20. | Religion | 2.30 | 1.28 | 2.00 |

Source: own work based on conducted research.

When analyzing the indications concerning the analyzed value categories, a relatively high agreement of the opinions obtained can be observed. As many as 14 obtained average values of at least 4.0, proving a wide range of values essential for the youngest generation of employees. It is worth emphasizing, however, that taking into account the median value (5.0), the most important for the respondents turned out to be the following of them: family, happiness, health, freedom, and friends. Free time and the related work-life balance, development, responsibility, commitment, relations, tolerance, perseverance, and empathy are slightly less important than the above. Interestingly, work as a value is relatively less important than the other values (mean = 3.43; median = 3.0). For Gen Z-ers, spirituality and religion are relatively the least important.

Another issue subject to the study was the recognition of the respondents' opinions on the legitimacy of having particular competencies needed for remote work. The authors asked the respondents whether, in their opinion, it was possible to talk about the so-called 'Home office personality'. As many as 2/3 (67.7%) of them answered the question in the affirmative, nearly every fourth person (23.9%) indicated the answer 'I do not know', and only one in ten denied it (8.4%). The above question continued to indicate the importance of the analyzed competencies and other conditions predisposing the employee to remote work. Similarly, as in the case of the value test, an evaluation scale from 1 to 5 was used, where 1 means an invalid competence and 5 is a very important one. Table 3 presents the ranking of the importance of individual competencies.

**Table 3.**
*Descriptive statistics of the importance of competencies and other conditions predestining an employee to work remotely – ranking of importance*

| Place in the ranking | Competences/conditions | Mean | Standard deviation | Median |
|---|---|---|---|---|
| 1. | Ability to use remote technologies | 4.27 | 1.08 | 5.00 |
| 2. | The ability to manage your own time | 4.25 | 1.05 | 5.00 |
| 3. | Independent problem solving | 4.03 | 1.12 | 4.00 |
| 4. | Self-motivation and commitment | 3.88 | 1.18 | 4.00 |
| 5. | Willingness to learn | 3.86 | 1.16 | 4.00 |
| 6. | Openness to changes | 3.86 | 1.11 | 4.00 |
| 7. | Family situation | 3.81 | 1.18 | 4.00 |
| 8. | Living conditions | 3.77 | 1.23 | 4.00 |
| 9. | Action-oriented | 3.65 | 1.12 | 4.00 |
| 10. | Not postponing tasks for later | 3.64 | 1.23 | 4.00 |
| 11. | Results orientation | 3.61 | 1.09 | 4.00 |
| 12. | Coping with stress | 3.56 | 1.12 | 4.00 |
| 13. | Work ethic | 3.35 | 1.20 | 3.00 |
| 14. | Assertiveness | 3.35 | 1.10 | 3.00 |
| 15. | Experience | 3.31 | 1.19 | 3.00 |
| 16. | Relationships with colleagues | 3.04 | 1.22 | 3.00 |
| 17. | Identification with the company | 2.79 | 1.32 | 3.00 |

Source: own work based on conducted research.

When analyzing the obtained values of three statistical measures, it is stated that the respondents rated the highest two, namely the ability to use remote technologies and manage their own time (median = 5.0). In their opinion, only slightly less important are such competencies as independent problem solving, self-motivation and commitment, readiness to learn, openness to changes, orientation to action and results, not postponing tasks, and coping with stress (mean = what least 3.5; median = 4.0). There are also additional conditions here, such as housing and family situations.

In deepening the research, factor analysis using principal component analysis (PCA) was used in further analysis. Based on it, components were distinguished for individual features of the questionnaire concerning the categories of analyzed values and competencies. Tables 4 and 5 show the results analyzed above with calculated factor loadings. The factors were distinguished based on the Kaiser criterion (eigenvalues > 1) and the scree plot. This way, the number of components and the features included in its structure were determined. In this analysis, the criterion of a factor load of > 0.5 was adopted. In other words, the respondents who rated one of the above-stroke features also rated the others high. Correspondingly, component C1 consists of such features as relationships with people, cooperation, friends, happiness, and free time; component C2: work, development, commitment, and persistence; component C3: empathy, tolerance, and concern for the environment; component C4: religion and spirituality. A similar analysis was carried out about the potential competencies of the so-called 'home office personality', which allowed determining the components of C5 (they are formed by as many as 13 analyzed features, except 4 of them, which make up the C6 component: identification with the company, ethical behavior, attitude to social contacts and the level of assertiveness). Then, Cronbach's alpha coefficient ($\alpha$) measuring the reliability of the adopted scales was calculated for the selected features.

**Table 4.**
*Main components of factor analysis according to the importance of life values and priorities*

| Life values/priorities | Component | | | |
|---|---|---|---|---|
| | C1 | C2 | C3 | C4 |
| | $\alpha = 0.811$ | $\alpha = 0.703$ | $\alpha = 0.657$ | $\alpha = 0.906$ |
| Work | -0.173 | **0.592** | 0.016 | 0.246 |
| Family | 0.470 | 0.096 | 0.091 | 0.431 |
| Health | 0.477 | 0.111 | 0.230 | 0.187 |
| Compassion | 0.126 | 0.100 | 0.610 | 0.423 |
| Religion | 0.047 | 0.056 | 0.058 | **0.908** |
| Spirituality | -0.024 | 0.051 | 0.232 | **0.859** |
| Work-life balance | 0.436 | -0.052 | 0.428 | -0.020 |
| Empathy | 0.352 | 0.011 | **0.682** | 0.203 |
| Freedom | 0.430 | 0.184 | 0.234 | -0.328 |
| Relationships with other people | **0.739** | 0.141 | 0.086 | 0.088 |
| Cooperation | **0.635** | 0.095 | 0.073 | 0.108 |
| Development | 0.219 | **0.632** | 0.169 | -0.118 |
| Tolerance | 0.184 | 0.331 | **0.661** | -0.125 |
| Friends | **0.682** | 0.080 | 0.305 | -0.015 |

Cont. table 4.

| | | | | |
|---|---|---|---|---|
| Happiness | **0.737** | 0.143 | 0.124 | -0.172 |
| Free time | **0.727** | 0.289 | -0.015 | -0.056 |
| Commitment | 0.333 | **0.766** | 0.093 | -0.020 |
| Responsibility | 0.150 | 0.835 | 0,138 | 0.103 |
| Persistence | 0.266 | **0.747** | 0,091 | 0.005 |
| Care for the environment | 0.023 | 0.152 | **0.720** | 0.114 |

Source: own work based on conducted research.

**Table 5.**
*Main components of factor analysis according to the importance of competencies and other conditions predisposing the employee to work remotely*

| Competencies/conditions | Component | |
|---|---|---|
| | C5 | C6 |
| | α = 0.905 | α = 0.417 |
| Self-motivation and commitment | **0.634** | 0.263 |
| Not postponing tasks for later | **0.578** | 0.468 |
| Action-oriented | **0.612** | 0.452 |
| Results orientation | **0.581** | 0.376 |
| Identification with the company | 0.098 | **0.730** |
| Experience | **0.564** | 0.335 |
| Work ethic | 0.401 | **0.593** |
| Independent problem solving | **0.807** | 0.178 |
| Willingness to learn | **0.758** | 0.284 |
| Openness to changes | **0.775** | 0.249 |
| Ability to use remote technologies | **0.865** | 0.121 |
| The ability to manage your own time | **0.881** | 0.156 |
| Coping with stress | **0.677** | 0.343 |
| Relationships with colleagues | 0.124 | **0.812** |
| Assertiveness | 0.460 | **0.578** |
| Living conditions | **0.570** | 0.415 |
| Family situation | **0.525** | 0.483 |

Source: own work based on conducted research.

When analyzing the obtained results, it is stated that the reliability of the components apart from C6 is relatively high. Table 6 presents basic statistics for the selected components. Table 7 presents the correlation coefficients between the identified components.

**Table 6.**
*Statistics for selected factors*

| Basic statistics | Components | | | | | |
|---|---|---|---|---|---|---|
| | C1 | C2 | C3 | C4 | C5 | C6 |
| Mean | 21.59 | 15.99 | 11.93 | 4.86 | 49.50 | 12.54 |
| Standard deviation | 2.97 | 2.37 | 2.20 | 2.50 | 11.15 | 3.66 |
| Median | 22.00 | 16.00 | 12.00 | 4.00 | 52.00 | 12.00 |
| Minimum | 11.00 | 8.00 | 5.00 | 2.00 | 13.00 | 4.00 |
| Maximum | 25.00 | 20.00 | 15.00 | 10.00 | 65.00 | 20.00 |
| Skewness | -0.97 | -0.61 | -0.68 | 0.50 | -1.60 | -0.32 |
| Kurtosis | 0.69 | 0.39 | 0.11 | -0.80 | 3.23 | -0.05 |

Source: own work based on conducted research.

**Table 7.**

*Pearson's r correlation coefficients between components relating to the values and life priorities*

| | | | Components | | | |
|---|---|---|---|---|---|---|
| | | | C1 | C2 | C3 | C4 |
| Components | C1 | r | 1 | .398** | .421** | 0.047 |
| | | p | | <0.001 | <0.001 | 0.558 |
| | C2 | r | .398** | 1 | .351** | 0.106 |
| | | p | <0.001 | | <0.001 | 0.189 |
| | C3 | r | .421** | .351** | 1 | .232** |
| | | p | <0.001 | <0.001 | | 0.004 |
| | C4 | r | 0.047 | 0.106 | .232** | 1 |
| | | p | 0.558 | 0.189 | 0.004 | |
| ** correlation significant at the level of 0.01 (two-sided), * correlation significant at the level of 0.05 (two-sided). | | | | | | |

Source: own work based on conducted research.

Analyzing the correlations between successive components, it can be concluded that at a moderate level, people who value relationships with people and friends, cooperation, free time, and happiness (component C1) will also moderately value work, learning, commitment, and perseverance (component C2) (r = 0.398) and empathy, tolerance, and care for the environment (C3 component) (r = 0.421). On the other hand, people who rated work, learning, commitment, and perseverance higher (component C2) will also rate the importance of values such as empathy, tolerance, or caring for the environment higher (component C3) (r = 0.351). In turn, respondents who value religion and spirituality (component 4) will value empathy, tolerance, and care for the environment (component 3) more (r = 0.232). It is worth emphasizing the strong mutual connection of the components C5 and C6 relating to the competencies under study. It means that the respondents who highly rate the importance of such competencies as focus on results, company, tasks, and the level of commitment will also rate the importance of identifying with the company, work ethics, relations with colleagues, or assertiveness higher (r = 0.677; p < 0.001).

# 4. Discussion

The Covid-19 pandemic significantly accelerated the trend that remote work and its associated technologies will be a transformative force for many organizations over the long term (Hadidi, Power, 2020). Gen Z-ers respondents quickly adapted to the new work mode dictated by the pandemic situation. Moreover, as they declared in previous authors' research, their commitment and the efficiency of work performed in remote conditions remained at the same level and even increased. Additionally, respondents reported other positive experiences related to working remotely. These include increased trust in the employer who did not apply

ongoing control but relatively large freedom, independence at work, and the possibility of a flexible combination of private and professional duties (Żarczyńska-Dobiesz et al., 2022). Answering the first research question regarding the fundamental values and life priorities of Gen Z, it is worth emphasizing that respondents highly appreciated the importance of the majority of the analyzed values. The most important, however, were: family, happiness, health, freedom, and friends, and slightly less important: free time and the related work-life balance, development, responsibility, commitment, relations, tolerance, perseverance, and empathy. In the context of the above, it is worth noting that the authors obtained comparable results on life values in the previously conducted own research (Żarczyńska-Dobiesz et al., 2021). Particular attention should be paid to the coherence and consistency of young employees regarding the identified hierarchy of values. Interestingly, work as a value is relatively less important than the other values. Young people do not treat work as a critical value, rather instrumental than autotelic, and are not ready to devote more time to it. The Gen Z value system is based primarily on pursuing self-fulfillment, not necessarily in the work environment, but as part of passions and interests, spending time with friends, and striving to be happy.

Searching for an answer to another question relating to essential and relatively less necessary competencies in remote work, in the opinion of the Z Generation, the research showed that specific competencies become particularly important. Most of them agree with the statement that employees should have a certain predisposition to work remotely. Moreover, in the opinion of most of them, one can even speak of a 'home office personality', within which selected competencies acquire special meaning in the face of remote work. Although respondents grew in the era of digitization, they are aware of their competence deficits in this area. They expressed it by defining the meaning of the ability to use remote technologies as the most important. Young people's second most crucial competence is the ability to manage your own time. Gen Z-ers realize that the Internet is a strong distraction, distracting them from their professional responsibilities. Therefore, for the Z generation, self-motivation and staying motivated while working from home are significant challenges. Moreover, it is worrying that the work ethic, identification with the company, and relations with colleagues obtained relatively the lowest values.

Answering the last research question about the strength of the connection of the analyzed components, it is stated that while the relationships between the components concerning competencies are strong, the strength of the correlation of the components related to the values and life priorities of Gen Z-ers is at a moderate level.

While there is a lack of research on the Z generation in terms of the remote competencies they desire, we can find considerations on the competencies of people working remotely in the literature on the subject. According to Haggerty and Wang (2009), employees must have specific competencies, including virtual self-efficacy, virtual social competencies, and the ability to use virtual media to work remotely effectively. In turn, Lönnblad and Vartiainen (2012) focused on new forms of work and ways of organizing work related to remote and

mobile work, with work in virtual and global teams, communicating through advanced ICT systems. These authors distinguished and divided competencies into three groups: personal competencies of employees and leaders, specific competencies of leaders, and team competencies. Moreover, Sawatzky, R. and Sawatzky, N.J. (2019) indicated communication, self-direction, self-motivation, discipline, critical thinking, taking the initiative, being trustworthy, flexibility, and empathy as necessary for the success of a remote worker. Similar lists of competencies necessary during remote work can also be found in business reports and publications (Jabra, 2021). It is worth noting that the desirable competencies proposed by the authors mentioned above refer to the remote employee without considering the perspective of his or her generation. However, it is difficult to say whether the indicated criterion is essential at this stage. At the moment, however, one may be tempted to say that, on the one hand, a remote employee's competencies will be important regardless of their generation affiliation. On the other hand, it is also possible to identify such competencies that will be specific and characteristic only for a given generation. Bearing in mind the results of the research conducted by the authors of this article, in the case of the Z generation, such competencies are, e.g., the ability to manage your own time and self-motivation and commitment, independent problem solving, and not postponing tasks for later. Generation Z, often presented as susceptible to various distractors, will undoubtedly need much support in these competencies.

## 5. Summary

The transition to a remote work format is the most relevant topic of the current year and subsequent years. In changing working conditions, employees need appropriate competencies. The ones that will allow them to be successful as remote workers. In this article, the authors focused on identification by representatives of Generation Z, the most important values in their life after the experience of remote work in an uncertain time of Covid-19, and competencies essentials at home-office. It is worth emphasizing that Gen Z-ers appreciate the remote working model. They have become convinced of a home office, even "choked" with its advantages, and many of them cannot imagine working in a different form of work. The possibility of remote work is a decisive factor in choosing an employer. Young people wonder whether returning to work at the company's headquarters will remove the privileges so vital for them related to the home office (Żarczyńska-Dobiesz et al., 2022).

As the presented research results show, young people, believe that to be effective and fully benefit from remote work benefits, they need specific competencies. They considered the most important: the ability to use remote technologies and manage their own time, independent problem solving, self-motivation and commitment. Therefore, human resource managers are challenged to develop the competencies necessary for effective work in a virtual environment.

It is also essential to determine which areas employees need support and appropriate training policy. Regarding the youngest employees, it is important to find a way to help Gen Z-ers grasp what they prefer and expect during remote work. Knowledge of the competencies they need to work in this environment will allow not only to define the requirements for job candidates but, above all, to manage these competencies. It is the foundation of a building and strengthening the motivation to work and the commitment of young employees and a way to unlock the full potential of the new way of working.

The authors of the article intend to continue the research carried out in the discussed topic, as well as in the field of adaptability to remote work of other three generations, i.e., Y, X and BB. Due to the limitations of the research sample, it is important to underline that generalizing the research results must be done with caution.

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# DIGITAL TRANSFORMATION OF ENERGY SECTOR ENTERPRISES IN POLAND. RATIONALE AND PRACTICES

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**Purpose:** With increasing digitalization, the debate on the direction of transformation in various sectors of the economy and their ability to keep up with the changes in this area is becoming increasingly complex. The energy industry is one of the key sectors in the economy, and as such it must follow trends and adapt to changing conditions. The aim of the paper is to diagnose and assess the level of progress in digital transformation among Polish energy sector enterprises.

**Design/methodology/approach**: The research was conducted on a group of 110 entities, with a survey questionnaire. The gathered data was analyzed using descriptive statistics.

**Findings:** Although the level of employing Industry 4.0 tools in Polish energy sector enterprises is at a low level, managers recognize the importance of following the path toward digital transformation. The awareness of particular digital transformation prerequisites differs depending on the phase of the digital transformation process.

**Research limitations/implications**: Among the limitations of the research procedure, issues such as the single respondent design and the exclusion of micro entities from the research should be noted. However, the exclusion of micro entities from the analysis was intentional, and this area deserves the attention of researchers. The specificity of the functioning and organization of the activity of micro enterprises may distort the image of the sector. Referring to the single respondent design, it was assumed that in this phase of the research it is reasonable to collect individual opinions specific to a given enterprise. It would be worth extending the analysis by conducting in-depth interviews or attempting more in-depth research at the level of individual entities.

**Originality/value:** This article contributes to the knowledge of the energy sector in Poland in the context of Industry 4.0.

**Keywords:** digital transformation, digital strategy, digital transformation strategy, prerequisites for digital transformation, energy sector companies.

**Category of the paper:** Research paper.

## 1. Introduction

Today's industrial environment is being shaped by incorporating the concept of Industry 4.0. This primarily involves the digitization of production, automation and the integration of production facilities into a comprehensive supply chain (Roblek, Meško, Krapež, 2016). This concept includes full network integration and real-time information exchange. It is an umbrella term for value chain techniques and principles collectively applying cyber-physical systems, the Internet of Things and cloud computing (Ghobakhloo, Fathi, 2021).

The importance of this concept is growing in the context of a dynamically changing environment, in which it is becoming increasingly important to keep up with technological changes (Ravichandran, 2018). Digital transformation is a wide-reaching process that affects a range of industries (Shahi, Sinha, 2021), on which it has a varying influence (Torkayesh, Torkayesh, 2021). The process of digital transformation is long-term and is shaped by advancements in digitalization and information and communication technologies. These affect not only socio-economic areas, but also different fields of business (Akberdina, Osmonova, 2021). Although research that adopts a societal perspective is crucial due to the participation of communities in sustainable urban development (Huang, Yu, Peng, Feng, 2017), the digitalization process also implies a change in the roles of managers, requiring them to become leaders of digitalization (Trzaska, Sulich, Organa, Niemczyk, Jasiński, 2021). Ultimately, the onus is on executives to capture and interpret changes that are crucial to their organization (Giones, Brem, Berger, 2019).

The issue of digitalization is emerging as a key issue in the context of discussions on the transformation of energy sectors around the world. It is therefore a current research problem as well as an issue for business practitioners. The process of digitalization of the energy sector is considered not only in the macro dimension. On the one hand, it is pointed out that the changes taking place are aimed at ensuring energy security and efficiency, as well as contributing to an increased commitment to renewable sources (Chebotareva, 2021). On the other hand, the issue of progressive digitalization is raised, which also brings with it changes in business models (Trzaska et al., 2021). Given the critical importance of digitalization in business development, it is important to note the variation in digital maturity levels across regions. It has been shown that in Central and Eastern Europe, the level of digitalization is relatively low (Tutak, Brodny, Bindzár, 2021).

Among the rationales for implementing digitalization solutions is the notion that digital technologies create new opportunities for value creation along the value chain (Reuter et al., 2019). However, as digital transformation requires changes to existing business patterns that can positively translate into performance (Singh, Sharma, Dhir, 2021), not all companies are willing to embark on the path of digital transformation (Shahi, Sinha, 2021).

In view of the above, it would appear highly relevant to conduct research on the practices adopted by energy sector entities, as these enable them to implement wide-ranging transformations.

The aim of the paper is to diagnose the level of progress in digital transformation among Polish energy sector enterprises. The article is empirical in character and is the result of research conducted into the transformation of enterprise business models in the energy sector in Poland[1]. This paper presents the results of a study that aimed to identify the practices of energy companies in the area of digital transformation and the reasons therefor. With reference to the main objective, the following research questions were formulated:

1) In what phase of digital transformation are energy companies in Poland?
2) What are the rationales for the implementation of digital transformation in power companies in Poland?
3) What is the meaning of digital transformation from the perspective of the strategy of energy companies in Poland?

The paper is structured as follows. Section 2 presents a literature review, while section 3 describes the methods and research sample. The research results are discussed in section 4, and the final part of the paper provides conclusions, research limitations and directions for further research.

## 2. Literature review

### 2.1. Characteristics of the Polish energy sector

The Polish energy sector has the seventh largest production of energy in the European Union. Compared to other European Union countries, Poland ranks first in terms of hard coal extraction and export, and fourth in terms of lignite extraction. Moreover, it ranks fourth in terms of obtaining primary energy. In the years 2015-2020, there was a decrease in energy exports, while a decline in energy imports has only been observed since 2018. Energy imports still significantly exceed exports. In addition, in the years 2013-2020, a 19% increase in dependence on energy imports was observed in Poland (GUS, 2021). The demand for energy in Poland is systematically growing, however, this situation applies to all highly developed countries. Taking into account the whole of 2021, domestic electricity demand increased by 5.7% compared to the previous year (Wiśniewski, 2022). To provide a comparison to other European countries, the gross available energy per capita in Poland in 2019 amounted to 114.9 GJ, while the EU average amounted to 137.3 GJ. An increase in global consumption was

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observed in 2020 compared to the previous year in the case of natural gas, renewable energy and other carriers, while there was a decrease in the case of hard coal, lignite and crude oil (Walkowska et al., 2021). In Poland, in December 2021, coal-fired power plants (76%), including lignite (28.3%) and hard coal (47.7%), had a dominant share in energy production. The third source of energy were wind farms, accounting for 11.6 percent (Wiśniewski, 2022).

In the light of the EU energy and climate policy aimed at increasing energy production from renewable energy sources and reducing carbon dioxide emissions by 80% by 2050 compared to 2006 emissions, Poland is faced with the need to make significant capital expenditure in order to reconfigure the production system (Lipski, 2016). The legal regulations of the European Union put the Polish energy industry in a particularly difficult situation. An obstacle in meeting EU requirements and standards in the energy sector is the high degree of dependence on coal. Coal fuel is the backbone of the national energy system. Therefore, in the coming years, it is not possible to abandon coal-fired energy production for two reasons. The first is that the increased demand for electricity and heat has to be met, while the second is related to the country's energy security. The main challenges that the energy sector is currently facing are the responsibility of the energy sector for climate change, and the need to ensure sufficient amounts of energy in the coming years. Such problems make it necessary for the Polish energy sector to take steps towards the development and construction of new production technologies. The current level of development of the production and transmission infrastructure in Poland has not kept pace with the changes in the environment (Szczerbowski, 2018).

Compared to the countries of Western Europe, Polish electricity infrastructure is in a poor technical condition. It is characterized by a low network density, a small number of extra high voltage lines, and above all its advanced age. The average age of power lines in Poland is estimated at 40 years, which means that it is close to being technically worn out (Jankiewicz, 2018). This fact implies not only significant energy losses, but also the risk of breakdowns and long-term interruptions to electricity supplies. The country as a whole, as well as households, are still not prepared to ensure the continuity of operation at an acceptable level in such cases. This is evidenced by incidental and small-scale interruptions in the continuity of energy supplies (Zakrzewska, Gil-Świderska, Szmitkowski, 2020). However, comprehensive transformation of the energy sector related to the reduction of the share of conventional energy based on coal in favor of new production technologies and a significant share of renewable energy requires the modernization of technological infrastructure and the implementation of innovative solutions. Resolutions related to the improvement of technological aspects of the energy sector are included in the document - "Poland's energy policy until 2040" approved on 2nd February 2021 by the Council of Ministers of the Polish government (Ministry of Climate and Environment, 2021).

Moreover, Polish energy policy also includes a departure from centralized generation towards distributed technologies, and from supplying only energy to end users towards combining innovative products. In this way, consumers will slowly become prosumers,

connected to the grid and producing more energy. In Poland, there is a noticeable increase in the use of green technologies (Pietrzak, Igliński, Kujawski, Iwański, 2021), which are becoming more and more profitable. Polish solar farms are experiencing a real boom. Poland was in first place in the European Union in terms of the growth rate of photovoltaic power, with a cumulative growth rate in 2016-2020 of 114%, while the EU average was 10.3% (Instytut Energetyki Odnawialnej, 2021). One of the most important reasons for installing photovoltaic panels is the growing interest of households in energy independence from external suppliers. Undoubtedly, green technologies are starting to compete with traditional power generation technologies, which drives the search for ongoing innovation and generates development. Further improvement of technological solutions, devices and energy storage systems is an activity that supports the spread of renewable energy in Poland and around the world (Zawadka, Pabian, Bylok, Chichobłaziński, 2015).

However, what should be underlined is that the transformation of the Polish energy sector is inextricably linked with the implementation of digital and IC technologies. Digital and mobile technologies in this sector are gaining more and more importance. A common practice among Polish energy companies is investing in implementation of intelligent metering systems and mobile applications, thanks to which their clients gain greater awareness of electricity consumption and can better manage it. According to the adopted assumptions, by 2028, 80% of households are to have remote reading meters at their disposal. The efficient functioning of a smart metering system in the energy sector is key to the implementation of prosumer energy. Furthermore, in accordance with the assumptions of the Polish energy policy, the basis of the energy system in the future will be a so-called distributed citizen energy system (Ministry of Climate and Environment, 2021). The European Commission underlines that digital technologies can unleash the full potential of flexible energy generation and consumption in various sectors, and can enable greater use of energy from renewable sources. The European Commission action plan applies not only to Poland, but to the entire European Union, and aims to help develop a competitive market for digital energy services and digital energy infrastructure that guarantee cybersecurity. Digitalization contributes not only to increasing the level of security, but also to the efficiency, availability and sustainability of energy systems (European Commission, 2021).

## 2.2. Rationale for digitalization of energy sector companies

The energy sector is one of the most important sectors of the economy, as the growing number of users of electronic devices translates into an increased demand for energy. High energy prices have an impact not only on individual companies, but also on countries and their international policies (Tutak et al., 2021). The development and implementation of new technologies and digital transformation strategies in the energy sector can help solve problems such as the growing demand for electricity and the transition to renewable energy sources (Szum, Nazarko, 2020). As a result, the importance of the energy sector continues to grow.

The application of digital technologies in this sector contributes to cost-effectiveness, increased energy efficiency, increased enterprise value and the quality of products and services (Trzaska et al., 2021).

The global energy system is transforming towards an integrated and hybridized grid, with both legacy and new technologies that can create synergies to deliver electricity to factories, businesses and homes around the world. Networking in this field is made possible by the implementation of digital transformation in various spheres of economic and non-economic activity (Paprocki, 2016).

The level of digitalization of energy sector companies is steadily increasing and is creating many opportunities, but also raising challenges. One of the rationales for digitalization of this sector is the desire to increase the transparency and security of digital platforms in the energy sector. This can be achieved by increasing innovation among companies within this sector. At the same time, it should be noted that this process brings with it some problems related to the implementation of integrated smart energy systems, in particular smart information and telecommunication technologies (Voropai, 2020).

Other rationales for digitalization of the energy sector include the need to comply with stringent regulatory requirements, the desire to reduce energy costs, and the aim to provide a real-time model for managing energy infrastructure as locations and energy sources change (Goosen, Nikitenko, Kagan, Pakhomova, 2020). Increasing profitability, efficiency and energy security are other arguments for intensifying the digital transformation process in energy companies. Furthermore, digitalization enables energy suppliers to establish direct relations with end users, who will be able to find intelligent ways of managing their energy resources. However, the main challenge and rationale behind digitalization is to transform the potentially disruptive effects of multi-source energy distribution into an efficient and profitable ecosystem (Zou, Zhao, Zhang, Xiong, 2016).

The development of new technologies, environmental changes and increased energy use are leading to fundamental changes and further growth in both the economy and the energy sector. One mega-trend that has a key impact on the development of the energy sector is scientific and technological progress associated with the emergence of breakthrough technologies in this sector, i.e. progressive digitalization. Digital transformation not only supports other trends such as decarbonization and decentralization of the energy sector, but also increases the possibilities of control, automation and optimization of all elements in the chain of production and consumption of electrical energy (Burda, Volkova, Gavrikova, Kosygina, 2019).

## 2.3. Digital transformation of the energy sector

Progressing globalization and technological changes are influencing the shape of both traditional business models at the industry level and business practice at the organizational level (Gao, Hakanen, Toytari, Rajala, 2019). The consequence of this trend is the development of strategies based on digital technologies, known as digital transformation strategies (Vial, 2019).

This results in emergence of new business models, which change products, services and operations (Chanias, Myers, Hess, 2019).

Digital transformation is defined as a new development in the use of digital artifacts, systems and symbols within and around organizations, and is seen as one of the main drivers of economic growth and sustainable development in today's business world (Litvinenko, 2020). Digital transformation strategies are based on the use of digital technologies, such as: (1) cloud computing, (2) edge computing, (3) big data, (4) artificial intelligence, (5) machine learning, (6) blockchain applications, (7) digital shadow, and (8) VR-reality (Al-Ruithe, Benkhelifa, Hameed, 2018; Kampker, Wessel, Lutz, Bildhauer, Hehl, 2020; López-Guajardo et al., 2021; Lytras, Visvizi, Sarirete, Chui, 2021; Mourtzis, Angelopoulos, Panopoulos, 2022; Munim, Balasubramaniyan, Kouhizadeh, Ullah Ibne Hossain, 2022; Schuh et al., 2020; Sestino, Prete, Piper, Guido, 2020; Tai, Ocone, Christie, Xuan, 2022).

As already mentioned, digitalization leads to changes in business models and enables a competitive advantage to be attained in various sectors, including the energy sector. In recent years, intensification has been observed of empirical research on the digital transformation of the energy sector (Giehl, Göcke, Grosse, Kochems, Müller-Kirchenbauer, 2020; Havle, Dursun, 2019; Loock, 2020; Remane, Hanelt, Wiesböck, Kolbe, 2017; Schaeffer, 2015; Weigel, Fischedick, 2019). Researchers claim that integration of energy companies with information and communications technologies will bring many benefits. As a consequence, companies aware of this fact are striving to implement the digital transformation process as a response to a rapidly changing environment (You, Yi, 2021).

The increased use of digital technologies in energy sector companies, and consequently the formulation and implementation of digital transformation strategies, has a positive impact on firms' operations by increasing the possibility of meeting the growing demand for energy and supporting the transformation towards clean and nuclear or more sustainable and renewable technologies (Sulich, Sołoducho-Pelc, Ferasso, 2022; Trzaska et al., 2021). Despite the benefits of using digital technologies and development in this area, the energy sector is adopting these practices more slowly than other sectors such as the technology, finance, insurance, media and information industries. Research conducted into the energy sector shows that the use of such technologies as automation, advanced data analytic techniques, mobile computing and machine learning have great potential to increase the effectiveness of company operations. At the same time, however, it is suggested that a great deal remains to be done in this area (Beyond the Supercycle: How Technology is Reshaping Resources, 2017). It is predicted that in order to maintain the current level of efficiency, ever more advanced digital technologies will be required as the technical realities of the energy sector become increasingly more demanding. This means that the need to absorb digital innovation in this sector is even greater than it may appear (Maroufkhani, Desouza, Perrons, Iranmanesh, 2022).

Digital transformation is a process that can be divided into specific phases. Based on research on energy sector companies, Dang and Vartiainen (2020) distinguished three phases in this process: the bootstrapping phase, the acceleration phase and the sustain phase. The bootstrapping phase is associated with creating a business environment suitable for the implementation of a digital transformation strategy, and making members of the organization aware of the need for digital transformation. The direction of changes in this phase is top-down, and their scope covers the entire organization. In the acceleration phase, the implementation of the digital transformation strategy is accelerated, and is accompanied by the delivery of tangible outcomes and the continuous increase in the company's value at an appropriate pace. The direction of changes remains top-down. The scope of changes moves from the organizational level towards the individual level. In this phase, the company uses modern information and communications technologies, processes are automated, and there is cooperation with partners and research centers to improve the product manufacturing process. The last phase – the sustain phase – means that all organization members become aware of the vision related to digital transformation, and take action to implement this vision. This means that the company's employees use and create new technological solutions. The direction of changes is both top-down and bottom-up. The scope of changes occurs both at the level of the entire organization and the level of the individual. In this phase, digital transformation becomes the foundation of the company's organizational culture.

Summarizing, it can be stated that the implementation of changes in the energy sector should take place relatively quickly. Successful transformation largely depends on the application of new technologies, such as new consumption and energy saving models. The digital transformation of the energy sector is not only inevitable, but also essential to the survival of the sector's companies. The use of new technologies in the energy sector should not be seen as a threat, but an opportunity to implement a more secure, reliable, cost-effective and low-carbon energy system (Makarov, Mitrova, Kulagin, 2021).

## 3. Research steps and sample

### 3.1. Research steps

In line with the concept of Fatma et al. (2014), the research procedure consisted of five stages. We excluded the factor analysis step due to the sector size and sample size. The research procedure was as follows (see Figure 1).

Critical analysis of the literature allowed the phases in the digital transformation process to be determined, defined in the article as levels of digital transformation, the rationale for the use of digital technologies, and the tools (technologies) of Industry 4.0. described in the previous

section. In the scale development process 12 of 13 invited experts took part in the expert survey. The experts were representatives of business practice working in the energy sector, in particular in managerial and decision-making positions. As a result of this step 6 items were excluded, 8 items were added and 19 items were reformulated. In the following part of scale development process the re-formulated questionnaire was discussed within a group of 12 academic researchers working on the problematics of the energy sector. As a result of the discussion 6 items were removed and 14 items were re-formulated. Subsequently, 4 pilot surveys were conducted in 16 companies with a view to the clarity of the formulated questions. As a results of the procedure the survey was enriched with explanations of technical terms regarding Industry 4.0 tools. Moreover, 11 items were removed, 7 items were re-formulated, and 3 new items were added. The actual research took place in the last part of the scale development process. In total, 110 enterprises were surveyed, including: 55 small-sized, 27 medium-sized, 26 large-sized enterprises.

## 1. Literature research

Literature analysis of research found in the Ebsco, Scopus, Taylor and Francis, Wiley Online Library, SpringerLink, Emerald, and Jstor databases, aimed at formulating research items.

## 2. Expert survey

Thirteen experts were invited to participate in the expert survey in order to discuss the proposed research questionnaire.

## 3. Group discussion

Discussion on the re-formulated questionnaire within a group of twelve academic researchers.

## 4. Pilot testing

Conducting a pilot study (a sample of 16 enterprises) in order to confirm the formulated research items.

## 5. Main survey

Conducting the main study (a sample of 110 companies, including 55 small, 28 medium-sized, and 27 large companies).

**Figure 1.** Research steps.

Source: Authors' own work, based on Fatma et al. (2014).

The respondents were asked to choose statements on a 7-point Likert scale (1 – very bad, 7 – very good) that corresponded to the level of digitalization in their company, and assess the rationale for the use of digital technologies, as well as indicate the Industry 4.0 tools used in their company. To determine the phase of digital transformation, the concept of Dang and Vartiainen (2020) was applied. After consultation with experts, a 'basic phase' was added, which characterizes companies where the management is considering implementing a digital transformation strategy in the long term, but in which it is not currently a strategic goal of the company.

The survey was conducted by a research company using the CAWI (computer-assisted web interview) method. This method was selected in order to achieve the aim of the work, as it was necessary to conduct quantitative research. Moreover, the CAWI method enables the acquisition of a relatively large sample of respondents.

The research was carried out in June 2021. The respondents were employees of energy companies holding managerial positions, with experience in the industry and knowledge in the field of research. This fact ensured reliable completion of the questionnaire. The one-respondent method was used in the study.

## 3.2. Research sample

The target group covered by the study comprises entities active in the energy sector, subclass PKD[2] 35.1: electricity generation (PKD 35.11), transmission (PKD 35.12), distribution (PKD 35.13) and trade in electricity (PKD 35.14). The activities of these entities are consistent with the implementation of the goal of energy security, which is perceived with a view to implementing the so-called full energy chain (Koczan, 2020), i.e. guaranteeing (both currently and in the long term) the security of resource supply, energy production, transmission and distribution.

Micro-enterprises were excluded from the research due to the specificity of resource management. The hallmark of microenterprises are limited human resources. The population of enterprises in the energy sector in Poland, excluding micro-enterprises, is estimated at around 180 companies. Figure 2 shows the structure of the research sample.

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[2] Polish Classification of Activities.
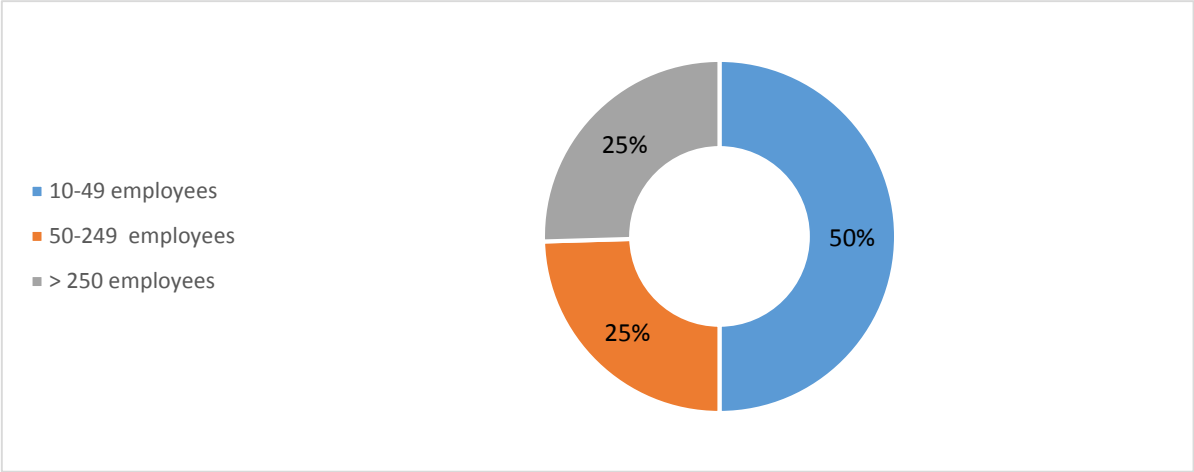
**Figure 2.** Research sample – company size (n = 110).

## 4. Results and discussion

In answer to the first research question about the phase in which energy companies in Poland currently are, it was found that energy sector companies in Poland are generally at a low level of digital transformation (see Figure 3), which is in line with the observations of Brodny, Tutak and Bindzar (2021). The majority of the enterprises studied are at the beginning of digital transformation. According to the concept of Dang and Vartiainen (2020), not even one-fifth of the entities studied have started real activities in this area.
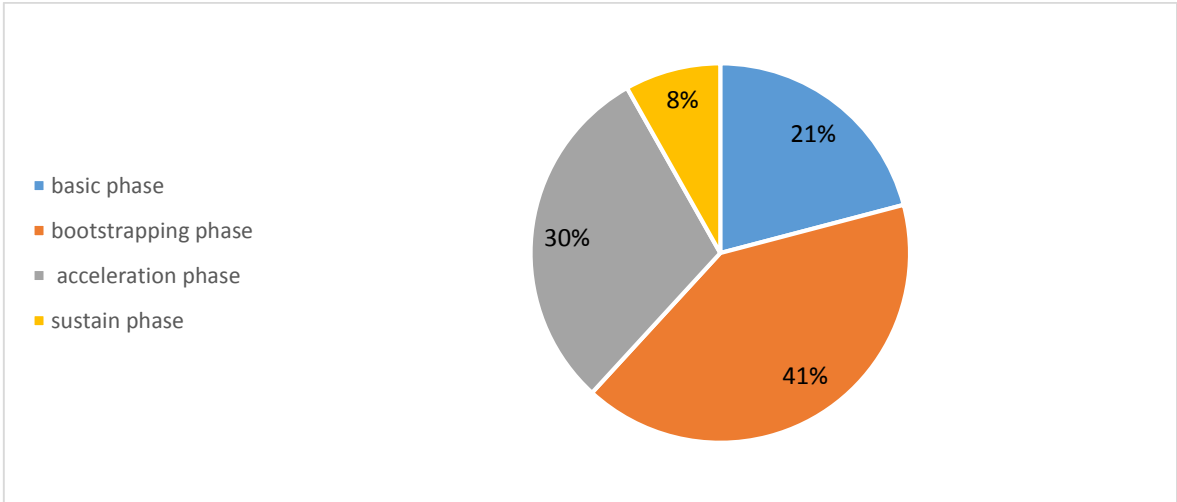


**Figure 3.** Phases of digital transformation strategy (n = 110).

A more in-depth analysis reveals that even in the group of medium-sized and large enterprises, the greatest proportion of companies are at the beginning of implementing a digital transformation strategy (Figure 4). Several indications of the 'sustain phase' among small energy companies suggest that small entities may be able to successfully enter the path to digital transformation. However, digitalization of small companies requires development of specific

digitalization capabilities (Ghobakhloo, Iranmanesh, 2021), therefore this area needs deeper scientific insight and more substantial analysis.
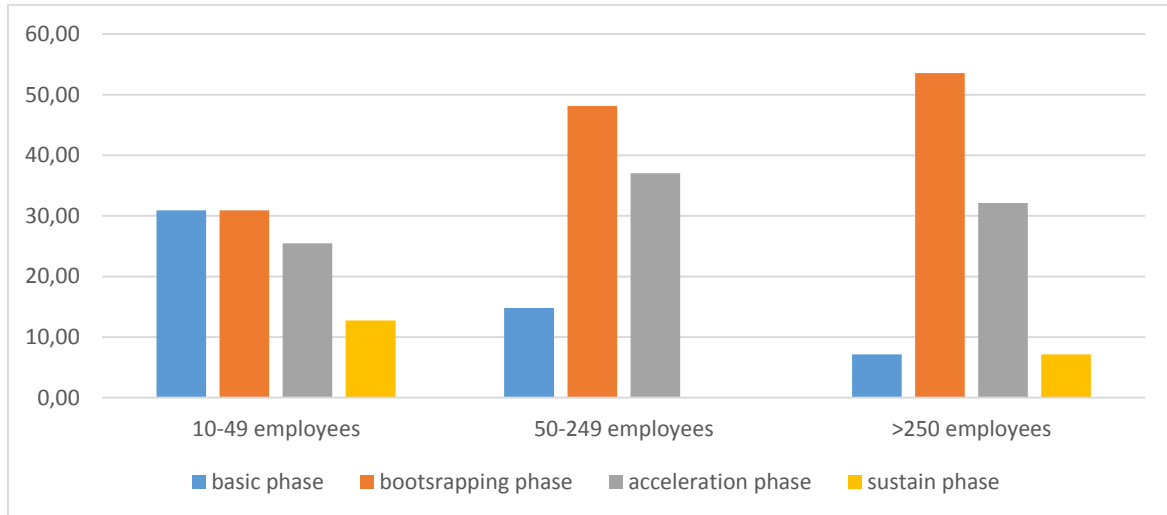


**Figure 4.** Phases of digital transformation by company size.

Despite the dominance of the initial phase of digital transformation, respondents declare that the level of preparation for the automation of processes is rather high. This observation may indicate the importance of being aware of the need for digital change. On the other hand, outdated Polish energy sector infrastructure (Zakrzewska et al., 2020) may hamper real efforts to implement digital transformation solutions.

The results shown in Figure 5 have been aggregated: indications 1-3 were considered as 'disagree', 4 – as 'neutral', while 5-7 qualified as 'agree'.
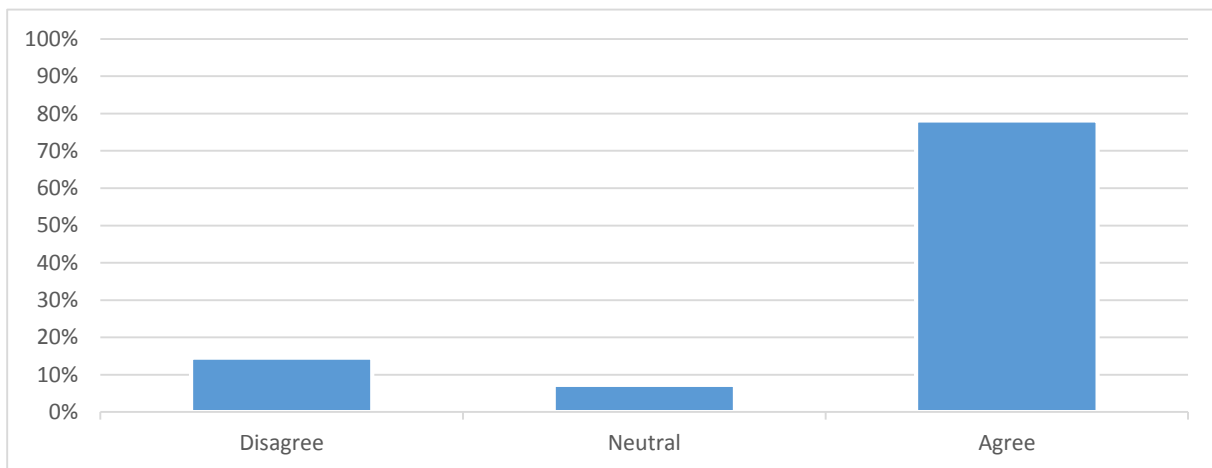


**Figure 5.** Our company is striving to digitalize and automate processes (n = 110).

Studies conducted by Polish researchers indicate the relevance of addressing the digital transformation of energy sector companies in Poland (Boichuk, 2020; Gawlik, 2018; Kiciński, 2021). This research confirms that the issue is also important for practitioners, due to the highlighted importance of implementing automation processes. When answering the second research question on the rationale for implementing digital transformation, respondents

indicated that each rationale was rather important. In-depth analysis of the answers according to the phase the company is in reveals the differences (see Table 1).

**Table 1.**
*The rationale for using digital technologies – means and standard deviations*

| | | enterprise value | customer expectations | maintenance management | energy efficiency | climate change | increase in efficiency | legislative rationale | stakeholders expectations | energy independence |
|---|---|---|---|---|---|---|---|---|---|---|
| **basic phase** | *average* | 4,65 | 4,96 | 4,39 | 4,57 | 4,87 | 5,04 | 4,48 | 4,61 | 4,74 |
| | *standard deviation* | 1,43 | 1,33 | 1,47 | 1,27 | 1,29 | 1,40 | 1,08 | 1,08 | 1,14 |
| **bootstrapping phase** | *average* | 5,42 | 5,71 | 5,29 | 5,38 | 5,16 | 5,51 | 5,27 | 5,29 | 5,31 |
| | *standard deviation* | 1,10 | 1,10 | 1,16 | 1,09 | 1,30 | 1,06 | 1,03 | 1,06 | 1,08 |
| **acceleration phase** | *average* | 5,91 | 5,91 | 5,70 | 5,82 | 6,12 | 6,03 | 5,97 | 5,85 | 5,61 |
| | *standard deviation* | 0,88 | 0,88 | 1,07 | 1,33 | 0,74 | 0,85 | 0,77 | 1,09 | 1,25 |
| **sustain phase** | *average* | 5,67 | 6,00 | 6,00 | 5,67 | 5,89 | 5,89 | 5,33 | 5,44 | 5,78 |
| | *standard deviation* | 1,58 | 0,87 | 1,12 | 1,00 | 0,78 | 0,93 | 1,58 | 1,42 | 0,83 |

When considering the importance of each rationale, the observation can be made that companies at the basic level more often ascribe lower importance to rationales such as stakeholder expectations or legislative rationales. An interesting observation is that customer expectations are a relatively important rationale for realizing digital transformation, regardless of the digital transformation strategy phase (see Figure 6).
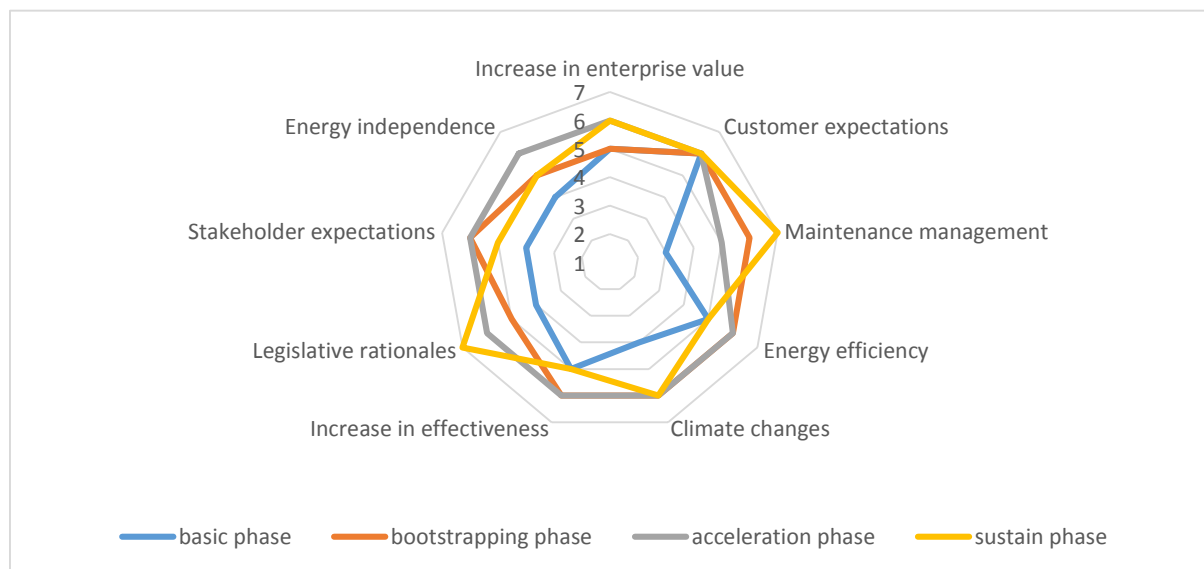


**Figure 6.** The dominant rationales for using digital technologies.

Referring to the third research question, the declared level of use of Industry 4.0 tools is in line with results indicating that the implementation of digital practices is just beginning. Although Figure 7 suggests that cloud computing tools are the most commonly used Industry

4.0 tools in energy sector companies in Poland, the level of use Industry 4.0. tools, regardless of the phase of digital transformation strategy, is low.
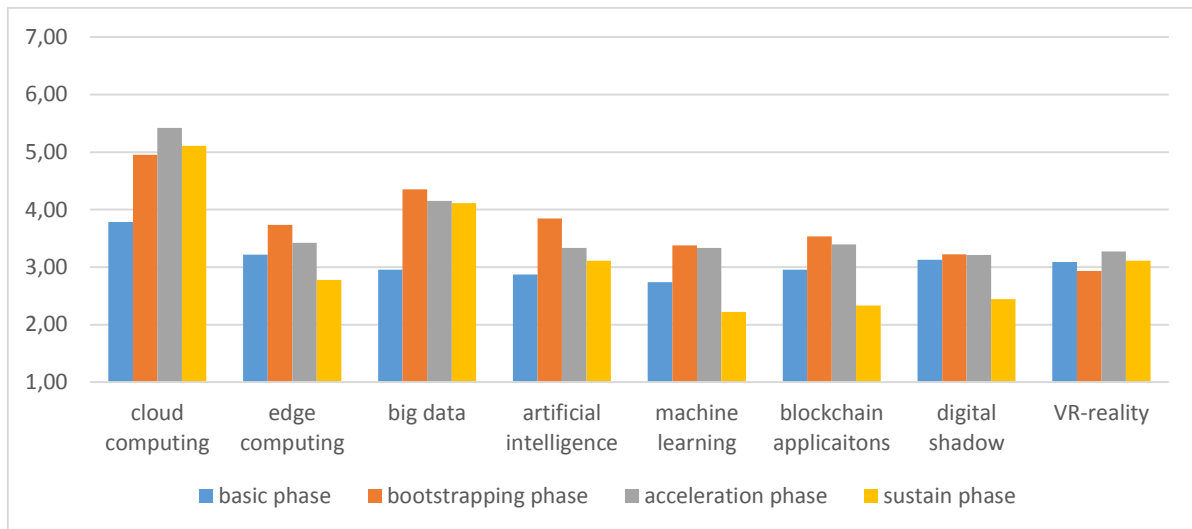


**Figure 7.** The use of Industry 4.0 tools (n=110).

**Table 2.**
*The use of Industry 4.0 tools – average and standard deviation (n = 110)*

| | | *cloud computing* | *edge computing* | *big data* | *artificial intelligence* | *machine learning* | *blockchain applicaitons* | *digital shadow* | *VR-reality* |
|---|---|---|---|---|---|---|---|---|---|
| **basic phase** | *average* | 3,78 | 3,22 | 2,96 | 2,87 | 2,74 | 2,96 | 3,13 | 3,09 |
| | *standard deviation* | 1,31 | 1,35 | 1,43 | 1,10 | 1,21 | 1,33 | 1,39 | 1,28 |
| **bootstrapping phase** | *average* | 4,96 | 3,73 | 4,36 | 3,84 | 3,38 | 3,53 | 3,22 | 2,93 |
| | *standard deviation* | 1,51 | 1,63 | 1,69 | 1,76 | 1,72 | 1,53 | 1,58 | 1,54 |
| **acceleration phase** | *average* | 5,42 | 3,42 | 4,15 | 3,33 | 3,33 | 3,39 | 3,21 | 3,27 |
| | *standard deviation* | 1,70 | 1,94 | 2,03 | 2,03 | 2,07 | 2,01 | 2,00 | 2,02 |
| **sustain phase** | *average* | 5,11 | 2,78 | 4,11 | 3,11 | 2,22 | 2,33 | 2,44 | 3,11 |
| | *standard deviation* | 1,90 | 2,28 | 2,57 | 2,20 | 1,48 | 1,94 | 1,88 | 2,26 |

# 5. Conclusions and further research directions

The research procedure provided answers to the research questions. Firstly, the results of the study show that companies in the energy sector in Poland are at the beginning of the path of implementing a digital transformation strategy, regardless of the size of the company. The outcomes are consistent with the observations of Brodny, Tutak and Bindzar (2021). Secondly, the level of use of Industry 4.0 tools confirms the low level of digitalization. Most of the respondents gave low marks to the use of particular tools. Nevertheless, in answer to the third research question, it is possible to formulate a conclusion that managers in energy

companies in Poland attribute importance to digital transformation processes. The low level of use and implementation of digital transformation strategies may be due to historical conditions, outdated infrastructure and financial constraints (Brzóska, 2016; Nogalski, Szpitter, Brzóska, 2017). Other researchers (Shabalov, Zhukovskiy, Buldysko, Gil, Starshaia, 2021; Zhukovskiy, Starshaia, Batueva, Buldysko, 2018) also point to the worn-out infrastructure as the main reason for the low level of implementation of digital transformation strategies. Światowiec and Stępień (2022) reports that the situation of the Polish energy sector compared to other EU countries looks extremely unfavorable and requires comprehensive investments in infrastructure. However, these issues require in-depth research, which points to directions for further research.

There are several limitations to this study, although these could be considered as an incentive for further research. Among the limitations of the research procedure, issues such as the single respondent design and the exclusion of micro entities from the research should be noted. However, the exclusion of micro entities from the analysis was intentional, and this area deserves the attention of researchers. Conducting research on this group of entities may broaden the picture regarding problems related to the implementation and realization of digital transformation. However, it must be taken into consideration that the specificity of the functioning and organization of the activity of micro enterprises may distort the image of the sector. Referring to the single respondent design, it was assumed that in this phase of the research it is reasonable to collect individual opinions specific to a given enterprise. It would be worth extending the analysis by conducting in-depth interviews or attempting more in-depth research at the level of individual entities.

Digital transformation research (Warner, Wäger, 2019) points out that leaders in various industries are not consistent in defining digital transformation practices. As a result, strategic thinking about digital transformation and engagement with tools takes different directions. A similar observation arises from our study, some of the research outcomes seem to be puzzling. A half of surveyed Industry 4.0. tools show a lower adaption in the 'sustain phase' than in the 'basic phase'. These results are implausible and require in-depth research. Moreover, it would be worthwhile conducting research on implementing digital transformation strategies and the use of Industry 4.0 tools in the energy sector in other European countries. The development of the energy sector is not only the result of political decisions made at a European or global level, but is also affected by the level of economic development and the availability of resources.

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# LEAN MANAGEMENT IN IMPROVING THE ORGANIZATION – CASE STUDY

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**Purpose:** The aim of this article is to present the results of research on needs and possibilities of implementing Lean Management concept at the university. Using the literature review and the results of empirical research, author proposes specific solutions (tools).

**Design/methodology/approach**: The aim of the research was carried out on the basis of latest world literature review and empirical research conducted at a Polish university, the domain of which is practical education. The article is a case study with a proposal for the implementation of LM in a selected university. The research covered selected organizational units of universities.

**Findings:** Recommendations for the use of selected Lean tools is the need to rationalize the activities undertaken in universities, including continuous improvement and flexibility of processes. There are economically justifiable actions to reduce waste and losses occurring in universities, as well as the integration of diversified and often non-cooperating organizational (functional) units. The proposals presented in this article may become an inspiration for universities that are thinking about implementing previously unused improvement tools.

**Research limitations/implications**: Empirical research has been limited to one university, and the proposed methods and tools relate to selected functional areas. LM implementation requires prior analysis of the needs and capabilities of each organization.

**Practical implications:** Due to the functioning of universities in an increasingly difficult to predict environment, they are forced to look for ways not only to survive, but above all to continuously improve the entire organization. The implemented rationalization and development measures should contribute to the improvement of the effectiveness and efficiency of management. Unpredictable changes concern the legal, socio-cultural, economic and economic environment, as well as the COVID-19 epidemic situation. These challenges are met by the concept of LM - as an inspiration and an opportunity to accelerate remedial and pro-development actions.

**Originality/value:** The article is dedicated to people interested in the theory and practice of the LM concept. The use of the methods and tools proposed by the author in various functional areas of the university may bring about beneficial changes in the form of improvements in activities, time savings, as well as rationalization and greater efficiency of the implemented processes.

# 1. Introduction

The special nature of higher education, including the exceptionally complex and increasingly difficult and hard to predict condition in both the micro- and macro-environment, mean university more and more frequently seek ways to increase their effectiveness and education quality (Avella, 2017; Detyna, 2018; Krdžalić et al., 2020; Gento et al., 2021). The quickly growing trend to introduce new educational, organizational and management related solutions started in at the beginning of 2020 when the Covid-19 pandemic started. Practically on a day to day basis, universities were forced to implement modern IT and communication solutions, which allowed to continue didactic, research and organizational activity. Both administrative and academic staff started to use in their work various tools, which very frequently they had not used before. Gaining new knowledge and skills in this respect can still be observed. Academic staff, while performing various roles and pursuing various tasks, are more willing now to use modern IT communication tools than before 2020. Undoubtedly, this new situation, observed in recent years, accelerated the pace at which universities were adapting to the IT communication needs of various stakeholders. This trend should be employed to tailor the university offer to the needs of the modern environment, and also to make informed decisions on remodeling its structure and organizational culture to adapt them to the contemporary needs (including the changing needs of staff).

The fast-paced changes one can observe now encompass the legal, political, economic and also social and cultural environment. Organizations in various sectors and areas, including universities, are confronted with numerous issues resulting from demographic changes, civilizational challenges, including the necessity to adapt their offer the needs of people at various ages, or people with disabilities. The reason why is that the needs of the elderly (e.g., students of third age universities), students with disabilities, other administrative or academic staff are different from the needs of the less digitally educated part of the society. One of the essential challenges faced by contemporary universities has been the arrival of war refugees from Ukraine (since February 24, 2022), including the need to allow Ukrainian students continue their education in Poland. An analysis of contemporary challenges faced by universities leads to a reflection that it is necessary to undertake dynamic actions aiming at making university organization more flexible, opening it to team work, including tightening cooperation with various groups of stakeholders (both internal and external ones), to name just a few. According to numerous authors, such changes form a basis for further organizational

changes in the organization and management of universities, which in effect should contribute to higher efficiency in the activity of such institutions (Bacoup et al., 2016; Wiśniewska & Grudowski, 2016; Ribeiro et al., 2019; Grudowski & Wiśniewska, 2019; Grudowski, 2021; Vasilieva et al., 2021; Adam et al., 2021; Yeh et al., 2021).

When faced by complex issues and numerous challenges, universities operate in difficult and unpredictable times, including increased risk, and so they use the experience of various businesses (including manufacturing enterprises), their strategies, concepts and tools (Mcguire et al., 2008; Osborne et al., 2012; Krdžalić et al., 2020). One of such concepts is, e.g., Lean Management (LM), which as yet is not so commonly used at universities (it is still wrongly associated with manpower reductions) (Allaoui & Benmoussa, 2020). In this context, it should be emphasised that the implementation of new methods and tools requires a detailed analysis of currently available resources (including knowledge), opportunities (e.g., staff), and real needs (Leana, Buren, 1999; Lam, 2015; Henry, 2016; Detyna & Detyna, 2016; Alefari et al., 2017; Klein et al., 2021). One of key management tools, used in decision making processes, planning, evaluation and forecasting, is knowledge, which should be understood here as information transformed into understanding and ability to act efficiently.

As a result of the situation when universities function in an increasingly unpredictable environment, they have to look not only for ways to survive, but also to constantly improve the whole organization. The implemented rationalization and development solutions should contribute to improved management efficiency and effectiveness. The response to such challenges can be the Lean Management concept, which can be an inspiration and opportunity to undertake numerous repair and pro-development actions. The goal of this paper is to present results of the analysis of needs and possible implementations of LM in a selected university. Based on literature review and empirical research results (a case study), the authoress proposes specific solutions (tools). Their application in various areas of university activity can prove to be beneficial, bring improved activity, contribute to time saving and the rationalization and higher efficiency of processes. The research goal was pursued based on literature studies and empirical research conducted in the years 2020-2022 at a university providing education in practical profiles. The research encompassed the selected organizational units of the university: promotion department, student work experience and careers department, training center and university institutes. The authoress indicates in the article the potential applicability of the LM concept at universities whose objectives include, among others, the efficient management of available resources, without excessive waste. The study recommends selected LM tools for office, project and service processes. The authoress focuses on the application the Lean Management concept in such areas as: marketing, project implementation, organization of trainings and courses, services for students, cooperation with the business and economic environment and lecturers. The presented recommendations are preceded by the presentation of the essence of the implementation and the goal of implementing the LM philosophy at universities, including the Kaizen continuous improvement model which the key strategy here (Imai, 2012).

## 2. Lean Management and its applicability in higher education

The Lean Management concept, usually refereed to as Lean, is an enterprise management philosophy developed based on the Toyota Production System – TPS principles. One of its founding fathers was Taiichi Ohno, who distinguished seven waste categories: overproduction, waiting, transport (understood as unnecessary transfer), overprocessing, inventory, motion (understood as unnecessary motion of staff, e.g. looking for something), and defects.

In the last 30 years, LM became a universal concept, applied in offices, banks and health service institutions. Such techniques as 5S, standardized work, clarity visual management or value stream mapping are more and more frequently used in, e.g., offices, customer service processes. The so called Lean techniques are becoming more and popular in such areas as project management, marketing, Human Resources management, finance, and customer service (Loher, 2011; Hafidzoh et al., 2016; Detyna, 2018; Adzhienko et al., 2021; Benuyenah, 2021). The key LM requirements encompass mainly leadership and the involvement of all employees, so that every effort made to streamline processes could bring a return on this investment in the form of time savings or reduced stress. Then, according to D. Locher, "the feeling of being in control replaces (…) the so common in many companies learned helplessness, questions about who is guilty – focus on the process" (Locher, 2011).

The correct and efficient implementation of the LM assumptions and goals at a university requires from the management and team members the knowledge and understanding of basic notions and definitions related to this concept – this is of paramount importance in the correct implementation and use of his philosophy, including LM performance monitoring in an academic environment (Mcguire et al., 2008; Yorkstone, 2016; Ribeiro et al., 2019; Gómez-Molina & Moyano-Fuentes, 2021). The terms, the knowledge of which is especially important in the context of the issues in question are as follows:

- Unit – understood as a workplace, usually U- or L-shaped so as to facilitate service provided by one or more employees (e.g., in offices).
- 5S – that is the concept forming the basis of the Kaizen philosophy, LM and Total Quality Management (TQM), whose goal is systematic striving to create and maintain orderly working environment. This can be reduced to: sort (Japanese term: Seiri), straighten (Japanese term: Seiton), shine (Japanese term: Seiso), standardise (Japanese term: Seiketsu), and sustain (Japanese term: Shitsuke).
- 5 Whys principle – the question 'Why?' is asked five times to correctly recognise the real reasons for a given problem. This rule is useful during e.g., teamwork for the purpose of plotting the Ishikawa diagram indicating potential causes of a problem (the fishbone diagram).
- Gemba – in Japanese it means site, which is understood here a workplace where a particular value is created (e.g., value for a student).

- Hoshin kanri – in Japanese it means strategy deployment and is understood as determining goals and implementing solutions using a set of selected management methods and tools.

- Just in Time – the concept in which materials and processes are delivered (made or pursued) at the right time and quantity – in accordance with the real needs (e.g., of training participants, students).

- Kaizen philosophy – in Japanese 'kai' means change and 'zen' – good. The term refers to continuous improvement.

- Kanban system – in Japanese 'kan' means see and 'ban' – card, it is a system used to signalize demand (needs) from a later process to an earlier one using cards, badges, baskets, and other visual indicators.

- PDCA – known also from IS standards, it is a cycle of streamlining (improvement) activities, compliant with the W. E. Deming concept, the so called Deming wheel: Plan – Do – Check – Act. It is a universal tool successfully used in various tasks, e.g., project management. Undoubtedly, it forms the basis for both TQM and LM concepts.

- Total Quality Management – the concept of complex (total) quality management, the approach which emphasises the significance of every employee in the process of continuous quality improvement. The element in this concept is the system and process approach, and also the role of customers (external and internal ones) – in the case of universities: students, the representatives of the social and economic environment, administrative, didactic and academic staff.

- Value stream mapping – it presents the concept of the whole process and its steps from the moment a need appears to the final stage when a product is ready. The process shows the flow of materials and information for the purpose of finding wastes and undertaking corrective actions (to repair the problem) – most frequently it is depicted using block diagrams or tables (Wamack & Jomes, 2001; Imai, 2012; Ciarniene & Vienazindiene, 2014; Lam, 2015; Singh, Singh, 2015; Yorkstone, 2016; Detyna & Detyna, 2016; Randhawa, Ahuja, 2017; Gómez-Molina & Moyano-Fuentes, 2021).

The basic steps leading to LM implementation in the academic environment encompass:

- Stabilization – its goal is the creation of predictable and repeatable results. Simultaneously, the reasons for process instability, which during service (educational) processes frequently results from misunderstanding students' needs, should be identified.

- Standardization – the development of practices consistently used by employees. One of the fundamental standardization areas is the work rationalization and streamlining.

- Visualization – it is used to create working conditions in which a workplace speaks to employees. One of the most efficient communication methods is visual communication. This is why, e.g., project timelines, instructions, and priorities are located in visible places.
- Continuous improvement – it means encouraging all staff (e.g., administrative and academic) to improve their work. This philosophy should become part of company organizational culture and it should encompass all process and elements in the university system (Locher, 2011).

The retrospective analysis of the scientific achievement in the LM area allows to highlight 5 basic Lean principles, which are based on the assumption that organizations act as part of processes – Table. 1.

**Table 1.**
*Basic principles and recommendations of Lean Management*

| Principles | Recommendations |
|---|---|
| 1. Define customers and determine their value | − It is assumed that only a small fraction of all time and effort in any organization increases the final value (according to the Pareto – 80/20 principle).<br>− The value of particular products and/or services should be clearly specified with respect to customers.<br>− It is necessary to identify all actions which do not contribute to the added value of the organization so as to eliminated them step by step.<br>− The identification of customer's value is important for the purpose of answering the following questions: What do customers need? When do they want it and in what way? What combination of functions, opportunities and price will be preferred by the customers? |
| 2. Define and map value streams | − It is recommended to map the organization to create value streams and then during particular actions it is possible to focus on tasks contributing to the added value.<br>− The value stream is a set of processes and actions in parts of an organization which contribute to its success.<br>− On should focus on those processes which deliver value to customers (stakeholders).<br>− The value stream is not limited to the boundaries of a particular organization – one should strive for the integration of suppliers, manufacturers, service providers, partners, allies, etc.<br>− It is recommended for the organization to make efforts to influence partner organizations (co-operators) to also recognise and analyse the value stream (so as to achieve better results in whole value chains).<br>− There are also three main categories of actions: a) the ones that add value, b) the ones that do not add value, but it is not possible to avoid them and c) the ones that do not add value and this is why they should be eliminated. |
| 3. Improve workflow | − Good workflow is the necessary condition of efficient processes, as a result of which products, materials, documents, and people smoothly pass through the subsequent stages of creating values.<br>− The elimination of the reasons for downtime and other workflow defects results in increased value and better satisfaction of the needs of various stakeholder groups.<br>− The rationalisation of the time devoted to particular tasks, projects, etc., (minimalization of time wasting) is also recommended.<br>− The processes which do not contribute to the added value of customers and the other stakeholders should be eliminated. |

Cont. table 1.

| | |
|---|---|
| 4.<br>Address customers and stakeholders' needs | – Understanding the demand is key – so first there is the customer's need followed by the creation of the system and processes which will allow to satisfy this need (with continuous cost-effectiveness practice).<br>– It is necessary to conduct constant monitoring of customers' needs and communication (exchange of information with the surrounding environment).<br>– It is important to adapt the organization offer to customers' needs in term of quantity, time, quality and costs.<br>– Organization activity should be justified – it should result from the real needs of various groups of stakeholders. This should be accompanied by the economic account. |
| 5.<br>Strive for continuous improvement and development | – Continuous improvement should become a standard – striving for better satisfaction of the needs of various groups of stakeholders, streamlining of processes, communication and staff competence development, etc.<br>– Process streamlining requires radical reorganization (rethinking and replanning) of particular stages (because there is a cause and effect relationship between these stages).<br>– The management all staff should be convinced that the improvement efforts will never be completed and the positive effects of LM require common and realistic goals, understanding, perseverance and consistency in undertaking corrective and preventive actions. |

Source: Own study based on: Radnor, 2010; Locher, 2011; Singh, Singh, 2015; Stoller, 2015; Yorkstone, 2016; Gómez-Molina & Moyano-Fuentes, 2021.

Aiming at the constant improvement of processes, management service quality, and also the minimalization of waste, the university management should identify potential sources of errors and ineffective actions (the sources of occurring risks). Waste (muda) may occur in all sorts of processes. Table 2 presents the losses which are the most common sources of waste in the academic environment. The losses are divided into four categories:

- work time,
- work system,
- staff,
- processes.

**Table 2.**
*Losses which are the source of waste in the academic environment*

| Work time | Work system |
|---|---|
| – too long waiting time for e.g., signatures, new computer software, etc.,<br>– too long time spend searching for documents, files, information, etc.,<br>– breaks in work time – downtime resulting from interferences in processes and tasks,<br>– too much time spent on preparing a concept or project, e.g., during extended consultations, arrangements and negotiations,<br>– unnecessary movement of people or transfer of documents,<br>– prolonged waiting for necessary documentation,<br>– planning errors with respect to time needed to implement projects and tasks, which increases the risk of failing to implement them or incorrect implementation, | – lack of leadership,<br>– lack of unified strategic, tactical and operating goals,<br>– unrealistic strategic goals,<br>– imprecisely formulated goals,<br>– lack of suitable tools to measure goal attainment degree,<br>– inefficient working environment, including technology,<br>– dominant functional and organizational structure which does not focus on the value chain but on its own functional tasks,<br>– excessively rigid organizational structure – low flexibility,<br>– excessive centralisation of decisions,<br>– excessive formality, |

| | |
|---|---|
| – failing to meet deadlines set earlier for task and projects, etc., which results in downtime and lack of timeliness,<br>– doubling the same activities done by a few people at the same time,<br>– excess information sometimes including incorrect information or messages which exclude one another,<br>– information chaos,<br>– efforts to gain the attention of other workers who are not available, e.g., the management staff,<br>– participation in too long ineffective meetings and trainings, etc.,<br>– attempts to arrange excess information, including e-mail, spam, adverts, etc.,<br>– explaining misassigned and wrongly formulated tasks,<br>– observing complex and too complicated, unnecessary and overly formal procedures while doing work. | – excessive bureaucracy,<br>– low information quality<br>– information overload – information chaos,<br>– inefficient technology, e.g., information and communication,<br>– lack of efficient motivation systems for staff,<br>– misallocation of resources,<br>– errors in the selection of teams assigned to particular tasks, projects, etc.,<br>– organizational chaos,<br>– university offer not adapted to the real needs of students and other groups of stakeholders,<br>– wasting space,<br>– inefficient use of infrastructure,<br>– thoughtless and unjustified purchases (e.g., equipment and software),<br>– lack of good communication between management, staff and organization units at university,<br>– lack of information on needs and opportunities, etc.,<br>– no coordination of activities,<br>– doubled competences |
| **Staff** | **Processes** |
| – organization culture not oriented or insufficiently oriented to cooperation, including teamwork,<br>– lack of creativity,<br>– lack of involvement,<br>– lack of know-how,<br>– absenteeism,<br>– underused staff knowledge and skills (their potential),<br>– professional burnout,<br>– lack of motivation to work,<br>– lack of identified staff potential,<br>– lack of real change leaders,<br>– unresolved conflicts,<br>– lack of appropriate communication between management staff, administration and academic staff,<br>– inconsistency in action, the so called flash in the pan,<br>– no willingness to help and support new initiatives,<br>– lack of understanding of organizational goals,<br>– lack of understanding of hierarchical connections,<br>– difficulties in promoting grassroots initiatives,<br>– lack of real dialogue between management and other staff – administrative and academic,<br>– too much work, e.g., per particular employee. | – lack of appropriate process identification,<br>– lack of knowledge on key processes at university,<br>– lack of right and careful planning (stages) within particular processes,<br>– no critical points taken into consideration at the stage when planning processes, which are sources of potential failures in process implementation,<br>– no indication who process owners are – the people responsible for process implementation,<br>– wrong task delegation,<br>– ineffective working procedures,<br>– human errors,<br>– lack of efficient monitoring system,<br>– lack of value stream analysis,<br>– too many processes,<br>– excessive physical effort put into the implementation of various tasks, as a result of e.g., wrongly designed processes,<br>– incorrect and inefficient procedures used to do tasks and pursue processes,<br>– errors in designating tasks and their implementation,<br>– too high inventory level (materials, goods),<br>– lack of clear and understandable procedures related to corrective (repair) and preventive actions,<br>– communication interference,<br>– competence conflicts – fuzzy responsibility. |

Source: Own study.

## 3. Research methodology

The research goal was pursued based on literature studies and empirical research conducted at a Polish university specialized in practical education. The paper is a case study on the proposed implementation of LM in a few selected university activity areas. The research was conducted in the years 2020-2022, it encompassed a few organizational units: student work experience and careers office, promotion department, training center and university institutes. The analysis encompassed, among others, management functions at the university, the number of employees in each organizational unit, management span, and also the tasks performed by offices (teams) as well as responsibilities at selected positions. The conducted research focused especially on such university activity areas as: marketing, project implementation, organization of trainings and courses, services for students, cooperation with the external social and business environment and also with lecturers.

The research object was a state university offering bachelor and master studies for nearly 25 years (currently educating about 1200 students). The courses offered by the university among others encompass: nursing, dental techniques, dietetics, cosmetology, logistics, management, interior architecture, work safety, administration, English philology, and pedagogy. The organizational structure is composed of, among others, the Rector's Office, General Office, Institutes, Department of Studies and Student Affairs, Student Work Experience and Careers Office, Library and University Publishing House, Training Centre, University Office of Promotion, Plenipotentiary for People with Disabilities, Erasmus Coordinator, Administrative Department, HR Organization and Employees Affairs Department, Bursary office, Third Age University, Academic Sport Association, and Archives.

## 4. Lean Management tools selected for universities – case study

The basic information on the organizational units encompassed by empirical research is presented in Table 3.

**Table 3.**
*Short characteristics of analyzed organizational units*

| Analysed functional area | Unit characteristics – activity profile | Functions and positions |
|---|---|---|
| Institutes | There are three institutes at the University: Institute of Health, Institute of Life and Technical Sciences and Institute of Social Sciences and Law. The Institutes are responsible for particular courses, management, organization as well as research and educational activity. There are Education Quality Assurance Teams in the Institutes, responsible for particular study courses, and Scientific Councils. | Institute Directors Deputy Directors for particular study courses Office staff |
| Student Work Experience and Careers Office | The Office is responsible for preparing students to enter the job market – it offers support and advisory services related to work experience. The Office cooperates with enterprises and institutions with regards to scientific activity, education and promotion, it also organises trainings for students and meetings with employers. | Vice-Rector for Development, Coordinator for Work Experience, independent clerk |
| University Promotion | The unit directly cooperates with the Student Work Experience and Careers Office. It is responsible for marketing activity, including university promotion and advertising. | University promotion specialist |
| Training Centre | This unit is responsible for postgraduate nursing and midwifery courses, and also courses for other medical professions. It offers a wide range specialist courses, qualifications and short educational events. | Training Centre Manager Training Specialist |

Source: Own study.

The author recommended some LM philosophy solutions for four selected functional areas – the character of their activity (needs and possibilities):

- Institutes (jointly employing several dozen employees).
- Student Work Experience and Careers Office (3 employees).
- University Promotion (1 employee cooperating with the Student Work Experience and Careers Office).
- Training Centre (2 employees).

The recommended Lean tools and actions for the selected organizational units are presented in Table 4. They refer to four dimensions: stabilization in offices, process standardization and their visualization and improvement.

**Table 4.**

*Recommended Lean Management tools and actions for selected functional areas of the university*

| Student Work Experience and Careers Office | | University Promotion | |
|---|---|---|---|
| **Stabilisation in offices** | – Processes should be defined, including decision making processes taking place in the DPSK unit which should be identified.<br>– The identification of needs is necessary for both students and employers to streamline the activity of the unit.<br>– Systematic identification of new opportunities will benefit the University – e.g., the development of a new, updated offer of services.<br>– Activisation and motivation initiatives for the staff are recommended.<br>– DPSK should maintain close relations with stakeholders and develop stable cooperation with them for the purpose of identifying their needs and gaining information, opinions and new ideas, etc.<br>– The Department should strive to streamline processes so as to save time necessary to undertake the most important activities for the university. | **Stabilisation in offices** | – Processes conducted in the Promotion Department must be defined.<br>– The improvement process should be started with the identification of issues occurring in the Department and their causes.<br>– The processes conducted by University Promotion should be interrelated with the processes conducted by the Student Work Experience and Careers Office due to close, formal relations.<br>– The processes conducted in the department should be interrelated with the key processes conducted at the University, including the Institutes and other organizational units.<br>– Verification of procedures and practices in terms of their efficiency and effectiveness.<br>– Support for operating activity (conducted in the Institutes and other organizational units at the University) by using marketing skills, etc.<br>– Process optimisation to gain time needed to improve work at this position and develop the university in general. |
| **Process standardisation** | – It is necessary to answer the question: how to conduct processes?, what stages should be introduced?, what procedures should be implemented?<br>– Processes conducted in the Department should be divided into subsequent steps, thus creating procedures compliant with both legal regulations and the needs of students and the other stakeholders, however, without over-formalisation of these processes.<br>– If possible, the used procedures should be simplified.<br>– The department staff should be offered an explanation why particular processes have to be conducted according to the specified steps.<br>– Standardised work is also recommended, which means that the Department staff will act in the same way and use the same methods. | **Process standardisation** | – Whenever possible, processes should be simplified and optimised to e.g., shorten them.<br>– It is worth reviewing the activities and processes implemented so far in terms of their usability and efficiency.<br>– Cooperation rules with other organizational units at the University must be established.<br>– On a day to day basis, important (priority) issues should be separated from the less important ones, and the former should be the focus of attention.<br>– The used communication methods with internal and external stakeholders should be verified.<br>– Ne standards simplifying the department operation should be introduced, this will increase its efficiency and effectiveness. |

Cont. table 4.

| | | | |
|---|---|---|---|
| **Process visualisation** | – Following the flow and queues (e.g., documents) at various stages of processes, using computer systems or simple visualisation tools.<br>– Use of standardised worksheets containing to do lists of activities, time and/or completion time , the number of tasks, task completion time.<br>– Whiteboards, magnetic boards or corkboards can also be helpful in organising office work.<br>– It is also recommended to use value stream maps, which present the whole process and emphasize the role of DPSK (including the role of particular employees) in a process, particular tasks and projects, etc.<br>– The use of boards presenting project/task schedule can also prove to be beneficial.<br>– The use of a complex visual system to present project management.<br>– It is also worth using such tools as: work results board, task implementation visualisation, project status using colours, problem table with and escalation procedure, etc. | **Process visualisation** | – Using visualisation methods and tools, one should control whether the University Promotion Unit meets the University needs and conducts its activity according to the adopted standards.<br>– Process visualisation in the Department should comprise monitoring queues (e.g., the information to be posted on the University website, in social media, etc.).<br>– Work schedules should visualised.<br>– Information on the visual management board should inspire employees to constantly improve.<br>– On the visual management board there should be, e.g.: each process plan with particular activities, completion time, key measurements (criteria, goals, completion, comments), information about continuous improvement (what, who, when, comments), weekly and monthly task schedules (depending on goals and adopted priorities).<br>– Flow diagrams can also be helpful (block diagrams), work results boards, visualisation boards for particular tasks, etc. |
| **Process improvement** | – Processes and procedures should be improved at every stage.<br>– It is worth developing a list of measurements and indicators which can be systematically monitored.<br>– It is recommended to identify the causes of problems (their roots) – techniques to be applied 5xWhy?<br>– It is necessary to eliminate waste at every stage of processes, which may allow to regain some time and energy to do subsequent tasks.<br>– Information and proposed corrective measures should be regularly collected from employees and other stakeholder groups.<br>– It is recommended to organise the so called Kaizen workshops for the staff to learn to solve particular problem. | **Process improvement** | – The improvement of the processes conducted at the University Promotion Unit may encourage the staff to be more involved in continuous improvement and thus serve the University with one's IT and communication knowledge and skills (in connection with promotional activity).<br>– Employees' skills should be cleverly used by all University organizational units.<br>– It is recommended to closely cooperate with particular functional areas of the University, and also with various teams.<br>– Another way of improving office processes can be equal workloads every month, which means that it is necessary to plan appropriately, especially in the periods of more intensive promotional activity (e.g., during recruitment). |

Cont. table 4.

| | Training Centre | | Institutes |
|---|---|---|---|
| **Stabilisation in offices** | – The Department should strive for process optimisation so as to gain time so as to save time necessary to undertake key activities for the centre and the University.<br>– It is recommended to conduct a detailed analysis of services provided by the Centre, including the offer and satisfaction level of training participants (including training quality).<br>– The Department should recognise the needs of potential training participants with respect to their organization and programmes, etc.<br>– It is recommended to verify (evaluate) the conducted processes, e.g., trainings. | **Stabilisation in offices** | – The improvement process should start with the identification of problems occurring in offices and their reasons.<br>– It is recommended to recognise the needs of both students and employees (administrative and academic ones working in a given Institute).<br>– It is recommended to carefully analyse complaints and the results of quality of service evaluations related to office workers as part of the adopted University Internal Quality Assurance System.<br>– It is worth searching for such improvements which will be noticed by students and staff and will be a response to their needs.<br>– The students service system should be corrected in a flexible way and also updated to meet the needs and new challenges. |
| **Process standardisation** | – The goal of process standardisation should be the optimisation of the whole value stream.<br>– The key element in the standardisation process is the evaluation of the Department work by training participants (including the training offer, professionalism of trainers, etc.) – the results should be documented and periodically analysed.<br>– The results of the assessment of the Department work should be analysed in terms of their efficiency and also the quality of service, which should translate into the development of the whole University (including its promotion).<br>– Another precious solution can be following the how much time employees spend on particular tasks, this can help to streamline these processes. | **Process standardisation** | – When students are satisfied with administrative service, the implementation of Lean should start with the standardisation of existing processes.<br>– In the case od dissatisfied students, the sources of their dissatisfaction should be identified as well as the errors committed by the staff and corrective measures should be introduced.<br>– The student service system and all processes conducted as its part should be identified.<br>– A detailed map can be made for each process and thanks to this it will be possible to identify opportunities to improve it, including streamlining.<br>– The best practices should be formulated and documented.<br>– When developing the standards it should be taken into account that student satisfaction is of paramount importance. |
| **Process visualisation procesów** | – It is recommended to develop a board visualising all activities performed by the Centre staff, there should also be the information whether the tasks are performed in accordance with the adopted schedule.<br>– It is worth visualising continuous improvement projects, e.g., training plans.<br>– The visual management board can also present, e.g., the key measures (criteria, goals, deadlines, comments), and also process schedules for each process (tasks, who, when, etc.). | **Process visualisation** | – Most of the work done in Institutes has an electronic form.<br>– A challenge for the department can the visualisation of information.<br>– It is recommended to visualise the stage of particular tasks, whether they are done according to the plan (standard).<br>– Standardised work instructions, referring to selected processes, could also be helpful.<br>– Process visualisation using and IT system could also be useful, e.g. referring to research projects implementation, particular investments, grant settlement of received funding, etc. |

Cont. table 4.

| Process improvement | Process improvement |
|---|---|
| – The identification of training participants' needs is essential (e.g., new skills, additional knowledge), another important element is the continuous improvement of employee potential (their professional competences).<br>– It is recommended to develop a special matrix with the identified needs of training participants (referring to programmes and used didactic methods, etc.) and to what extent these needs are satisfied (level of satisfaction with the current Centre work).<br>– The Centre staff should participate in systematic meetings of e.g., Kaizen teams within their units and also in interdisciplinary teams, e.g. in a given Institute.<br>– Benchmarking can also prove useful, it is visiting other Universities (their training centres) and introducing god, tested practices. | – The optimisation of processes will allow to regain precious time which can be used to improve processes with the employees of other organizational units.<br>– Cooperation with units whose work has influence on the quality of tasks conducted in the in the Institute.<br>– The employees should participate in regular Kaizen team meetings.<br>– It is recommended to improve the result measurement system, including the quality of prepared reports and studies, and also their usability.<br>– If the University goal is continuous improvement, then it is necessary to develop such measurement and assessment (efficiency) criteria that will support it, to achieve this the work of all Institute employees is the key. |

Source: Own study.

According to the authoress, the adoption of the LM philosophy, including the Kaizen principles, in a relatively short time and without large investments, could improve time efficiency, while time is often wasted during projects and office work. Aspiring to increase university efficiency, including the quality of management and education, it is worth focusing not only on investments in new IT solutions or infrastructure, but also undertake systematic actions aiming at the identification of and elimination of unnecessary muda. The questions that should be asked include:

- How much time do I need during a day/week/month to organize excess information?
- How much time do I need during a day/week/month to gain all the information I need to do my duties/tasks?

The results of this simple analysis may be the beginning of the implementation of selected LM tools at a given position, or in a given organizational unit.

The universities which decide to implement LM must remember, however, that the key principles of this concept are: customer orientation, leadership, employee involvement, process approach, system approach, designing improvements and taking preventive measures, taking decisions based on evidence, and also partnership development. The application of these principles in practice may contribute to obtaining the added value which will be measurable both in terms of the organizational, educational, scientific, financial, and social context. The potential LM benefits for universities, according to the authoress, are mainly:

- reducing waste in various activity areas, including time wasting,
- better work organization, including orderly workplaces,
- improvement of internal and external communication,
- better opinions of students and the other stakeholders about the university and quality of education,

- better addressing the needs of stakeholders (both internal and external ones),

- better understanding of how the university operates by all staff – its structure, connections, organizational ties, necessity to cooperate – to achieve the synergy effect,

- increased awareness of the management and staff of their role in the organization (responsibility for themselves and their team),

- higher motivation and increased university staff involvement,

- smaller number of students' complaints,

- improved efficiency in meetings,

- simplification of complex procedures used to conduct projects and tasks, etc.,

- reduction of excessive, inefficient bureaucracy,

- university image improvement, strengthening its market position.

## 5. Discussion and conclusions

The literature does not provide a ready success recipe in which the Lean Management concept was used in the academic environment. Such success is usually influenced by a number of mutually correlated factors, including a detailed analysis preceding the implementation of new solutions, verifying their legitimacy and evaluating success probability (Halling, 2013; Jedynak, 2015; Yorkstone, 2016; Krdžalić et al., 2020; Klein et al., 2021). In this context, it is worth emphasizing that striving for perfection in an organization should not be a single action, it should be a continuous process.

The article presents a proposal to use Lean tools in selected university organizational units. However, these tools can be also used in other areas (educational, scientific and organizational activity, etc.), certainly after the necessary modifications related to the needs. Undoubtedly, one of the key conditions in LM and Kaizen implementation at university will be the involvement of university management, management staff and all employees in connection with the continuous improvement process. Based on the analysis of the primary sources, it is possible to give examples how to influence the awareness and motivation of staff. According to the authoress, the following could prove efficient in the academic environment:

- rational persuasion – logical arguments and facts to convince employees,

- inspiring appeals – referring to the values, ideal and emotions of an employee,

- consultations – employee inclusion (involving them) in the planning process, change introduction, asking their opinions and suggestions when priorities and new actions are established,

–   praise – emphasizing the role and importance of an employee at university, their good work, signaling their significance in the change implementation process (e.g., new didactic methods, ways of communicating),

–   coalition tactics – searching for help and support of other people and working together on change implementation,

–   sanctioning strategy – referring to the agreement on the new solutions with university policy (its mission and strategy), principles, traditions, etc.,

–   trainings – they can be used to explain the reasons for implementing new solutions, their goals and potential benefits (including how the changes will influence employee development),

–   support – help and cooperation with employees offered resources necessary to implement changes (equipment, information, HR, financial, etc.).

Simultaneously, there are some limitations to the efficient implementation and functioning of the LM concept in the academic environment. The authoress would emphasize among others:

–   incorrect recognitions of needs and own possibilities,

–   inappropriate planning,

–   lack of management involvement (leadership deficit),

–   employee resistance,

–   lack of suitable trainings,

–   no adaptability to contemporary challenges and needs in the university organizational structure (creating structures without prior analysis of key processes),

–   difficulties in changing the organizational culture (including the mentality of management staff and employees),

–   insufficient resources (knowledge, human resources, equipment, financial, etc.),

–   lack of strong motivation and understanding of the essences of and significance of LM in the continuous improvement process,

–   too wide definition of processes (frequently taking process for tasks and activity areas and the other way around), e.g., university management, human resources management,

–   lack of time to conduct systematic improvement activities,

–   lack of cooperation in teams (e.g., between organizational units).

To sum up, the model of organization support and reform, in accordance with the Lean principles, should take into account the coordination of operation between four key areas or stages (the so called Model 4P). The model encompasses: involvement of people, improvement of physical working conditions, process improvement and verification of adopted policy. The essence of the described philosophy is based on continuous improvement, including the elimination of waste. Such an approach requires the involvement of not only university management and more generally management, but also all employees – all process owners. The practical application of the 4P model at universities may increase their opportunities and

make them visible to students and the other stakeholder groups in terms of activity efficiency, including education quality or research projects. This effect is frequently possible without the necessity to implement expensive investments. However, the necessary element is sometimes hard to achieve as these are mature employees, who will be willing to participate in continuous development and also motivated in teamwork.

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# SEMANTIC PRODUCT PERSONALIZATION BASED ON THE COGNIPY ENVIRONMENT

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**Purpose:** The aim of the publication was to visualize the process of creating knowledge on the example of the CP Factory production line. For this purpose, the data contained in the relational databases and data of the operating production line were used. This data was converted to the form required by the CogniPy environment to create a semantic ontology for product personalization.

**Design/methodology/approach**: With the available software based on ontologies and knowledge charts, the possibility of common human-computer reasoning has been opened, especially in production management.

**Findings:** During the activities carried out, the on-conceptualization of the knowledge contained in the production management system was brought to an ontological form. At the moment, the information contained in the database is not very different from the data existing in the relational database. However, further modeling of ontology can be directed towards the creation of rules, logic and axioms of production processes.

**Practical implications:** The operations and transformations performed presented the operation of CogniPy in the process of creating ontology and materializing the graph and queries. The created ontology takes the form of a universal set of knowledge that makes it open to wide integration with other systems.

**Originality/value:** The publication shows the possibilities of using the CogniPy environment in the construction of ontology and semantic product personalization.

**Keywords:** ontology, semantics, CogniPy, CP Factory.

**Category of the paper:** Research includes model construction and testing and dataset testing.

## 1. Introduction

In today's knowledge-based society, how it is represented is an important issue. Managing knowledge, and especially production knowledge, would be difficult if you relied only on informal records. Today, natural language sentences formulated in information systems are no

longer a problem for people. The problem arises when computers are unable to accept knowledge in the shared form. Machine-readable resources must be properly constructed, and this requirement is met by ontologies combining both formal and practical aspects.

Thanks to the developed applications based on ontologies and knowledge charts, many opportunities are opened to improve human-computer interaction, and especially in production management.

The publication focuses on the presentation of the process of creating a knowledge graph on the example of the CP Factory production line. For this purpose, it was necessary to use data managed by a relational database on a working production line. The next step was to transform them into the form required by the CogniPy community to create an ontology. CogniPy itself is an ontology editor in the form of an open-licensed library in the Python programming language. CogniPy argues about creating an ontology that complies with RDF, OWL standards and thus greatly facilitates the management of ontologies and other knowledge bases using CNL (Controlled Natural Language). The created ontologies can be both presented in the form of graphs and be a source of queries in the SPARQL language.

As a result, using CogniPy, a knowledge graph was constructed, which is an image of the ontology of the production process. This chart makes it easy to get acquainted with the new solutions, make it easier to edit and integrate with other production systems.

## 2. Ontology editors

The concept of ontology is known from philosophy, where ontology is understood as "... the theory of being, the basic branch of philosophy concerned with the study of the character and structure of reality" (Goczyła, 2011). In the context of semantic networks, the most well-known and widely accepted definition of ontology is that of Thomas Gruber: "Ontology is the formal specification of a common conceptualization" (Goczyła, 2011). In this case, formal means that it is machine-readable. Formal ontologies are defined in languages with strict syntax and precisely defined semantics. Today, there are many languages and systems based on formal ontology. There are systems derived from classical software engineering, such as ontologies expressed by UML (Unified Modelling Language), ERM (Entity Relationship Modelling) diagrams or ontologies expressed in RDF (Resource Description Framework) threes. These systems have inference capabilities that can be used in ontology processing. Logic-based (Goczyła, 2011) inference is an open-world assumption and leads to richer conclusions, while other data-based ontologies assume a closed world.

Among ontologies one can find a division into general, high-level, foundation ontologies – very general concepts taken from the theory of being from philosophy are defined and serve as foundations, on which further more specialized ontologies are superimposed, such as domain and application.

In domain ontologies, concepts from general ontologies are used, while defining entities specific to a given field, for example medicine, art, science, resulting in constructions useful in many contexts and applications (Goczyła, 2011).

Application ontologies are an additional narrowing of the field, and it concerns specific applications. It is possible to apply domain ontology in many applications, and thus in many application ontologies, but it is rare to use application ontology in a system other than the one for which it was created (Goczyła, 2011).

There are various applications for creating ontology, among which we can mention:

- Protégé.
- SWOOP.
- SemanticWorks.
- Fluent Editor.
- CogniPy.

For further analysis of tools for building ontology, three were selected: Protégé – the most popular ontology editor created by scientists from Stanford University and polish firm Cognitum applications – Fluent Editor – an editor running on Microsoft Windows and CogniPy – a multi-platform editor created in Python.

**Protégé**

The Protégé (Stanford University School of Medicine, 2022) project originated in the eighties at The University of Stanford and is still the most popular tool for programmers to construct usable ontologies and systems based on knowledge bases. It has already been awarded for its maturity, the length of this project makes it unique. Currently, it exists in the form of many "frameworks". The desktop version**Figure 1**) is supported by various tools supporting the management of ontologies. The browser version of "Protégé" is supposed to be simpler to use, and the functionality is not inferior to the desktop version, and is available immediately after logging in at the appropriate address in Internet. Protégé is built on the Java platform and fully supports OWL 2 (Web Ontology Language), which is a semantic network language. The tools also include visualizations with the ability to interactively navigate ontology connections – relationships, and active tracking of inconsistencies supports their avoidance and removal during the creation of the database. The project has in the past been supported by various funds and now operates in the form of open license software.
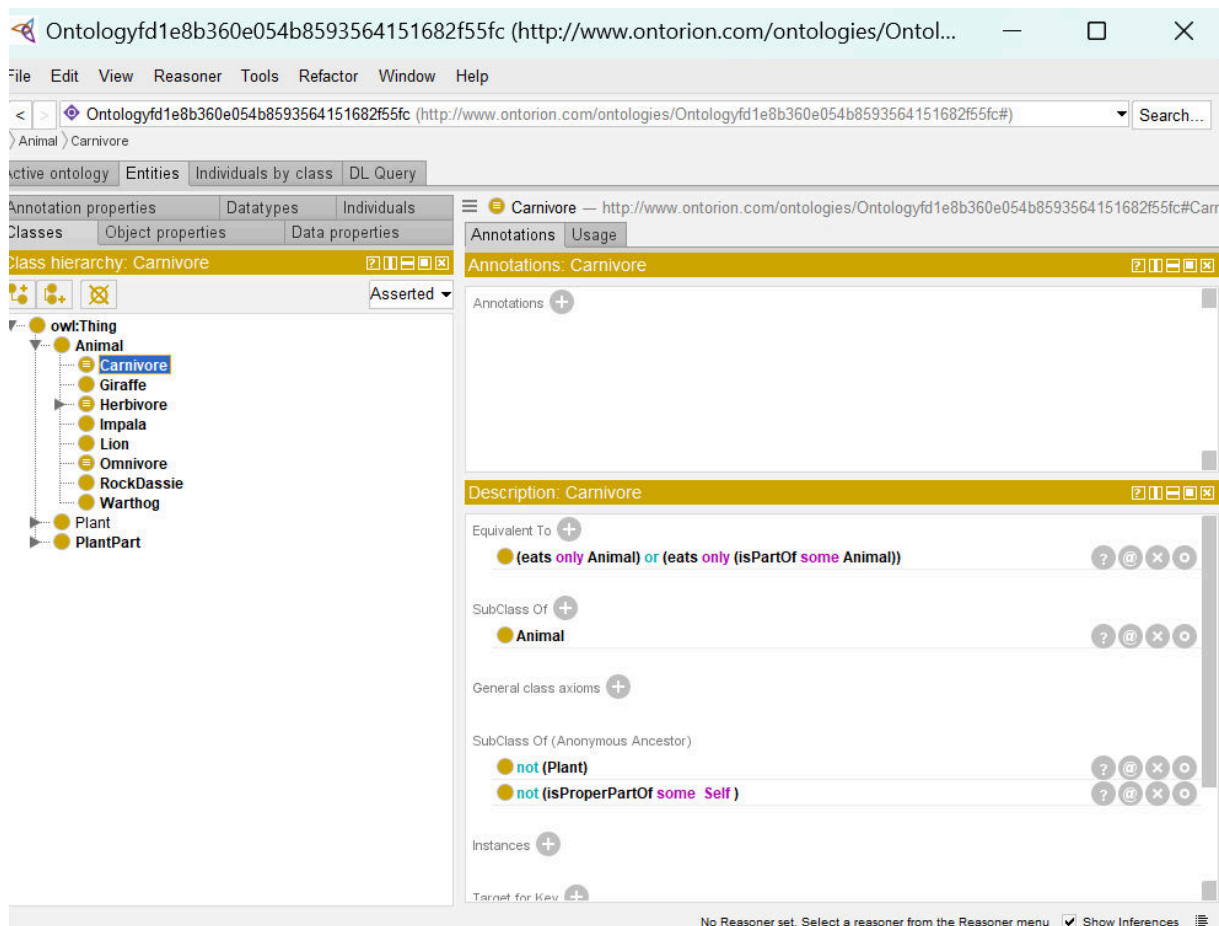
**Figure 1.** Example of Protégé editor.

### Fluent Editor

The Cognitum FluentEditor (Cognitum, 2022) is designed for a user-friendly environment. Visually, the editor is similar to Microsoft Office, has the ribbon and customizable windows. The built-in graphics engine edits high-quality ontology diagrams (**Figure 2**). However, the most important element of the editor is the application-supported CNL (Controlled Natural Language). Allows you to easily create sentences for users who are not fluent in English.

Fluent Editor works with the aforementioned Protégé editor, which allows you to take full advantage of their capabilities.

Fluent Editor also has a built-in mechanism that allows you to monitor the course of modeling. Selecting text that contains potential errors and prompts you to edit words is a helpful attribute.
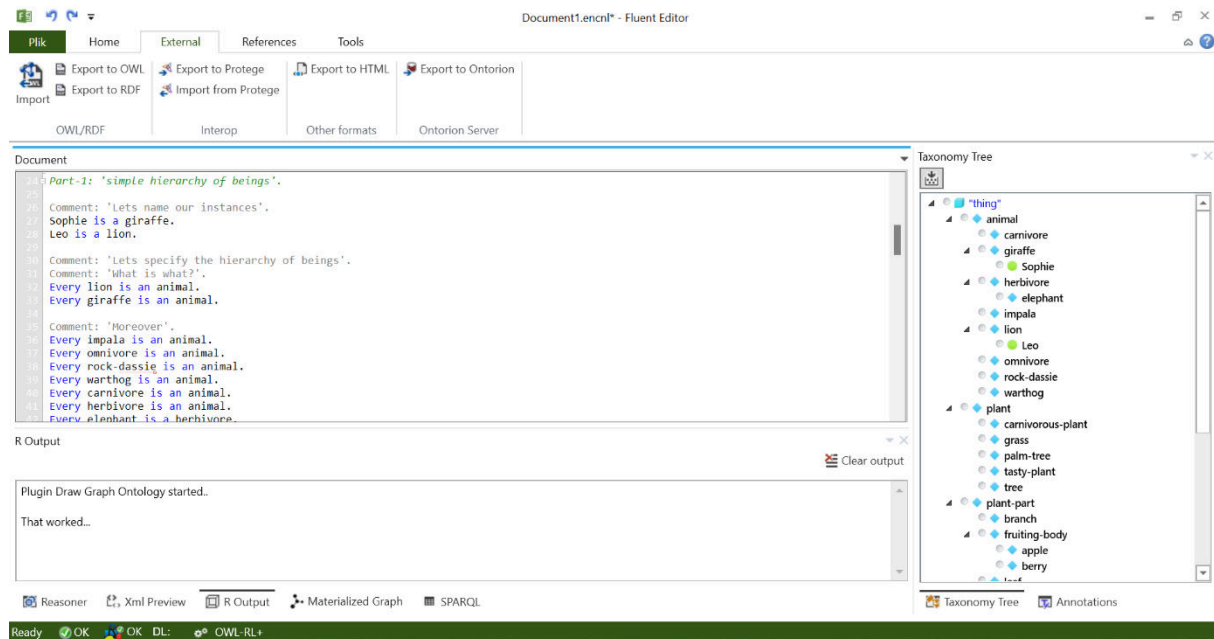
**Figure 2.** Fluent EditorEditor Window Example.

CongiPy is the successor to FluentEditor, it is an ontology editor in the form of a library with an open license for the Python programming language. It supports the creation of ontologies, allows them to be imported from files compliant with RDF, OWL standards and facilitates the management of them and other knowledge bases using CNL (Controlled Natural Language). Ontologies/graphs stored in the operating memory can be drawn in the form of graphs and SPARQL queries can be executed on them. The results in the form of data frames from Pandas used are a good source for further data processing. Based on the knowledge in the field of a given ontology, it is possible to infer new facts from existing ones. Going further, we can add inference rules (T-Box) on ontologies in CNL.

CogniPy is based on:

- IKVM.
- CommandLineParser.
- Newtonsoft.JSON.
- ELK.
- Hermit.
- Apache Jena.
- OWL API.

Like most programmable languages, CogniPy also presents its own example of "Hello World" (Listing 1) written in the Jupyter notebook. This is the importance of the Ontology class, creating a "hello.encl" file and typing two simple sentences into it, and then creating an object of the main CogniPy class. The last line of code prints the result of the graph query.

Listing 1

```
from cognipy. Ontology import Ontology #the ontology processing class
%%writefile hello.encnl
World says Hello.
Hello is a word.
onto = Ontology("cnl/file","hello.encnl")
print(onto.select_instances_of("a thing that says a word")[["says","Instance"]])
```

## 3. Production processes

The production process is a set of phenomena and carefully planned activities, performed in the right order. The process is used with raw material, which then, as part of the established scheme of activities, is subjected to processing, gradually shaping it and successively completing subsequent stages (Wawak, 2022). The result of completing all levels of production is the desired final product – the product. Currently, the production process is treated quite broadly, including research and development processes, distribution and customer service processes and the manufacturing process. The assembly system described in this publication implements the manufacturing process, and the semantic personalization of it is a process of research and development.

In the Laboratory of Modeling Intelligent Production Systems of the Kielce University of Technology, the CP Factory project is being implemented - a production assembly system. The system is divided into five modules that are separate production cells (**Figure 3**) (Luściński, 2021):

- Module 1: assembly robot station.
- Module 2: a basic linear module equipped with two application modules: tunnel heating and vision inspection.
- Module 3: basic module with branch equipped with mounting press.
- Module 4: automatic pallet storage and retrieval system.
- Module 5: basic module with branch equipped with a warehouse application (stack release).

**Figure 3.** CP Factory.

The dedicated production management and control system MES4 (Manufacturing Execution System) is an integral part of the modular production system. It is installed on the PC controlling the assembly process. It communicates with PLCs controlling the modules of the production system using the TCP/IP protocol.

The MES production management system enables (Lusinski, 2021):

- defining production order flows and planning a technological route,
- automatic updating of the status of orders,
- assigning a transport pallet to the order,
- defining the product and its structure, considering the graphical representation of the constituent elements,
- defining machines, including operating costs and energy consumption,
- creating storage data and material buffers,
- creating and managing customer data,
- defining the configuration of the production system; graphic, with the use of icons,
- automatic routing (routing) of the process flow in accordance with the work plan and production capacity of the machine,
- generating OEE, PLC, failures and faults reports, graphical representation of data,
- import/export of data as a file in .csv format,
- export of completed production orders in a file in .xls for further processing.

## 4. Implementation

The Microsoft Access database located on the production control computer on the CP Factory line has been exported to a file with the extension .accdb. Thanks to Microsoft Access, review the contents of the tables and that the exported database contains and the relationships connecting them, which is illustrated by **Figure 4**, which is a fragment of the entire database.
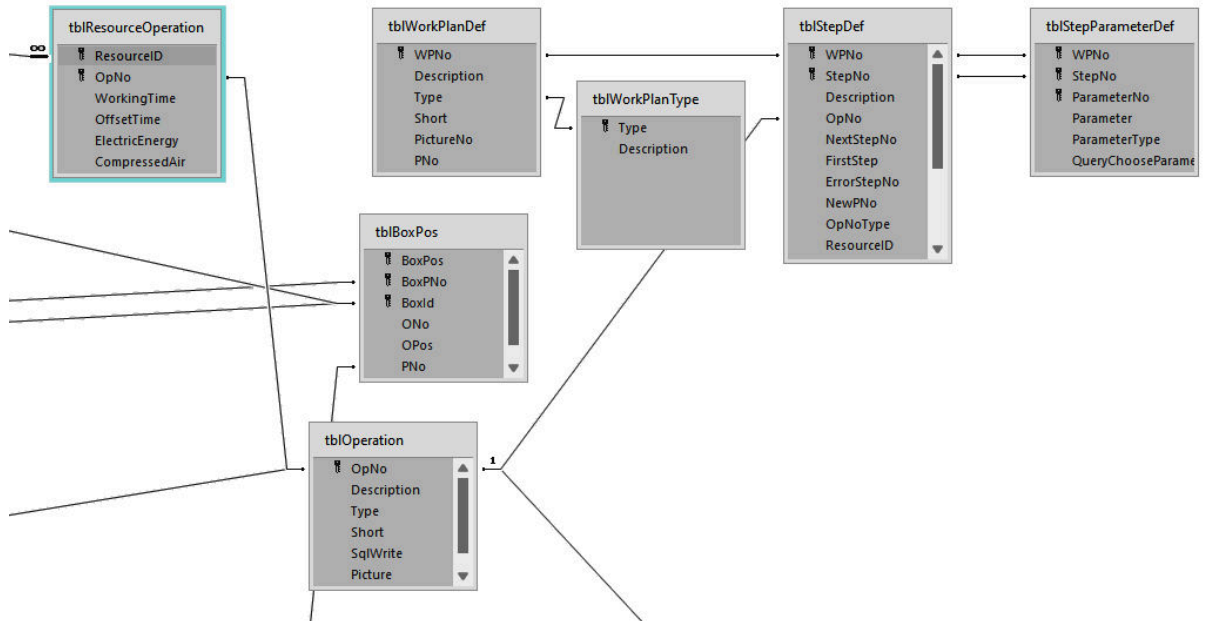


**Figure 4.** MES database structure.

Prepared sets of sentences based on data are provided by the Constructor of the Ontology class. Defined in Listing 2. Function a is helpful in calling the constructor. This function collects all lists with strings in one place by concatenating these strings into one string and giving them as an argument to the constructor. The "graph_attribute_formatter" function created at the beginning of the notebook is used here as the second argument to the constructor. Calling the "build Ontology" function and executing it flawlessly testifies to the correct construction of sentences and the correct creation of ontology in CogniPy.

Listing 2

```
def build Ontology():
return Ontology("cnl/string",
'\n'.join(resources_cnl)+'\n'.join(operations_cnl)+'\n'.join(work_plans_cnl),
graph_attribute_formatter = graph_attribute_formatter)
onto=build Ontology()
```

## Operations on ontology

The variable "onto" is now a reference to the Ontology object. An object of this class has many methods that allow you to view the ontology in various forms and modify it. Having such an object, it is also possible to further develop ontology through methods that accept additional knowledge in cnl in the argument, getting rid of knowledge from ontology, making queries on it.

## Graphical representation

To obtain a graphical representation of the accumulated knowledge, the functions from Listing 3 were called. This function creates an image based on the knowledge contained in the Ontology object and writes it to a disk with the name and extension given in the arguments of the function (**Figure 5**).

Listing 3

onto.create_graph(filename="CPFactoryOntologywithoutnoresurce.png", format="png", layout="force directed")
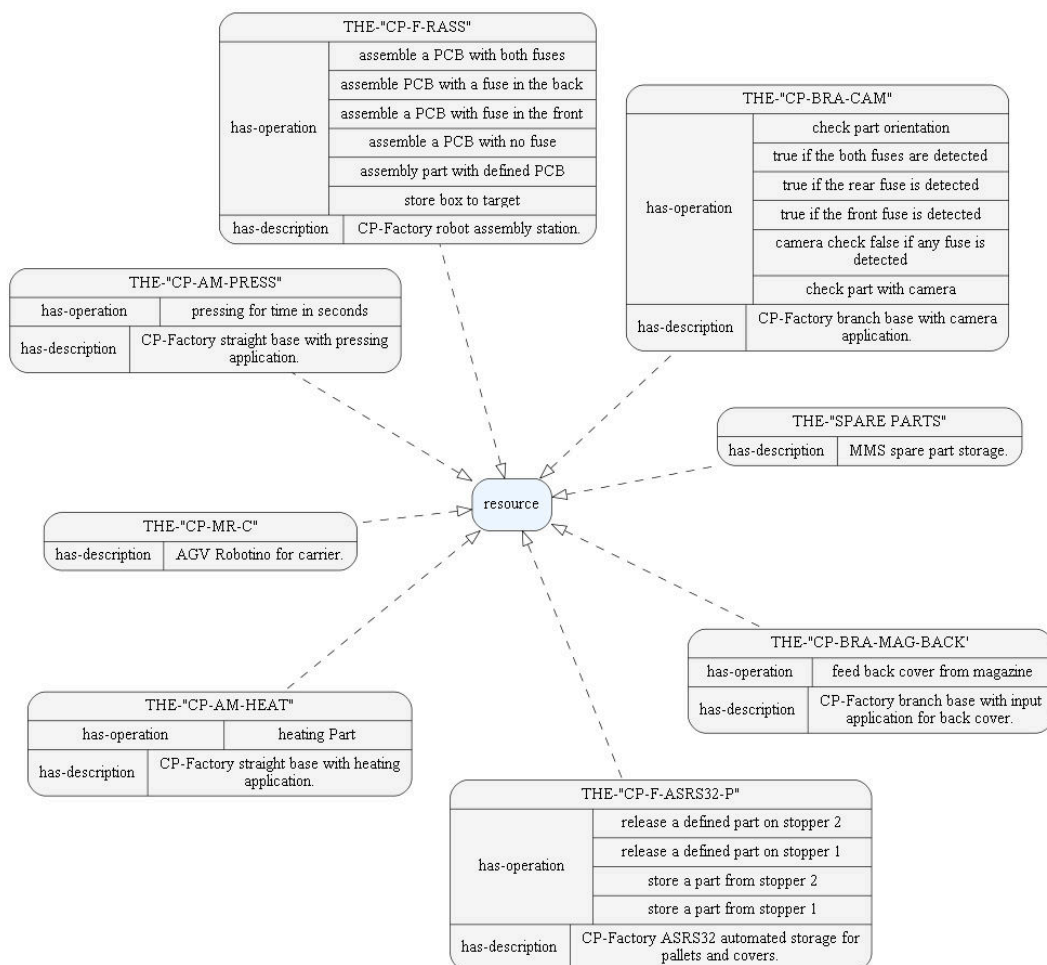


**Figure 5.** Knowledge Representation Graph.

The concept is a "workplan", and instances are given work plans. Each plan has its own name and attribute "has-operation" more often with many values than one. These values are operations in steps as components to be executed in the plan (**Figure 6**).
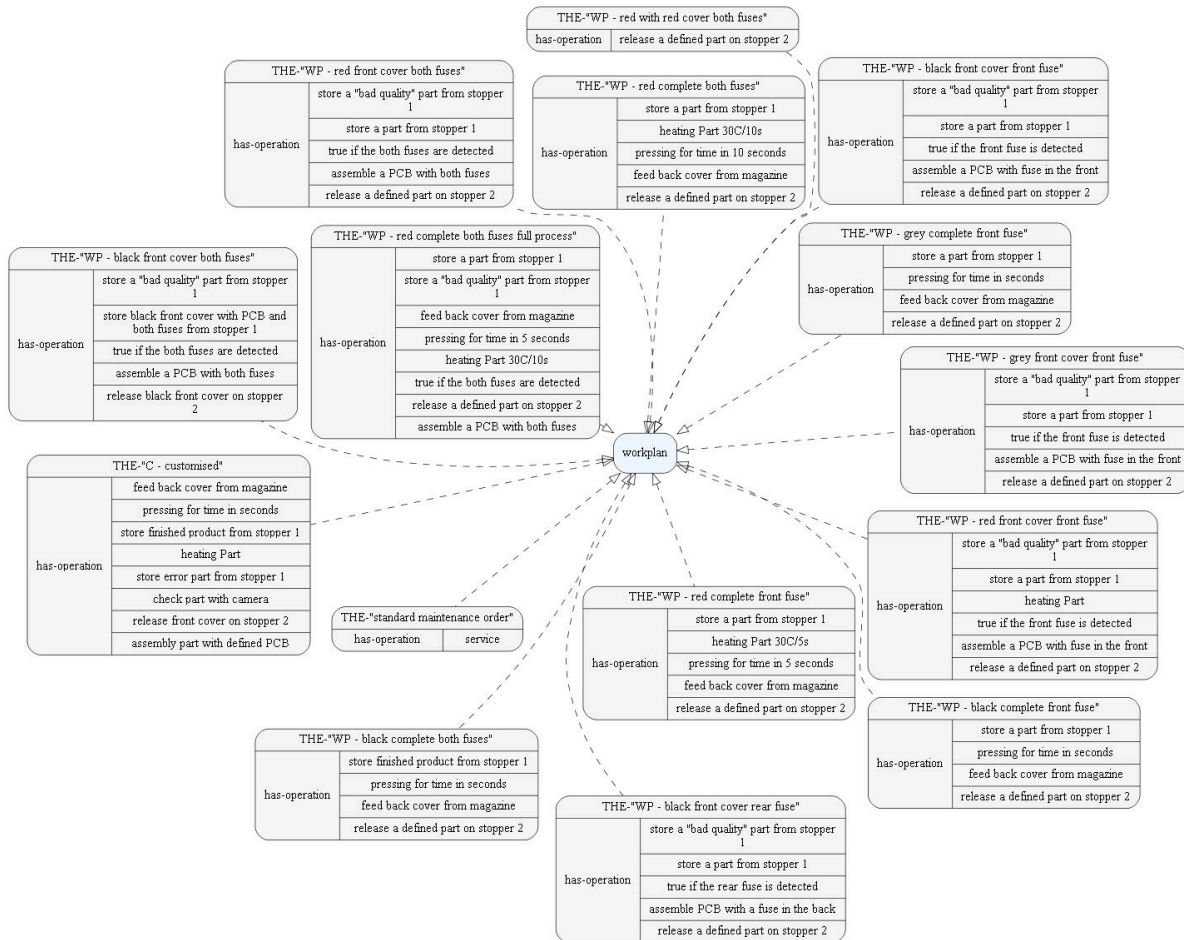


**Figure 6.** Workplan ontology.

## Queries in ontology

Another of the possibilities offered by the ontology supported by CogniPy are graph queries. A query constructed as in Listing 4 allows you to discover the identity relationship of the values of the "has-operation" attributes in resource instances with instances of work plans. Such a comparison gives an answer to the potential question of what resources perform what operations, in which work plan. A SPARQL natural language query can be understood as follows: "Select plans, operations, resources, where the resource is a "resource" instance and has a "has-operation" attribute of a given value, and where a work plan is a "workplan" instance that has a "has-operation" attribute of the same value." After the query, the function printing the results is called, sorting them according to work plans, which is partly presented by**Figure 7**.

Listing 4

```
df=onto.sparql_query(CQL("""select ?workplan ?operation ?resource {
?resource rdf:type <resource>.
?resource <has-operation> ?operation.
?workplan rdf:type <workplan>.
?workplan <has-operation> ?operation.
}"""))
df.sort_values(['workplan'])
```

| | workplan | operation | resource |
|---|---|---|---|
| 1 | THE-"C - customised" | feed back cover from magazine | THE-"CP-BRA-MAG-BACK" |
| 28 | THE-"C - customised" | assembly part with defined PCB | THE-"CP-F-RASS" |
| 20 | THE-"C - customised" | check part with camera | THE-"CP-BRA-CAM" |
| 7 | THE-"C - customised" | heating Part | THE-"CP-AM-HEAT" |
| 9 | THE-"C - customised" | pressing for time in seconds | THE-"CP-AM-PRESS" |
| 31 | THE-"WP - black complete both fuses" | release a defined part on stopper 2 | THE-"CP-F-ASRS32-P" |
| 5 | THE-"WP - black complete both fuses" | feed back cover from magazine | THE-"CP-BRA-MAG-BACK" |
| 11 | THE-"WP - black complete both fuses" | pressing for time in seconds | THE-"CP-AM-PRESS" |
| 41 | THE-"WP - black complete front fuse" | store a part from stopper 1 | THE-"CP-F-ASRS32-P" |
| 12 | THE-"WP - black complete front fuse" | pressing for time in seconds | THE-"CP-AM-PRESS" |
| 34 | THE-"WP - black complete front fuse" | release a defined part on stopper 2 | THE-"CP-F-ASRS32-P" |

**Figure 7.** Query result.

## 5. Summary

This publication presents the conceptualization of the knowledge contained in the production system configured by FESTO to ontological form. At the moment, the information contained in the database is not very different from those in the relational database, but that further modeling of ontology may be aimed at establishing rules, logic and axioms. The performed operations and transformations presented the operation of CogniPy in the process of creating ontology and materializing the graph and queries.

The created ontology takes the form of a universal set of knowledge, making it open to integration with other systems thanks to RDF formalism. A narrow field, production line modules and the operations performed by them can be developed by including other branches of knowledge about the production process. In this way, unified knowledge bases can be created.

This work is an introduction to the construction of an ontological production management system.

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# IMPACT OF ARTIFICIAL MANAGEMENT ON THE WORK OF A TEAM OF HUMANS. RESULT OF RESEARCH

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**Purpose:** The purpose of this paper is to present an answer to the research question of what could be the real impact of an artificial manager on the work of a team consisting of humans.

**Design/methodology/approach**: In presenting the arguments for one way of proceeding AI-based management, a review of the recent literature in the field of artificial management and artificial leadership was used. The artificial manager used in the research was the result of a non-participating, long-term observation of a group of students working on an specific task, whose activity was recorded by online management tools called TransistorsHead.com.

**Findings:** The real impact of the artificial manager on the human team members was very weak. Although team members were taking similar managerial actions as they were told by the system of TransistorsHead.com, they mixed the order and decreased or increased a period of the managerial actions.

**Research limitations/implications**: Human members did not feel any emotional pressure on their behaviour from the artificial manager and they do not treat the system too seriously. What is interesting, the most obedient person was the appointed assistant of the artificial manager. The rest two members did not obey the rules.

**Practical implications:** If we manage to create an artificial manager, it will be much harder to make it effective in working with human team members. The research on team management automation will impact upon the business by giving a chance of implementing artificial management.

**Social implications:** even if we manage to create an artificial manager, it will be much harder to make it effective in working with human team members.

**Originality/value:** There is a new research problem of replacing a human manager with an artificial manager which has to be solved in management sciences and managerial practice in the future. This paper contains findings which are the next step in solving a new research problem of replacing a human manager with an artificial manager.

**Keywords:** artificial management, artificial leadership, virtual team, system of organizational terms.

**Category of the paper:** Research paper, case study.

# 1. Introduction

After the first age of robotics in mechanical processes and manufacturing it appeared rapid development of computer science and Internet which created opportunities to replace team managers with artificial managers (McAfee, and Brynjolfsson, 2016). Research on Artificial Intelligence (AI) in management has slowly appeared as a challenge for the future (Teddy-Ang, Toh, 2020). AI in management seems to exceed any other technological breakthrough that humanity has ever seen (Antonescu, 2018) and human-machine teamwork seems to be a promising paradigm to approach future situations in which humans and autonomous systems closely collaborate (van der Vecht et al., 2018).

Despite the fact that there are still discussions if AI management will evolve in artificial management (Franken, and Wattenberg, 2019) or in artificial leadership (Derrick, Elson, 2018), it seems that AI will overwhelm team management in the future (Webber et al., 2019). Even popular science and business journals raise this aspect of team management as the most important challenge in the next few years (Khan, 2020; Dzieza, 2020). If it happens, this would be the real accomplishment of Peter Drucker's words that in the future "computers" will not only make decisions but they will do much more (Drucker, 1967).

Therefore, there is a new research problem of replacing a human manager with an artificial manager. This problem is not yet sufficiently defined in the literature. However, we can predict that before implementing an artificial manager, it is necessary to make a choice of management with AI and answer if it should be more like team management or team leadership. Even if we discover which option is better, the research problem mentioned above entails a number of challenges that arise during the implementation of AI-based management. Some of these have already been discussed in the author's previous papers, such as how to represent manager's actions and how to imitate them. The purpose of this paper is the next step and it is to present an answer to the research question of what could be the real impact of an artificial manager on the work of a team consisting of humans.

The paper uses two research methods. In presenting the arguments for one way of proceeding AI-based management, a review of the recent literature in the field of artificial management and artificial leadership was used. While the answer to the research question was formulated based on the results of the author's research on the management of a virtual team by an artificial manager which he created. The artificial manager used in the research was the result of a non-participating, long-term observation of a group of students working on an specific task, whose activity was recorded by online management tools called TransistorsHead.com.

Section 2 of the paper presents definitions of a virtual team and a review of the literature on artificial management and artificial leadership. Section 3 describes the methodological basis of the non-participant, long-term observation carried out, which is the system of organizational

terms, the author's original methodological concept used by him to study organizational reality using online managerial tools. Section 4 presents the results of the study, which guides the answer to the research question on the impact of the artificial manager on the human members of the virtual team.

## 2. Artificial management or artificial leadership in a virtual team

### 2.1. Virtual teams a new organizational environment of management

Scholars traditionally define a team as a bounded and stable set of individuals as a group of people who are interdependent for a common purpose or who work interdependently towards shared goals (O'Neill, and Salas, 2018). Thus, teams have two required elements: membership and collaborative tasks. Team memberships in the past were often mutually exclusive, with members working in only one team at a time. Traditional teams are located in the same place and have easy access to both face-to-face and electronic communication. These teams have been formally studied for more than half a century, resulting a huge body of literature (Kozlowski, Chao, 2018; Mathieu et al., 2017). Contemporary the term membership tends to overlap, because members working virtually and simultaneously in more than one team.

Virtual teams in organizations appeared in the last decade of the 20th century and they are associated with accelerating business activities and increasing innovations (Ebrahim, Taha, 2009). A virtual team as a group of people who do not stay geographically, organizationally or temporally in the same place, but co-operate with each other through the use of ICT for one or more organizational tasks (Kożusznik, Pollak, Chrupała-Pniak, 2020).

The virtual team is also described by the category of temporality when short, undefined time of the team's activity is conditioned by the needs of the organization and individual motivations of its members (Gassmann, Von Zedtwitz, 2003). Virtual teams are also found in organizations which bring together specialists (Engerer, 2019). During the COVID-19 pandemic virtual teams appeared in organizations as a necessity to meet the challenges of isolating employees and virtual teams became a hallmark of the pandemic. The pandemic has boosted the implementation of virtual teamwork, with many employees working at homes using virtual tools to collaborate with their teammates (Feitosa, Salas, 2020). These changes are linked with uncertainty because of the growing variability and complexity of many work processes. Result of this is that teamwork has become more cognitively demanding due to increased technology, task variety and knowledge-based work together with ICT tools. For this reason, AI-enabled management has become an important research topic in many areas of management science, bringing with it many opportunities and challenges (Xiong, Xia, Wang, 2022).

## 2.2. Differences between artificial management and artificial leadership

The first vision of artificial management were spoken in words that in the future "computers" will not only make decisions but they will do much more (Drucker, 1967). Looking for an answer if it is possible to replace human team managers with artificial ones, it is necessary to consider two terms "artificial management" and "artificial manager" created nearly 40 years ago (Geisler, 1986).

On the one hand, it is true that the concept of artificial management and its operational consequence of implementing an artificial manager were seen as a dehumanizing attempt to eliminate participation of human in the management processes in the organization. Therefore, traditionally most of researchers considered artificial management applications only in organizational decision systems or routine operational processes which were well structured (Mitroff, Linstone, 1993; Courtney, 2001; Gigerenzer, nd Gaissmaier, 2011). After decades it led to focus mostly on automated decision making (Zimmermanna et al., 2019). However, in literature we can find research on influence of AI management on such aspects as planning (Liu et al., 2020), decision making (Smith, Green, 2018), problem solving (Waizenegger et al., 2020).

On the other hand, after decades AI overwhelms more and more areas of business management. Artificial intelligence is emerging as a potential growth area for facilitating the improvement and development of teams in the workplace. AI in team management is currently underdeveloped and limited, despite the wide-scale adoptions and implementations of AI to improve team leadership (Webber et al., 2019). New applications such as artificial agents, automation or intelligent assistance are becoming drivers of a wide-ranging change process in companies which requires reorganisation of team management according to a leadership approach (Franken, Wattenberg, 2019). AI-based leadership could theoretically be deployed at a local level in their scope of operation (Chen, 2019). There is also further philosophical dilemmas about ethical aspects of artificial leadership (Brendel et al., 2021). This will decreased focus on getting machine followers to feel part of a virtual team (Smith, Green, 2018).

As can be seen from the above literature review, the dilemma of whether to direct efforts toward artificial management or toward artificial leadership has not been resolved. However, in the author's opinion, the artificial management approach is more feasible, and this is the approach the author has been using in his research for several years. The most important arguments in favor of artificial management are the problems of adequate and sufficiently accurate representation of a manager's work, recording and recognizing patterns of his behavior, and then implementing artificial actions taken by an artificial manager. Since these problems have not yet been fully solved, the artificial leadership approach still seems beyond the reach of management science, not to mention the practical implementation of such solutions.

Section 3 presents a methodological approach, the system of organizational terms, which is compatible to the artificial management trend, as well as an example of research tools in this approach, online managerial tools called TransistorsHead.com.

## 3.  Methodology of research based on the system of organizational terms

The system of organizational terms has been developed and tested in the last years (Flak, 2017, 2021; Yang, Flak, Grzegorzek, 2018; Flak, Hoffmann-Burdzińska, Yang, 2018). This methodology lets us record managerial actions one by one and it is possible to answer what a team manager and his team members really do (Sinar, Paese, 2016). The philosophical foundation of the system of organizational terms is based on Wittgenstein's philosophy. According to this approach team management can be organised by events and things. As it is shown in Figure 1, each event and thing have the label n.m, in which n and m represent a number and a version of a thing, respectively. Event 1.1 causes thing 1.1, which in turn releases event 2.1 that creates thing 2.1. Thing 1.1 simultaneously starts event 3.1 which creates thing 3.1. Then, thing 3.1 generates a new version of the first event, i.e. event 1.2. In such a way, a new version of the first thing is created, which is called thing 1.2. So, the managerial action structure consists of, e.g. event 1.1 and thing 1.1. As it is shown in Figure 2, differences between features of things let us do reasoning on the team management process (Yang, Flak, Grzegorzek, 2018).
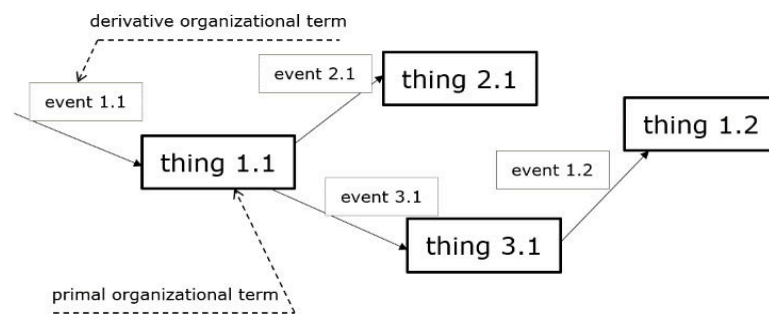


**Figure 1.** Types of organizational terms.

Source: Own elaboration.
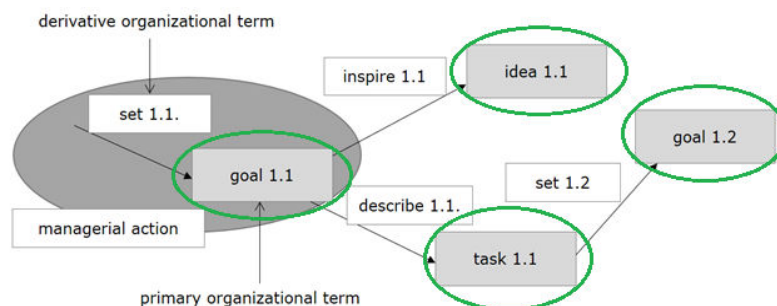


**Figure 2.** Structure of a managerial action.

Source: Own elaboration.

The important aspect of this methodology is the set of online management tools (Figure 3) which record parameters if the managerial actions (effects marked with a green round, e.g. a goal 1.1 as a result of set 1.1 in Figure 2). TransistorsHead.com records changes in team management processes. It reminds making a movie of teamwork with frames of features team management processes in 10 areas of team management. However, not only it can learn the human managerial actions (taken by a human manager and its team members), but also allows to implement an artificial manager. This is an extraordinary combination self-learning research tools imitating main common managerial actions of a human manager.
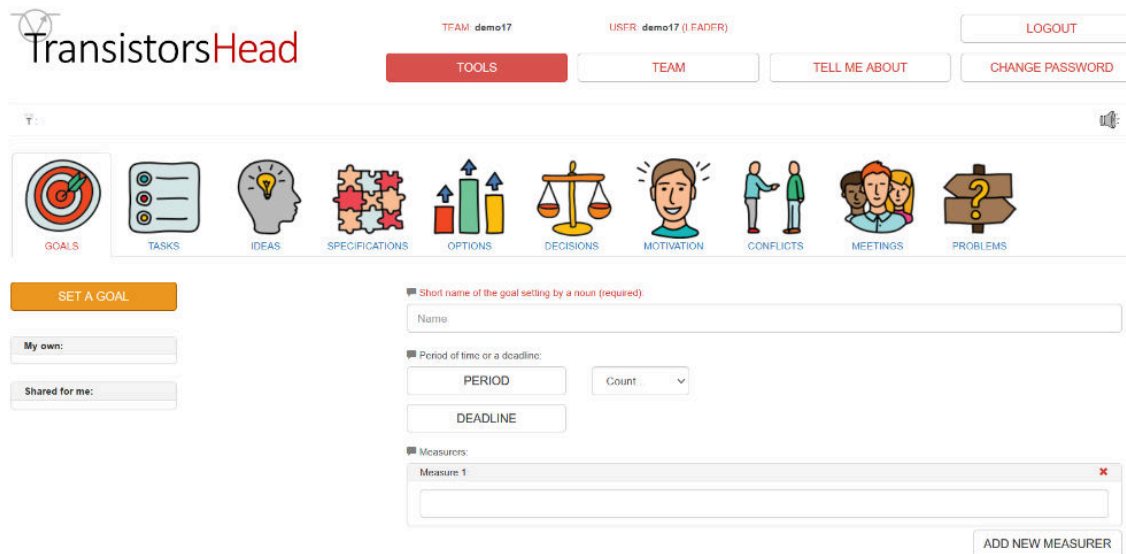


**Figure 3.** Online management tools in TransistorsHead.com as research tools.

## 4. Results of research

The non-participant, long-term observation was conducted in two parts in June (Team A) and December (Team B) 2021 and both lasted 36 hours. The groups of participants in the observations consisted of 3 students of the University of Silesia in Katowice (different students in both parts), working in virtual teams, each of whom was assigned the role of team manager. Participants could work at any time between 9 a.m. on the first day and 9 p.m. on the second day of observation using online management tools at TransistorsHead.com and the MS Teams communication tool. Participants had basic competencies in managerial techniques, acquired during the "Managerial Techniques" and "Business Plan" courses. Both groups were given the same task, which was to design an entertainment program in Talent Show format on a YT channel.

However, Team A was completely free to do the task using the online management tools in TransistorsHead.com. The tools were recording 8 of their managerial actions (Table 1). 6 months later Team B was asked to work with the artificial manager embedded in TransistorsHead.com. The sequence of managerial actions which the artificial manager took was a result of analyzing managerial actions taken by the team manager in Team A. Another words, the system of TransistorsHead.com was taught by Team A how to do the task and during the second part of the research the system played a role an artificial manager in Team B. During the second part of the study, members of Team B saw on the screen what managerial action should be taken at the moment and 5 managerial actions which the artificial manager wanted to take in the future, along with the time to start them.

The results of both parts of the research contain hundreds of thousand of records in SQL database which, on the one hand, describe behaviour of human members and a human manager during the first part of the research (Team A) and human members of the virtual team in the second part of the research (Team B).

Figure 4 shows the function of time in giving orders by an artificial manager in the second part of the research. The artificial manager was leading human members in a virtual team (Team B). Figures 5, 6, 7 present which managerial actions were taken by every one of human members cooperating with the artificial manager in Team B. A special member is presented in Figure 6, because he was an assistant of the artificial manager. This person was instructed by the investigator about his special role as an intermediary between the artificial manager and the other team members.

In Figures 4, 5, 6, 7 we can see 10 types of managerial actions. Their meaning is described in Table 1.
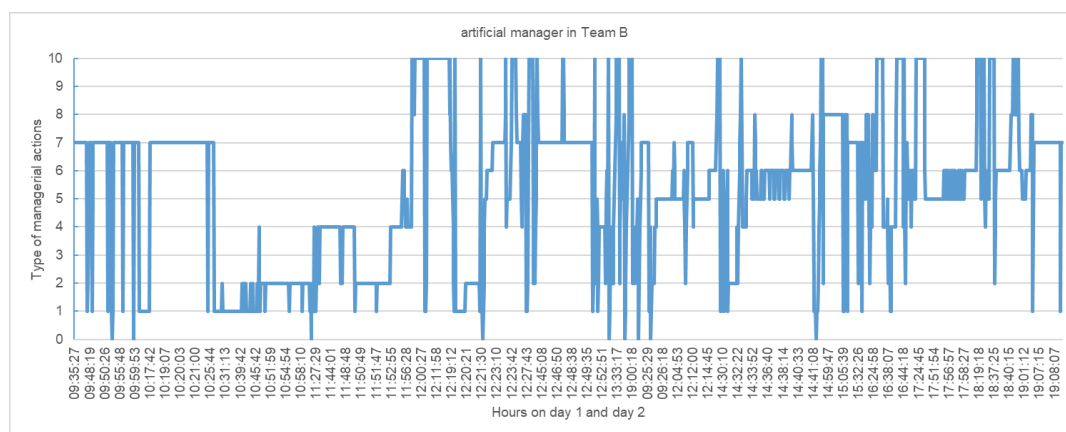


**Figure 4.** Managerial actions taken by an artificial manager.

Source: Own elaboration.
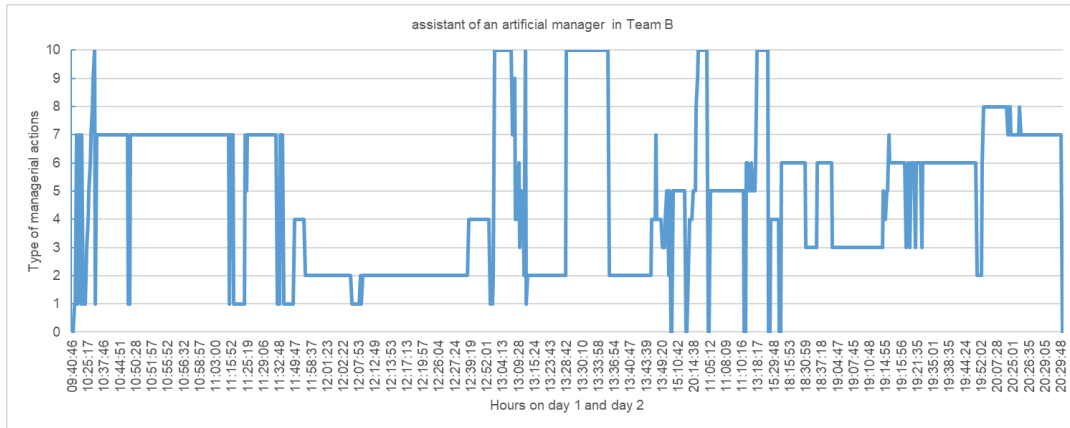
**Figure 5.** Managerial actions of a human assistant of an artificial manager (Team B).

Source: Own elaboration.
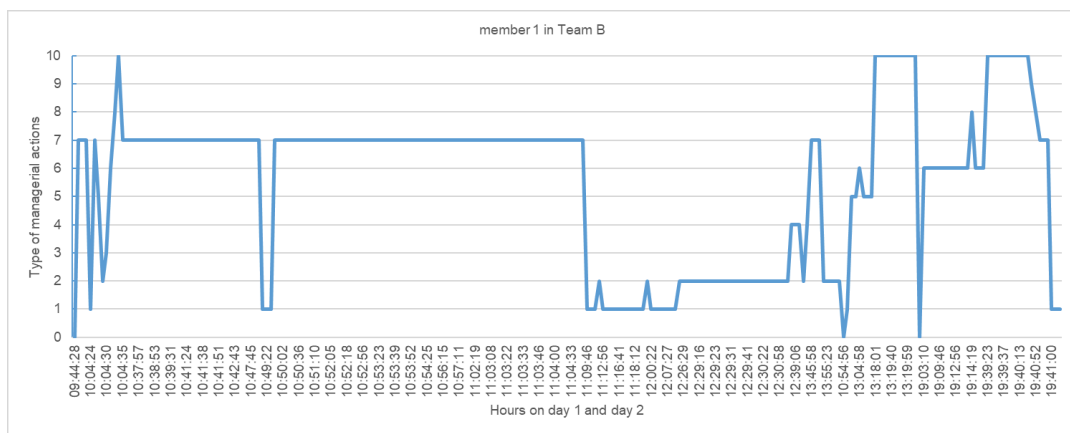


**Figure 6.** Managerial actions of a human member 1 (Team B).

Source: Own elaboration.
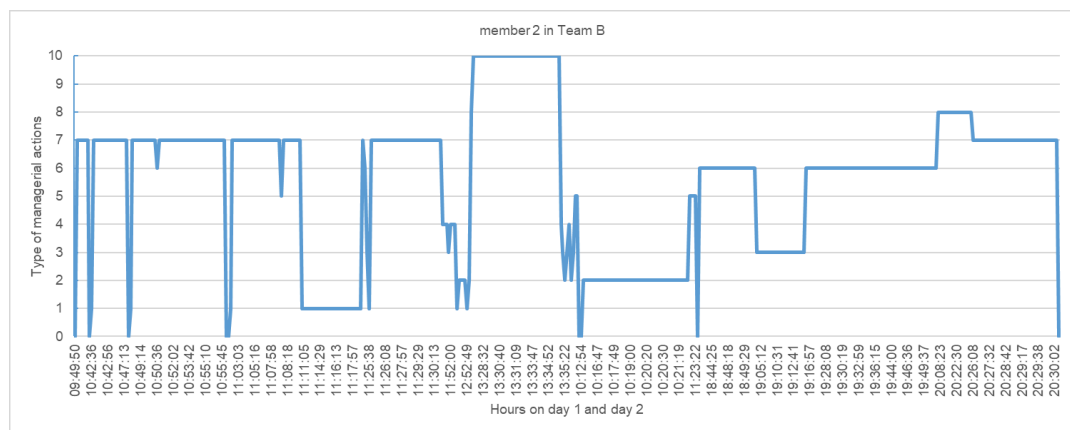


**Figure 7.** Managerial actions of a human member 2 (Team B).

Source: Own elaboration.

In Table 1 there are numbers of managerial actions given as orders to a human virtual team and numbers of real managerial actions taken by human team members.

**Table 1.**

*Numbers of managerial actions taken by all members of team A*

| Number of a managerial action | Type of a managerial action (name of a managerial tool in TransistorsHeac.com) | Artificial manager | Assistant of an artificial manager | Human member 1 | Human member 2 |
|---|---|---|---|---|---|
| 1 | set goals (GOALS) | 157 | 46 | 29 | 36 |
| 2 | describe tasks (TASKS) | 247 | 234 | 37 | 59 |
| 3 | generate ideas (IDEAS) | 0 | 69 | 1 | 29 |
| 4 | specify ideas (SPECIFICATIONS) | 167 | 59 | 4 | 8 |
| 5 | create options (OPTIONS) | 212 | 63 | 6 | 7 |
| 6 | choose options (DECISIONS) | 220 | 121 | 17 | 95 |
| 7 | check motivation (MOTIVATION) | 447 | 214 | 123 | 179 |
| 8 | solve conflicts (CONFLICTS) | 82 | 29 | 3 | 18 |
| 9 | prepare meetings (MEETINGS) | 0 | 3 | 1 | 0 |
| 10 | explain problems (PROBLEMS) | 164 | 79 | 23 | 43 |
| | Total: | 1696 | 917 | 244 | 474 |

Source: Own elaboration.

We can compare charts of managerial actions in function of time of the artificial manager (Figure 5) to any other member of Team B (Figures 6, 7, 8). None of them did not follow the orders given by the artificial manager. For example, if the artificial manager showed all members to do a motivation check (Tool 7 - CHECK MOTIVATIONS), they turned it on, however, they stayed longer than the artificial manager wanted and they did not skip to setting goals (Tool 1 - SET GOALS), despite the fact they were told to do it.

Very few of the managerial actions taken by team members were concurrent with those imposed by the artificial manager. Only 17% of them were started within 5 seconds or less of the artificial manager's command, 8% of which was by the assistant of the artificial manager designated by the investigator. As can be seen in Figures 7 and 8, the other two participants were rather passive and remained "in the activity" for a long time, meaning that they did nothing at the time, and only the online management tool was open on their computer screen.

The insignificant impact of the artificial manager's commands on the work of the team, which meant that the members simply ignored the commands of the artificial manager, is confirmed by the data on the numbers of managerial actions taken of a given type. For example, the artificial manager gave the command to set (or re-set) goals 157 times (Tool 1 - SET GOALS), while team members took this action a total of 111 times. The artificial manager instructed to create, improve or just see what decision options could be considered 212 times, while team members responded only 76 times (Tool 5 - OPTIONS). Interestingly, team

members tried to prepare a meeting 4 times (Tool 9 - MEETINGS), while the artificial manager did not mention this managerial action even once. Admittedly, the sum of instructions given by the artificial manager to all managerial actions taken by Team A is similar, but their structure and arrangement in time is completely different.

## 5.  Conclusions

The purpose of the paper is to present an answer to the research question which derived from the research problem about replacing a human manager with an artificial manager. Basing on the non-participant, long-term observation there is an attempt of answering what could be the real impact of an artificial manager on the work of a team of humans.

The general answer is that the real impact of the artificial manager on the human team members was very weak. Although team members were taking similar managerial actions as they were told by the system of TransistorsHead.com, they mixed the order and decreased or increased a period of the managerial actions. It seems that human members of Team B did not feel any emotional pressure on their behaviour from the artificial manager and they do not treat the system too seriously. What is interesting, the most obedient person in Team B was the appointed assistant of the artificial manager. The rest two members did not obey the rules. In informal talks with the author of the paper they said that the orders given by the artificial manger were even an obstacle in their performance and they did not want to listen to "him" (the artificial manager).

General conclusion which can be drawn from this research is that even if we manage to create an artificial manager, it will be much harder to make it effective in working with human team members. Even if the area of team management automation and its consequences seem to be dominant area of research in the nearest future (Derrick, Elson, 2018; Franken, Wattenberg, 2019; Webber et al., 2019; Teddy-Ang, Toh, 2020), we need to answer two other research questions in social domain of team cooperation: (1) how an artificial manager and team members influence on team management processes, (2) in what extent team members take actions of an artificial manager and other way round. Both aspects are planned to be involved in the author's research projects in the future. Both research questions could let introduce further discoveries in the nature of cooperation between artificial team members and human members. In the future it is planned to organize a group of about 100 participants working within a year on certain projects which could let distinguish main sequences of managerial actions and discover their semantic meaning.

## Acknowledgements

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# THE IMPACT OF COVID-19 PANDEMIC ON CONSUMER PURCHASING DECISIONS

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**Purpose:** The main objective of the survey is to identify changes in consumer behavior and the determinants that influenced purchasing decisions during the Covid–19 pandemic.

**Design/methodology/approach**: An interview questionnaire was used in the survey. The survey was conducted through a random selection of a sample. The electronic survey was conducted in April 2021. The questionnaire was completed by 220 people. The media were the tools to reach the respondents social networking and the survey itself was made available on the facebook.com portal, on thematic groups associating consumers of various products. The research was of a pilot nature. This limited the sample size and scope of the research.

**Findings:** The analysis of the survey results shows that the COVID–19 pandemic affected the purchasing behavior of 76% of women and 62% of men. Surveys have shown how shopping habits have changed during the coronavirus pandemic. The respondents said they started purchasing more products online and that the frequency of shopping decreased, but they purchased more products at one go. The respondents bought only essential products and spent a larger portion of their money on protective measures than before. For 24% of women and 38% of men the pandemic had no impact on their consumer behavior.

**Originality/value:** The analysis of the literature leads to the conclusion that there is not much research on consumer behavior during the COVID–19 pandemic. The paper is addressed to representatives of the scientific world dealing with the topic of consumer behavior and all those interested in this issue.

**Keywords:** consumer, COVID–19 pandemic, purchasing decisions.

**Category of the paper:** Research paper.

## 1. Introduction

Consumer behavior in the market is the sum of activities related to obtaining and using goods or services, but also disposing of them. Consumer behavior arises from the individual's experience of needs and refers to the totality of impartial and biased, logical and emotional, responsible and impulsive actions in the process of preparation for decision-making in the market of consumer goods and during consumption (Liczmańska, 2015). The Covid–19

pandemic has changed consumer behavior. The restrictions that were put in place and the ubiquitous sanitation rules caused specific behavior in buyers. Safety has become a priority. The volume and frequency of purchases had changed. Sales of some products that previously had no sales fluctuations, except for holiday periods, increased over a very short period. This mainly concerned necessities, mainly food products, with a long expiration date. Consumers felt fear of the vision of empty shelves in stores, causing them to stockpiling.

## 2. Factors shaping consumers' purchasing behaviors

### 2.1. Psychological factors

The behavior of buyers in the market depends on psychological determinants, categorized as internal determinants. These include motives, needs, emotions, personality, learning process, perception, attitudes, and risk propensity when making a purchase decision (Rudnicki 2012).

It is believed that needs are the foundation of the consumer behavior in the market. Motives, in turn, are the main impulse for human behavior. A motive can be defined as any experience that either stimulates the buyer to act or inhibits their actions, supports or hinders their behavior. It occurs when a person experiences a characteristic internal state characterized by an awareness of unfulfillment and a desire to initiate action (Światowy, 2006). Emotions are also an important factor influencing people's behavior, which are defined as strong feelings of positive or negative tinge, preceded by some event. Another factor influencing buyers' behavior is personality. It can be defined as a relatively fixed set of mental as well as physical characteristics of an individual that decides on the characteristic forms of his/her behavior and adaptation to specific environmental conditions (Światowy, 2006). The next factor influencing consumer behavior is the learning process. Learning can be defined as a process based on the achievement and gaining of experiences, which leads to the relentless modification of a person's behavior or allows for a change in behavior that has been previously developed. The result of the learning process and constant repetition of the same actions are habits (Rudnicki, 2012; Zalega, 2012; Dushigg, 2019).

Among the psychological factors shaping consumer behavior, perception also plays a crucial role. Perception is understood as identifying, selecting, preparing and analyzing all types of impulses through which a person registers reality. The way market offers are perceived is influenced by opinions generated from previous experiences (Łodziana-Grabowska, 2015). Consumption behavior is significantly influenced by attitudes, that is, a kind of inclination to act in a particular way. Attitudes are influenced by external actions, such as marketing activity, but also by the experience of the individual. They can create themselves with the influence of information derived from other people, which is broadcast with the help of mass media (Rudnicki, 2012; Światowy, 2006).

Making a purchase decision is a risky activity, mainly when a consumer is buying a good or service for the first time. These risks have to do with making wrong decisions or the possibility of experiencing, for example, damage or loss. If the risk is identified by the buyer, it can be decisive in terms of the consumer behavior and greatly influence it. In a situation where buyers in the process of purchasing a particular product do not see the danger integrated into their decision, the fact of the real presence of this risk will not have any impact on consumer behavior (Rudnicki, 2007).

## 2.2. Demographic factors

Age has a special impact on the behavior of buyers in the market. People who belong to different age groups have different needs and shopping goals. The market for goods divided into goods intended for the youngest, teenagers or seniors in a simple way shows the characteristic activities of companies. At the same time, consumer preferences are changing over the years. Young people entering and exploring the world often purchase functional, low-priced and modern equipment, meanwhile, older people often search for durable, standard and reasonably priced items. It is not uncommon for young adults to visit furniture stores, electronics stores, bookstores, boutiques, cafes, etc. Older people, on the other hand, rather avoid shopping malls or hypermarkets, opting instead to shop at a small local store (Rudnicki, 2012; Gracz, Ostrowska, 2013).

Consumer behavior in the market is largely determined by gender. It is not uncommon for women to indicate that the appearance of goods has a huge importance for them when shopping, while men are more likely to follow a functional product. Women sometimes treat the acquisition of goods as a way to spend leisure time, and also buy more often on impulse, but also in order to be able to stand out with the purchased items. Men, on the other hand, tend to approach shopping more prudently. They go for shopping when the previously used product has deteriorated. When they decide to buy a new product they mostly already know what to buy and where (Rudnicki, 2012; Gracz, Ostrowska, 2014).

The set of demographic factors includes also education. Consumers, having reached a higher level of education, are much more demanding on themselves, but also on others around them. Higher-order needs are more strongly emphasized for them than for people with lower education. One cannot overlook the fact that usually with an increase in education, the social and professional position improves, and consequently a consumer earns a high income.

One important factor is the lifestyle chosen by buyers. Lifestyle is defined by clothing, diet, leisure activities, such as physical activity, cultural activities, form of work or values. (Łodziana-Grabowska 2015; Zalega, 2012). Lifestyle is often an important motive for purchasing processes. It is also a widely used criterion for dividing the buyer's market. Knowing more about customers' lifestyles makes it easier to match goods offerings to their requirements (Rudnicki, 2012).

## 2.3. Economic factors

Income is one of the most important economic factors affecting consumption. It is a major element in determining the quality of life, allowing to satisfy basic needs, but also those of a higher order. The amount of disposable income (the totality of current household income earned from various sources, reduced by direct taxes) affects consumption, especially in the long term.

The price level is another determinant affecting people's purchasing behavior. Price is a determinant of the decision to buy a product, unrelated to the consumer's age, place of origin, gender or occupational group. The level of price affects the consumer's perception of the characteristics of a particular good. Usually, the higher the price of items, the more valuable they are considered by people to be, having better quality, mainly when they carry a recognizable and reputable brand name. At the same time, expensive items or services are not in high demand. The more expensive the goods, the lower the demand. Expensive goods make the purchase decision more thought-out (Maciaszczyk, 2014).

## 2.4. Marketing factors

A product, in marketing terms, refers to a set of tangible and intangible characteristics, such as the form of packaging, price, brand, quality, color range, company reputation and services offered by the seller, which buyers may consider as proposals to satisfy their needs. The components of the product's design are its equipment. A product can specify a good, service, zone, person or concept. The main role of a product is to satisfy specific needs of buyers. Promotion is an important factor. It influences the buyers of a certain company by giving them information, which is designed to expand their knowledge of the company, its sales offer, as well as induce inclination in them. The fundamental premise of promotional activities is to popularize information so that it reaches likely new customers (Łodziana-Grabowska, 2014; Nowacki, 2006). One of the most widely used activities is advertising. It is defined as a large, paid and interpersonal form of transmission and support of concepts, goods and services by a specific sender. Its system of operation is multifaceted.

## 3.  Research sample characteristics

An interview questionnaire was used in the paper. The electronic survey was conducted in April 2021. The questionnaire was completed by 220 people. The media were the tools to reach the respondents social networking, and the survey itself was made available on the facebook.com portal, on thematic groups associating consumers of various products. The research was of a pilot nature.

Due to the nature of the survey and the place of its performance, it was carried out through random sampling. The survey aimed to understand consumer behavior and the determinants that influenced purchasing decisions during the Covid–19 pandemic.

The survey included 119 women and 101 men. The level of education was matched with the gender of the respondents, as shown in Figure 1.
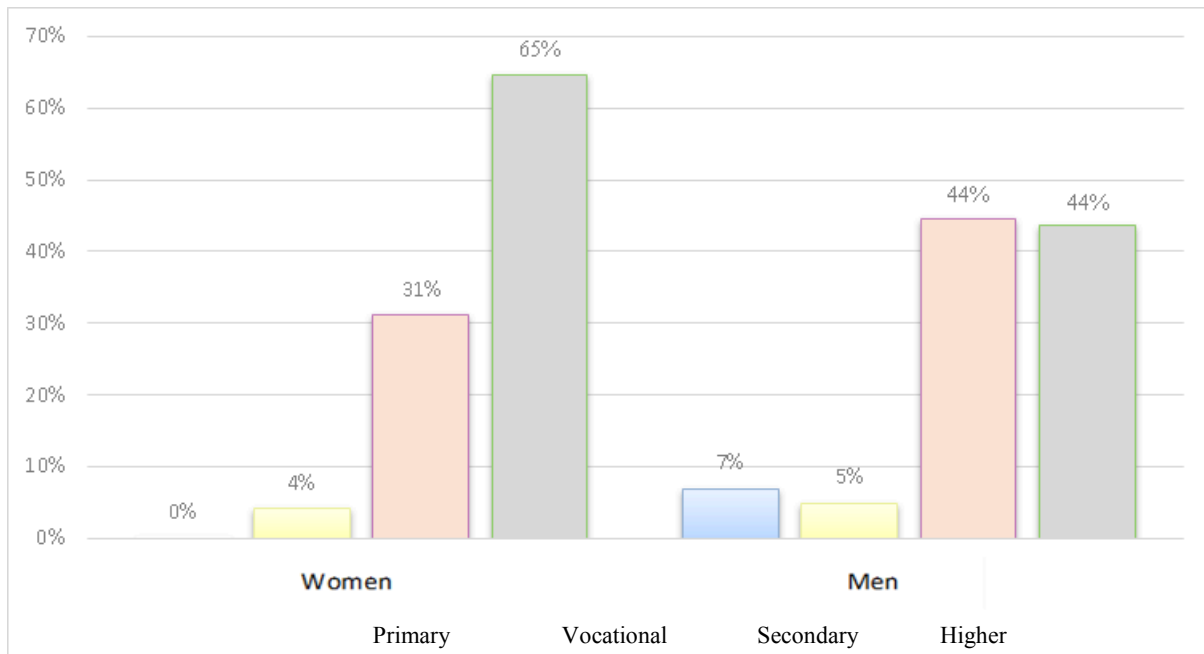


**Figure 1.** Gender versus education of respondents.

Source: Own elaboration.

65% of women and 44% of men had higher education, and 7% of men and no women had primary education. Due to the random research group, the level of education of the respondents does not reflect the level of education of the society in the country.

## 4.  Shopping habits during the pandemic

The SARS-CoV-2 coronavirus pandemic has led to many changes in society. It has influenced people's behavior and previous lifestyles. It has influenced consumer buying behavior.

The question "Has the pandemic affected your purchasing decisions?" was answered by the majority of respondents, including women (76%) and men (62%), in the affirmative (Figure 2).
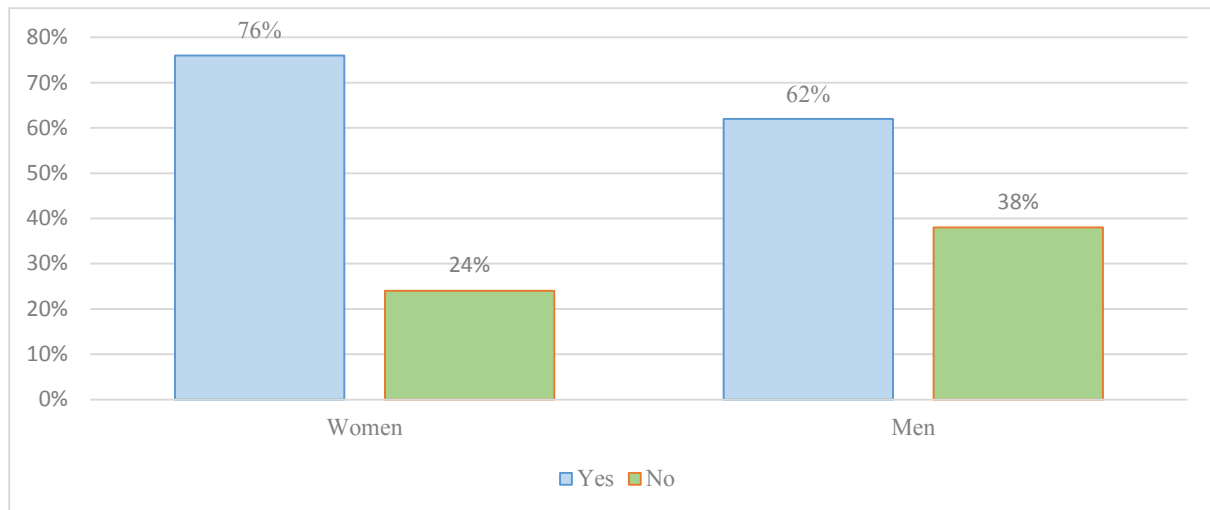
**Figure 2.** The impact of the pandemic on purchasing decisions.

Source: Own elaboration.

Women were more afraid of the pandemic. They also complied with pandemic restrictions. This also had an impact on purchasing decisions, size and choice of products.

During the pandemic, consumers making purchases valued their own safety the most (61%), which may have been due to a shaky sense of safety due to the spread of a potentially dangerous virus (Figure 3).
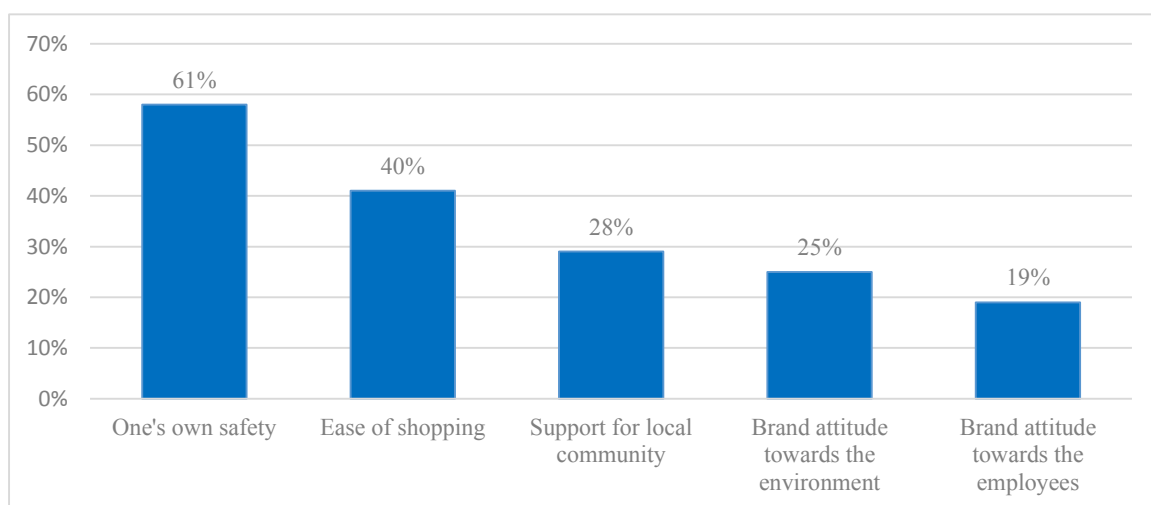


**Figure 3.** Increasing importance of determinants of consumer behavior during the COVID–19 pandemic.

Source: Own study.

The second most frequently indicated answer regarding important determinants of consumer behavior was the "ease of shopping", which amounted to 40%. The reasons can include limitation of the possibility to go out and new sanitary rules that made it difficult to access points of sale (e.g., limits on the number of people per m² in a room, shopping hours for seniors). Least important was the brand's approach to employees during this difficult time (19%). The fact whether the company tried to keep jobs or laid off employees for financial

reasons was not reflected in consumers' perceptions of the brand and thus did not affect their purchasing decisions.

The pandemic situation has forced changes in virtually every facet of human life. Respondents were asked about the impact of the pandemic on their behavior. More than 42% of respondents said they shopped online more often (Figure 4).
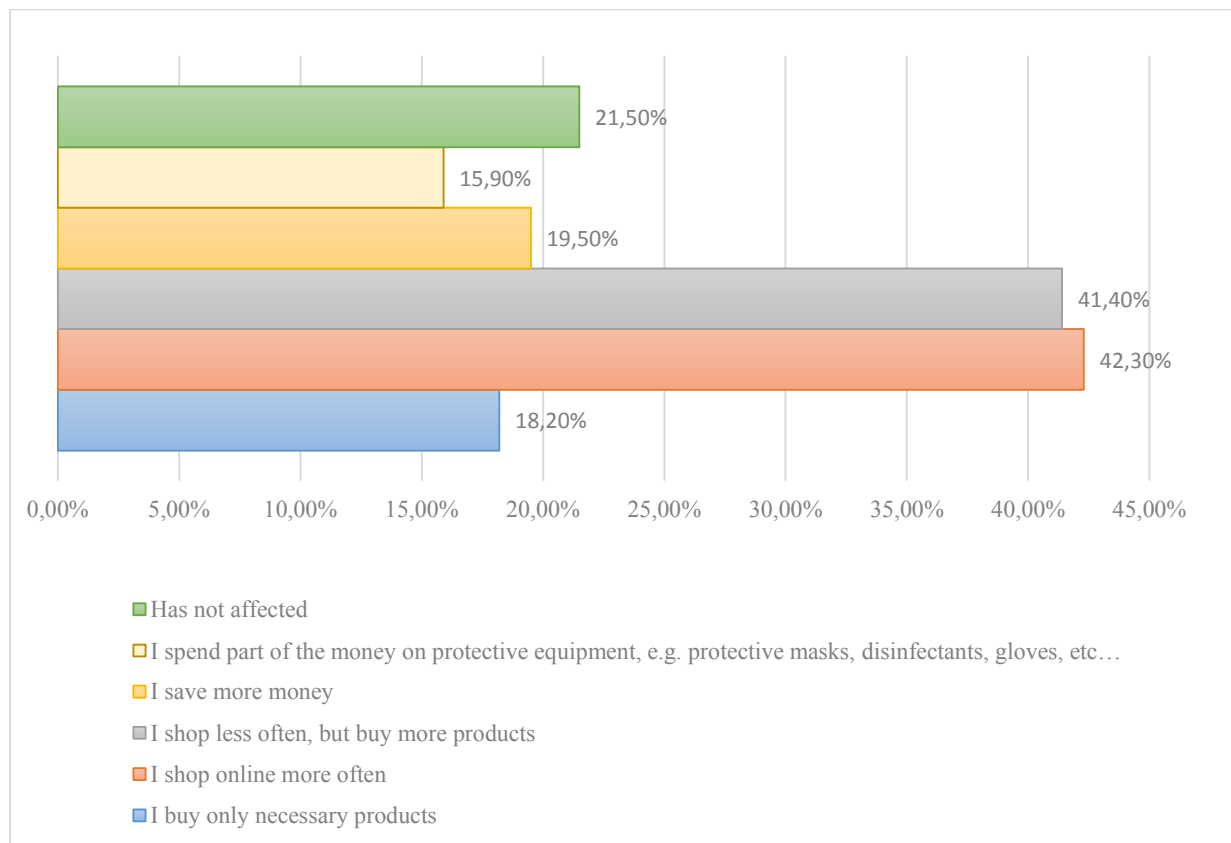


**Figure 4.** The impact of the pandemic on consumer behavior.

Source: Own elaboration.

41.4% of respondents said they purchased more products, but much less frequently. These results are consistent with data from a survey conducted in 2020 by M/platform, which reported a 20% decrease in the average number of receipts in April 2020, and the increase in the size of an average basket in small stores by 64% compared to reference months (https://mplatform.com.pl).

More than 21% of respondents believe that the pandemic did not affect their consumer behavior. Among those surveyed, 19.5% decided to save more on shopping. Having a financial reserve has become more popular, but for some it has also become essential. Due to sanitary restrictions, masks, protective gloves and disinfectants became new, but important, purchases. This was the answer indicated by 15.9% of respondents.

## 5. Determinants of purchasing decisions during the pandemic

The new market situation has caused many negative consequences on the financial level. Some people have lost their jobs, and many businesses have decided to cut salaries. Some smaller companies did not survive this test. And as a result, the economic situation for some people has deteriorated.

The majority of respondents (56%) believe that the pandemic did not affect their existing financial situation in any way. On the other hand, 39% of them assess its effects negatively. Less than 5% think that their financial situation had improved (Figure 5).
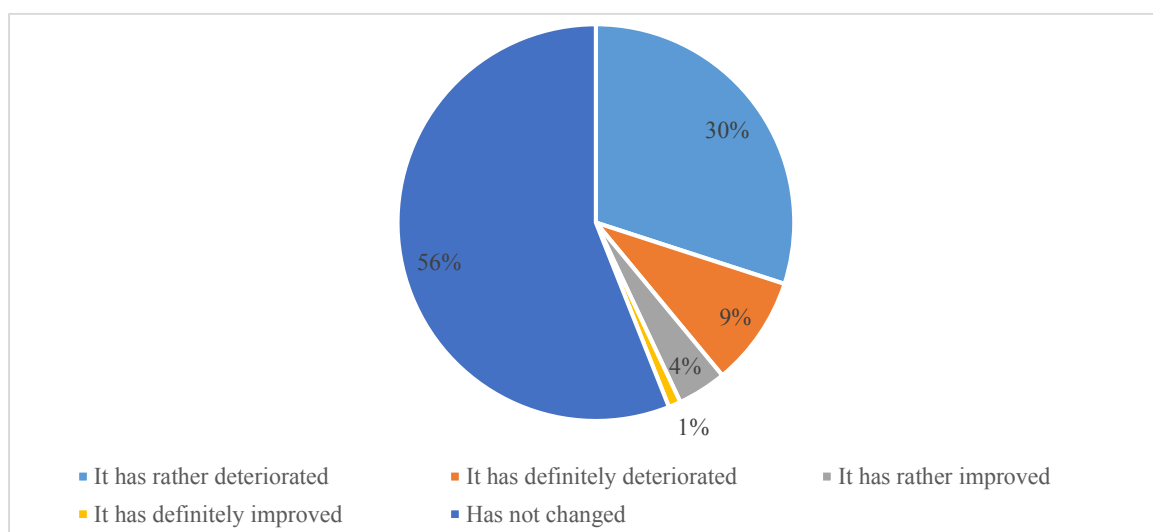


**Figure 5.** The impact of the COVID–19 pandemic on the financial position of households.
Source: Own elaboration.

The survey showed that 30% of respondents spent more money than they did before the outbreak of the COVID–19 pandemic (Figure 6).
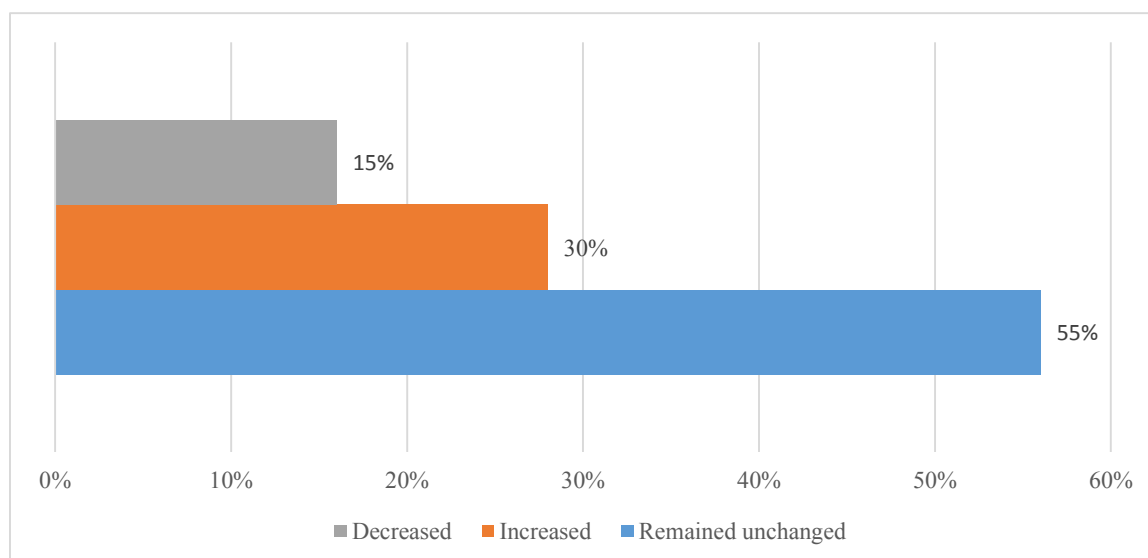
**Figure 6.** The impact of the COVID–19 pandemic on household spending.

Source: Own elaboration.

These could have been, for example, expenses for protective measures or for food and water supplies. In contrast, 55% say the pandemic had no impact on their financial situation Among those surveyed, 15% think that their spending had decreased. This may have been caused by a desire to save money in extraordinary times.

At the same time, it should be added that the Polish Economic Institute estimates that the pandemic has not taught Poles to save money. Experts say that efforts made to save money were short-lived. The study, conducted by Corona Mood, showed that the number of people with savings at their disposal dropped by 17% between November 2020 and March 2021 (https://businessinsider.com.pl).

The restrictions that were put in place and the ubiquitous sanitation rules caused specific behavior in buyers. As the survey showed, 49% of respondents limited trips to the store to the bare minimum. Respondents were asked to indicate the inconveniences experienced during stationary shopping (Figure 7).
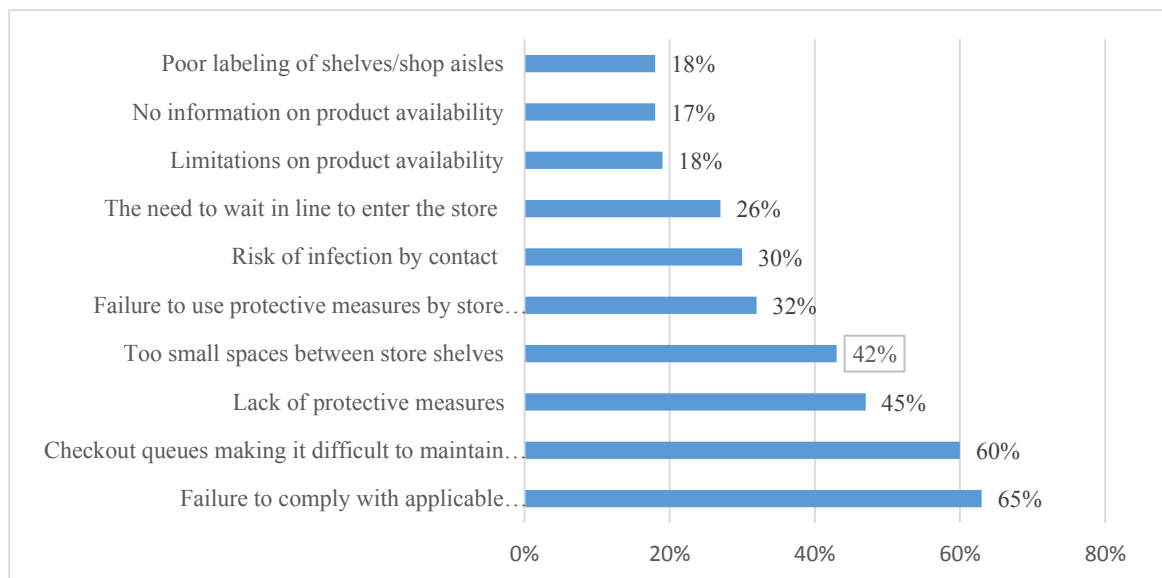
**Figure 7.** The impact of the COVID–19 pandemic on perceptions of stationary shopping.

Source: Own elaboration.

Among those surveyed, 65% of respondents felt that non-compliance with existing rules by other customers was a very significant impediment. A large number, as many as 60% of respondents, pointed to the problem of checkout queues as an obstacle to social distancing. Thus, the most frequently selected inconveniences concerned the lack of safety or partial violation of health safety of those interested in shopping. The least selected impediment had to do with product availability.

Nearly 70% of those surveyed, decided to abandon the idea of shopping stationary during the COVID-19 pandemic and shop online (Figure 8).
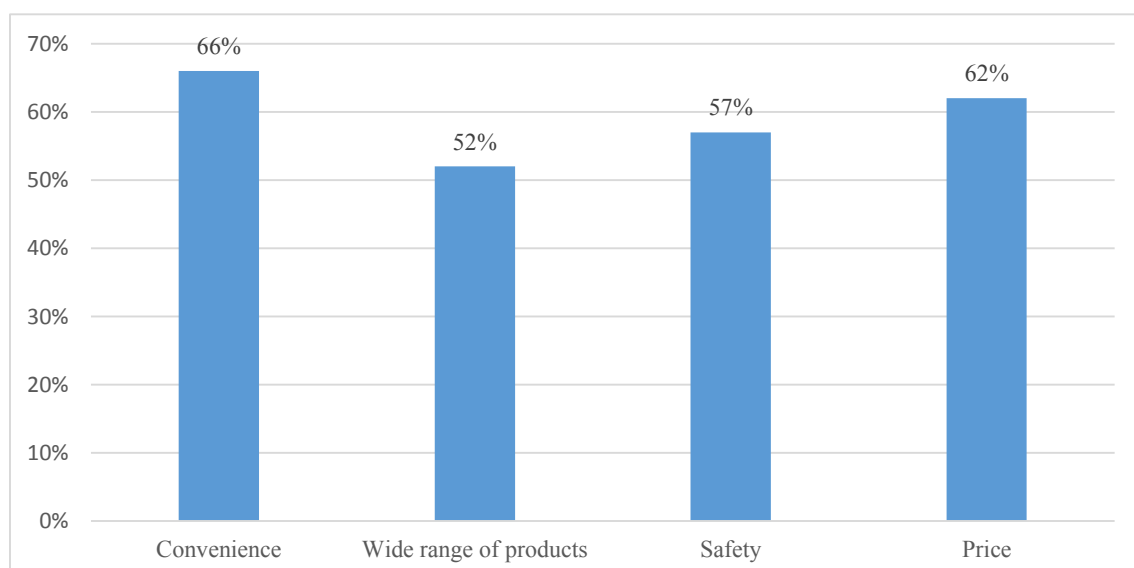


**Figure 8.** Factors affecting online shopping during the COVID–19 pandemic.

Source: Own elaboration.

65% of respondents shopped online because of convenience, with 62% of respondents citing price as the main determinant. In contrast, more than 50% responded that the safety of such purchases and a wide range of products was the reason for online shopping

The pandemic has changed consumer preference for Polish and global brands. It caused an increase in the share of local (38%) and national brands (40%) in the "basket" of respondents (Figure 9).
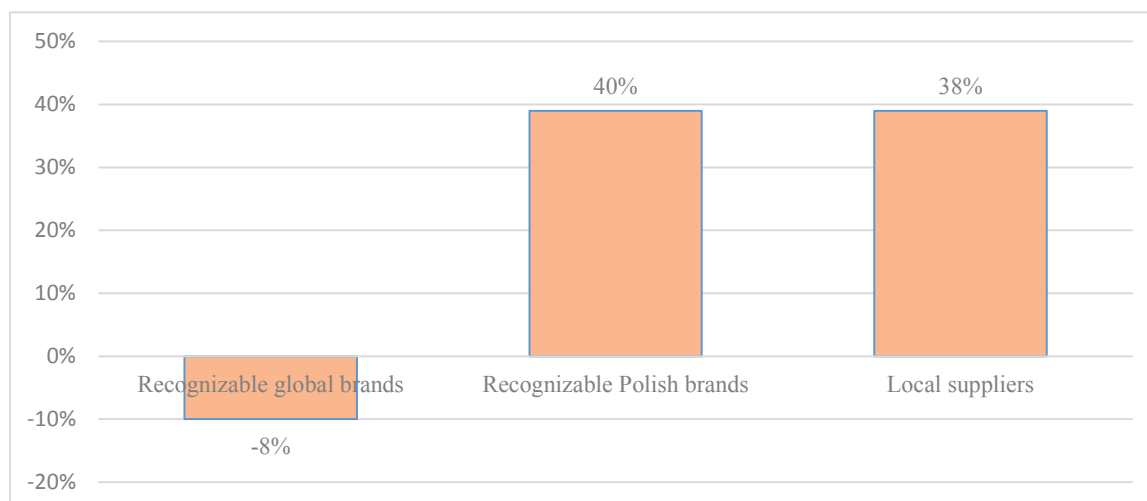


**Figure 9.** The impact of the COVID–19 pandemic on household brand preference.
Source: Own elaboration.

In contrast, recognizable global brands recorded a decline (8%). Given the scale of losses that also Polish entrepreneurs have suffered, this may indicate an act of solidarity towards them and support for domestic producers. This could also have been caused by border closures, which meant that many shipments did not reach their destination countries on time.

At the beginning of the outbreak of the COVID–19 pandemic, but also with its subsequent waves, certain behavior could be observed among buyers. Sales of some products that previously had no sales fluctuations, except for holiday periods, increased over a very short period. According to data from the M/platform portal, over a week, stationary sales of pasta increased by 127%, groats by 158%, soaps by 165%, flours by 175%, rice by 189%, toilet paper by 263% and spirits by 458%. These are necessities, mainly food products, with long expiration date. The purchase of these products was related to the fear of a complete lockdown and provided a protection against such an eventuality. Spirits may have acted as a disinfectant, which was in short supply at the time or was at unfairly high prices (https://mplatform.com.pl). Residents of other countries and continents made similar purchases.

After the outbreak of the pandemic, some countries applied the rules of a partial or complete lockdown. Operations of, for example, transportation, gastronomy and hospitality industry have been limited. The borders, initially, were also closed. The unavailability of goods has intensely affected the assessment of their importance or value. Consumers felt fear of the vision of empty shelves in stores, leading to stockpiling.

## Summary

In conclusion, the article presents the most relevant and common factors shaping purchasing attitudes of consumers in the market. There are many of these determinants, and each of them has a greater or lesser impact on a particular person making purchasing decisions. That is why it is so difficult to classify a potential customer, because each person is a unique combination of different determinants.

The COVID–19 pandemic affected the purchasing behavior of 76% of women and 62% of men participating in the survey. The survey showed how shopping habits have changed during the coronavirus pandemic. About 42% of respondents said they started purchasing more products online and that the frequency of shopping decreased, but they purchased more products at one go. The respondents bought only essential products (18.2%) and spent a larger portion of their money on protective measures than before (15.9%). For 21.5% of the respondents, the pandemic had no impact on their consumer behavior.

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# PREVENTION OF THREATS FROM THE AREA OF FOOD DEFENCE AND FOOD FRAUD ON THE EXAMPLE OF THE SUSHI&FOOD FACTOR COMPANY

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**Purpose:** The main purpose of this article was to present the actions taken by the company in the field of its food defence and food fraud.

**Design/methodology/approach**: The article presents the approach used in the analyzed company to supervise the food defence and food fraud area. As part of the analysis, the applicable documents in the scope of the conducted risk analyzes were presented. The adopted methodology for the evaluation of raw materials and their suppliers in the food fraud area is based on the IFS guidelines, as well as an approach developed by the authors of this study, who participated in the implementation of this methodology in the company.

**Findings:** The presented approach to supervision in the area of food defence and food fraud in the analyzed company ensures its continuous development depending on the changing environment and risk factors. The Sushi&Food Factor company is characterized by a high culture of safety and quality of the produced food. Actions are still being taken to support its development in various areas, such as communication, employee involvement, risk awareness. The activities used by the company related to the verification of the effectiveness of supervision over the areas of food defence and food fraud, such as the simulation of unauthorized access or the review and assessment of incidents that have currently occurred on the market, allow for the necessary preventive measures to be taken.

**Originality/value:** The article presents a practical approach to the implementation of the requirements of standards in the area of food defence and food fraud. The article may be an element influencing the improvement of activities in the discussed areas in other enterprises, which may contribute to the development of their food safety and quality culture.

**Keywords:** Food defence, food fraud, food safety.

**Category of the paper:** Case study.

# Introduction

Ensuring food safety comes down to supervising the threats introduced unintentionally and those threats that may arise as a result of planned (intentional) activities. Hazards introduced unintentionally are supervised under the obligatory HACCP system (Hazard Analysis and Critical Control Point), including microbiological, chemical and physical hazards. The basic requirements to prevent the occurrence of this type of risk are set out in Annex I of the Regulation of the European Parliament and of the Council (EC) No. 852/2004 of April 29, 2004 on the hygiene of foodstuffs (Regulation 852/2022). The threats introduced intentionally include threats related to an attack on food motivated, for example, ideologically - this area is supported by the TACCP (Threat Assessment Critical Control Point) tool. The food defence area has not been regulated by the EU legal requirements. Enterprises operating in the food chain, in order to ensure food safety as part of the food defence area, support the requirements specified in the standards of quality management and food safety. Table 1 presents the requirements of selected food defence standards. On the other hand, when the motivation for an attack on food is the desire to obtain economic benefits, and the result of these actions is fraud (e.g. food/raw material forgery), then the VACCP (Vulnerability Assessment and Critical Control Points) tool can be used to ensure food safety (Górna, 2020). Food safety should be considered in several layers in terms of many factors affecting it, such as (Górna, Kaźmierczak, Zapata, 2021):

- physical, chemical and microbiological hazards,
- food fraud,
- deliberate attacks on food (food defence),
- supply chain security,
- identification and traceability of raw materials, finished products, processes,
- management systems,
- the culture of the organization.

**Table 1.**
*Requirements of selected food quality and safety management standards in the field of food defence*

| Standards | Requirements of food defence |
|---|---|
| GlobalG.A.P.<br>point AF 10 Food defence | "Potential intentional threats to food safety in all phases of the operation shall be identified, assessed, and prioritized. Food defence risk identification shall assure that all input is from safe and secured sources. Information of all employees and subcontractors shall be available. Procedures for corrective action shall be in place in case intentional threat". |

Cont. table 1.

| ISO/TS 22002-1 point 18. Food defence, biovigilance and bioterrorism | A company that wants to meet the requirements of ISO 22000 must also meet the requirements of the technical standard ISO / TS 22002-1, which regulates the area of food defence: „Each establishment shall assess the hazard to products posed by potential acts of sabotage, vandalism or terrorism and shall put in place proportional protective measures. Potentially sensitive areas within the establishment shall be identified, mapped, and subjected to access control. Where feasible, access should be physically restricted by use of locks, electronic card key or alternative systems". |
|---|---|
| BRC point 4.2 Site security and food defence | "The company shall undertake a documented risk assessment (threat assessment) of the potential risks to products from any deliberate attempt to inflict contamination or damage. This threat assessment shall include both internal and external threats. The output from this assessment shall be a documented threat assessment plan. This plan shall be kept under review to reflect changing circumstances and market intelligence. It shall be formally reviewed at least annually and whenever a new risk emerges (e.g. a new threat is publicized or identified), an incident occurs, where product security or food defence is implicated. Where raw materials or products are identified as being at particular risk, the threat assessment plan shall include controls to mitigate these risks. Where prevention is not sufficient or possible, systems shall be in place to identify any tampering. These controls shall be monitored, the results documented, and the controls reviewed at least annually. Areas where a significant risk is identified shall be defined, monitored and controlled. These shall include external storage and intake points for products and raw materials (including packaging). Policies and systems shall be in place to ensure that only authorized personnel have access to production and storage areas, and that access to the site by employees, contractors and visitors is controlled. A visitor recording system shall be in place. Staff shall be trained in site security procedures and food defence. Where required by legislation, the site shall maintain appropriate registrations with the relevant authorities". |
| IFS Food point 6 Food defence plan | "The responsibilities for the food defence plan shall be clearly defined. Those responsible shall have the appropriate specific knowledge and training, and have full commitment from the senior management. A food defence plan and procedure shall be developed based on probability and be implemented in relation to assessed threats. This shall include: legal requirements, identification of critical areas and/or practices and policy of access by employees, visitors and contractors, any other appropriate control measure. The food defence plan shall be reviewed at least annually, and updated when appropriate. The test on the effectiveness of the food defence plan and the related control measures shall be included in the internal audit and the inspection plan. A documented procedure shall exist for managing external inspections and regulatory visits. Relevant personnel shall be trained to execute the procedure". |

Source: (GlobalGAP, ISO/TS 22002-1, BRC, IFS).

When analyzing the presented requirements of selected standards, it should be stated that the necessary action in the field of food defence is to conduct a risk assessment in a given enterprise and, on this basis, to adjust the methods of operation. This article presents the procedure to be followed in this regard in the analyzed enterprise.

Deliberate contamination of food can be initiated by various groups, both direct entities, e.g. an angry employee, or indirect entities, i.e. suppliers and subcontractors. Before starting the implementation of the TACCP system and implementing an effective control system,

it is first necessary to understand the potential offenders, who can be divided into four categories according to their relationship with the company (Adams, Marsh, 2014):

- insiders (internal) - these may be current employees (including temporary employees). This is the most important category of potential perpetrators due to their possible high level of access to the production area and products. This access may cause direct contamination of the product or raw materials. These people often have an emotional connection with the company.

- suppliers and contractors - these can be contractors such as security, cleaning, catering, maintenance companies, which may also have legal access to some of the processes. The lack of effective on-site controls could allow these units to easily access sensitive areas and launch an attack.

- supply chain personnel - may have access to raw materials as well as the finished product. Controlling these areas can be a big challenge for companies due to their remoteness.

- a person from the outside - these are the most distant units for the company. Outsiders may have little chance of access, but may be highly motivated. They may try to increase their access through insiders (bribery, threats).

The perpetrator of the attack is guided by a specific motivation, it may have a financial or ideological basis. A successful finance-driven attack results in property benefits for the perpetrator, loss or costs for the enterprise, and depending on the nature of the threat, the attack may or may not result in harm to the consumer. While an ideologically motivated attack (e.g. terrorist contamination of food stocks with toxic agents) is more likely to result in harm to the consumer and at the same time loss and cost for the enterprise. Revenge of a disgruntled employee may also be enough motivation to attack.

In response to the needs of the agri-food sector, among others, the BSI organization has developed the publicly available PAS 96 specification, which is intended to help prevent deliberate terrorist attacks. The goal of PAS 96 is to improve the resistance of all parts of the production and supply chain to attack. PAS 96 covers the types of attackers and identifies a number of specific threats, including: Extortion; Malignant contamination; Cyber Crime; Espionage; Economically motivated adulteration; Counterfeiting (Wysokińska-Senkus, Górna, Kaźmierczak, Mielcarek, Senkus, 2022; PAS 96:2017).

The practice of adulterating foods is as old as the art of buying and selling food for cash or commodities. In ancient Rome and Athens, laws were enacted regarding the adulteration of wines with flavors and colors. However, it was not until the thirteenth century that Europe saw the beginnings of legislation prohibiting food adulteration when France and Germany passed food control statutes and King John in England issued a proclamation regarding penalties for the adulteration of bread. More extensive legislation regarding adulteration of human food was passed by Henry III (Sumar, Imail, 1995). Food counterfeiting and fraud have long ago forced specific actions to limit this practice. The first Food Adulteration Act was passed in 1860 in

Great Britain (Shears, 2010). In the context of food scandals – the horse meat scandal or methanol scandal, the European Commission launched the Administrative Assistance and Cooperation (AAC) System. This IT platform enables cross-border administrative cooperation among national authorities to swiftly obtain information on deceptive and fraudulent activities in the food sector (Montanari et al., 2016; Kubova et al., 2018).

The case study presented below can undoubtedly be a guide for other companies in improving the culture of quality and food safety. Actions taken as part of the food fraud and food defence area undoubtedly testify to the level of quality culture and food safety in the company. In addition, due to the new legal requirements regarding the obligation to plan and develop a food safety culture, this case study is all the more important, especially since the presented approach was verified in the examined enterprise during numerous external and internal audits.

## 2. The functioning of the food defence area at Sushi&Food Factor

The Sushi&Food Factor company was established in 2015 and specializes in the production of ready meals and sushi sets for the needs of Polish and foreign retail chains. In order to guarantee customers and consumers that the company carries out the production and distribution process with the greatest care for the quality and safety of products, a management system has been implemented and maintained in accordance with such standards as GlobalGAP, MSC, ASC, IFS, BRC. In Sushi&Food Factor, a HACCP team has been appointed, whose responsibilities also include the Food Defence and Food Fraud areas. The HACCP team consists of employees representing the following departments: Quality Department, Maintenance Department, Production Department, Technology Department, Purchasing Department, Logistics and Warehouse Department. The HACCP team leader is the Quality Manager.

The HACCP team is responsible for carrying out a risk analysis related to the functioning food defence system, facility and organization. The risk analysis is verified annually or after changes affecting the integrity of the food.

Team members have the right to access all plant documents and obtain all information necessary to develop a food defence system, facility and organization. All employees are required to provide the members of the team with the necessary information and to cooperate in the implementation of the food defence system, facility and organization.

The food, facility and organization defence system includes:

- raw materials and finished products,
- infrastructure,
- personnel,
- third parties (guests and other persons entering the territory of the organization, including service companies),
- clients,
- national security.

The task of the team is:

- identification of people or groups that may have the intention to harm the food, facility or organization,
- assessment of the likelihood of product contamination,
- identification of the most vulnerable points at risk of attack,
- identification, recording and implementation of preventive actions adequate to threats,
- developing a risk analysis,
- periodic review and verification of findings.

The methodology for estimating the significance of threats is presented in Table 2, while in Table 3 an example of a hazard analysis and risk assessment is presented.

**Table 2.**
*Methodology for estimating the significance of threats*

| PZ | The probability of an event |
|---|---|
| IZ | The significance of the event on the quality and safety of products |
| R | Risk (ratio PZ*IZ)<br>(score: 1-3 low risk; 4-6 medium risk; 7-9 high risk) |

The source of the identified threats can be both internal and external factors, e.g.:

- external threats - organized terrorist groups or groups of activists, drivers of rented means of transport, suppliers of raw materials and packaging, visiting persons,
- internal threats - employees, cleaning crew, repair services.

**Table 3.**
*Hazard analysis and risk assessment in the area of food defence*

| Area / Factor of the Hazard | Place / stage of the hazard occurrence | Description of the hazard | The type of threat (Y - possible occurrence; N - no possibility) | | | | Monitoring measures | Actions in case of occurrence (reactive) | Risk assessment of the occurring threat | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Microbiological | Chemiczne | Radiological | Physical | | | PZ | IZ | R=PZxIZ |
| The area around the facility | Fence | Fence height - possibility of unauthorized access to the area around the Plant | N | N | N | Y | - suitable height<br>- fence monitoring | - arresting an unauthorized person<br>- contact with facility security<br>- monitoring control<br>- contact with the appropriate services | 1 | 2 | 2 |
| | Possibility of unauthorized access | Fence tightness:<br>- Open barrier,<br>- Bad technical condition of the fence | N | N | N | Y | - monitoring the barrier by a security officer<br>- regular security guards around the fence<br>- identification and registration of people entering / entering the area around the Plant by a security officer<br>- admission for pedestrians and motorists only upon presentation of a pass<br>- periodic simulation tests of access to the area around the Plant | - arresting an unauthorized person<br>- contact with facility security<br>- monitoring control<br>- contact with the appropriate services<br>- training for security employees | 2 | 3 | 6 |
| | | Lighting:<br>- Lack / insufficient lighting<br>- Limited identification of people and incidents after dark and during difficult weather conditions | N | N | N | Y | - lighting the area around the company<br>- monitoring of the company's surroundings | - arresting an unauthorized person<br>- contact with facility security<br>- monitoring control<br>- contact with the appropriate services<br>- additional lighting for the area around the plant | 2 | 3 | 6 |
| | Square in front of the Plant | Lack of supervision by a security officer,<br>Insufficient lighting of the square,<br>Monitoring dead spots | N | N | N | Y | - the arrangement of the monitoring vision in different directions<br>- lighting of the square<br>- daily security guard inspection (1 per hour) | - arresting an unauthorized person<br>- contact with facility security<br>- monitoring control<br>- contact with the appropriate services<br>- additional lighting for the area around the plant<br>- increasing the amount of cameras | 2 | 3 | 6 |

An analysis such as that presented in Table 3 was also carried out in the following areas:

- media (water, air, gases, electricity energy, fire protection installation),
- sewage (septic tank, treatment plant),
- external waste storage site,
- supply chain (warehouse – collection of raw materials and packaging; warehouse – pick up of chemicals; courier deliveries; external warehouses),
- office building (office premises; human resources department; the entrance to the office building; windows),
- manufacturing plant (entrance to the plant; canteen; emergency exit – hall I, II; emergency exit – packing; expedition – loading ramps; communication corridor),
- distribution of the finished product.

No high risk was found in any of the analyzed areas, only in the analyzed area "the area around the facility" the risk was found to be medium.

Therefore, activities have been planned in which the Quality Manager and/or a person designated by him will go around the plant at least once a month, checking the effectiveness of the product defence and the plant's condition. The celebration is carried out in the company of representatives of departments such as the Maintenance Department and the Production Department. The records of the round are made on the document "Inspection card – product defence" (Table 4).

**Table 4.**

*Inspection card – product defence*

| No | CONTROL AREA | RATING ☺/☹ | Description of irregularities/ comments, suggestions for improvement | Action taken Signature of the inspector/ responsible person |
|---|---|---|---|---|
| 1 | Inputs / outputs - secured. | ☺ ☹ | | |
| 2 | Tight windows / protected against opening from the outside. | ☺ ☹ | | |
| 3 | Doors / gates tight / closed / protected against opening from the outside. | ☺ ☹ | | |
| 4 | Plant fencing without cavities / unsealing, protected gates and entrances. | ☺ ☹ | | |
| 5 | Water network - direct connections / main intakes, no external access, effectively secured. | ☺ ☹ | | |
| 6 | Ventilation is effectively secured / no possibility of interfering with the cleanliness of the air and getting through the inlet and outlet channels. | ☺ ☹ | | |
| 7 | Video monitoring system / operational efficiency and recording / tracking area control. | ☺ ☹ | | |
| 8 | Control of entries in the register of visitors to internal zones / verification with the actual state. | ☺ ☹ | | |

Cont. table 4.

| 9 | Service Provider Access Verification Control. | ☺ ☹ | | |
|---|---|---|---|---|
| 10 | Do drivers have access to internal zones / interview result. | ☺ ☹ | | |
| 11 | Test result - simulation of unauthorized penetration to the internal zones of the plant / simulation of product or raw material contamination. | ☺ ☹ | | |
| 12 | Has the following been reported in the last month: - presence of people unauthorized in external or internal zones of the plant? - unusual behavior of plant staff? - what were the reasons and what actions were taken based on them? | | | |
| | **☺ – positively, ☹ – negatively**<br>(the need for corrective and corrective actions, notification of the top management of the plant) | | | |
| | The person responsible for carrying out the inspection is a representative of the Quality Department / Production Department / Maintenance Department | | | |
| Date | Controlling persons / signatures | | | |
| | | | | |
| | | | | |

In the case of non-conformity related to product safety, on the basis of the card presented above (Table 4) corrective/corrective or preventive actions and deadlines for their implementation are specified, as well as the persons responsible for supervising their implementation.

## 3. The functioning of the food fraud area at Sushi&Food Factor

The HACCP team, in order to minimize and/or eliminate the risk, conducts a susceptibility assessment to reduce the possibility of food adulteration. In case of a problem, the Quality Manager may involve people who are not members of the HACCP team, e.g. external experts. The team is supported by the Management Board and the Operation Director. The analysis of the team's activities is periodically subject to an internal audit. The team uses various data sources that it collects and analyzes (media, trade literature, industry associations, industry portals, RASFF - Food and Feed Safety Alerts, EFSA - European Food Safety Authority, AAC - Administrative Assistance and Cooperation System, External supervision authorities). On this basis, it makes a vulnerability assessment. Records from the review of information on adulteration in the market are recorded, the significance of the incident on the manufactured product is assessed and, if necessary, additional information is obtained from suppliers on raw materials that may have a significant impact on the stability of the finished product. Table 6 shows an example of records that have been recorded for incidents with raw materials used in Sushi&Food Factor.

**Table 5.**

*Review of incidents of adulteration - selected examples*

| Classification, group/ Assortment name | Product description | Date | Reporting country | A kind of adulte-ration | Significance of an incident for our product | Comments |
|---|---|---|---|---|---|---|
| Fats and oils/ Cooking oil | As a result of an inspection carried out by the Food Safety and Standards Authority of India (FSSAI) found numerous discrepancies in the parameters of the cooking oil. Among of the samples taken, 2.42% of the 4,461 tested, were non-conform safety features that included the presence of aflatoxins, pesticide residues and heavy metals at levels higher than those specified in the norms and norms Food Safety Regulation (FSSR). Also 24.2% of the tested samples it did not meet the quality criteria indicating possible adulteration of the oils groceries in the market. Other non-conformities observed with respect to quality were not meeting the durability standards (acid number, moisture content, rancidity, peroxide number, etc.) and prescribed standards for additives. In addition, 12.8% of samples were found to be non-conformity with the labeling rules. | 29.12. 2021 | India | Dilution | Yes | Letter to the supplier; no oil supplies from India |
| Sugar and sweeteners/ Sugar | EU reports: The Philippines, in the port of Subic, the authorities seized smuggled sugar worth 300,000 euros. | 4.02. 2022 | Philippines | Gray area - illegal trade | No | Letter to the supplier: The sugar used in the production does not come from the Philippines |
| Sugar and sweeteners/ Sugar | EU reports: Argentina, authorities seized 14 tons of smuggled sugar. | 7.02. 2022 | Argentina | Gray area - illegal trade | No | No sugar supplies from the raw material from Argentina |
| Fishes and seafood/ Salmon | Belgium. The company is recalling skinless salmon fillets due to the lack of an 'use by' date on the label, which is 19/04/2022. | 20.04. 2022 | Belgium | Incorrect labeling | No | Salmon delivered to Sushi&Food Factor, not under contract with suppliers from Belgium; Fishing for salmon: Norway |
| Sugar and sweeteners/ Sugar | Peru. The authorities seized 2 tonnes of smuggled sugar. | 12.05. 2022 | Peru | Gray area - illegal trade | No | None of the sugar suppliers for Sushi&Food Factor source raw materials from Peru. |

The team carries out a product fraud vulnerability assessment for each raw material and packaging. In order to document the product fraud susceptibility assessment process, a product fraud reduction plan was designed[1]. The vulnerability risk assessment is carried out in the following manner:

a. Product susceptibility risk assessment:

- assessment of the likelihood of a case occurring,
- assessment of the likelihood of rapid detection.

b. Supplier vulnerability risk assessment.

c. Assessment of current control measures.

The following risk factors were taken into account when assessing the risk of product vulnerability: historical data on product fraud, economic factors, ease of fraud, supply chain structure, current fraud detection control measures (IFS, 2018; Górna, 2020). Based on the matrix from the IFS guide, the probability of occurrence and detection of the above-mentioned risk factors, and the results were recorded in a developed product fraud reduction plan. An overall risk assessment of the product was then obtained.

Then, the supplier's vulnerability risk was assessed, taking into account the following risk factors (IFS, 2018; Górna, 2020):

- economic stability of the supplier,
- were any suppliers affected by layoffs or pay problems?,
- historical data on business contacts with the supplier (complaints, withdrawals),
- results of qualification and periodic assessment of suppliers,
- supplier's openness to audit/inspection,
- supplier management systems used,
- work ethics in the supplier's region/country (the worse the ethical working conditions at the supplier, the greater the risk),
- level of legal control in the supplier's region/country (the higher the level, the lower the risk).

Based on the above risk factors, the level of trust in a given supplier was assessed. The overall score was then calculated - multiplying the overall product risk score with the supplier's vulnerability risk score. Based on an arbitrarily set criterion for the interpretation of scores, adequate actions are determined (Table 6) depending on the assessment of the applied control measures (Table 7).

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[1] The product fraud mitigation plan sheet and procedure in this company were designed by the authors of this publication based on the guidelines of the IFS guide. The IFS guidelines have been developed by the authors for the needs of this company.

**Table 6.**
*Interpretation of the overall score obtained as a result of the assessment of susceptibility to adulteration of the raw material and the supplier*

| Total scoring | Assessment result |
|---|---|
| up to 64 points | acceptable |
| 65 - 80 points | acceptable for medium to high control measures |
| 81-100 points | requiring action to be taken in the event of low level control measures |
| above 100 points | requiring action to be taken irrespective of the control measures applied so far |

In the next step was assessing the company's current controls in terms of preventing product fraud, including: analytical testing of raw materials, additives, packaging, laboratory analysis certificates, mass balance testing, supplier assessment, suppliers questionnaires, control and inspection 3$^{rd}$ site, frequency of checks. Evaluation of control measures used can be high, medium or low. For the analyzed enterprise, the criteria taken into account for the assessment of the control measures applied were specified (Table 7) (Górna, 2020).

**Table 7.**
*The criteria adopted for assessing control measures in the company*

| Assessment of control measures | Assessment criteria |
|---|---|
| High | Amount of control measures ≥ 5, including mandatory:<br>• analytical testing of raw materials, additives, packaging,<br>• supplier certification towards compliance with the BRC, IFS, FSSC 22000 standard or the supplier audit. |
| Medium | Amount of control measures from 3 to 4, including mandatory:<br>• the supplier is subject to audits or approval based on a questionnaire. |
| Low | Amount of control measures from 1 to 2, including control measures implemented in the plant, do not include analytical testing of raw materials, additives and packaging, and the supplier is subject to approval only on the basis of a questionnaire. |

Source: (Górna, 2020).

As a result of the assessment, the team takes a decision regarding the need for other actions, these may include (IFS, 2018): breaking of or limiting use of raw material, additive, packaging; ceasing to use the given supplier(s); reducing the purchase of the amount of raw material, additive, packaging from a specific supplier (suppliers); change of current control measures depending on the product and control measures, e.g. increased analytical supervision, use of accredited laboratories and methods, increased consumption control, independent pre-shipment control, etc.; maintaining the current level of control.

The product fraud reduction plan (Table 8) in the Sushi&Food Factor company is subject to reviews and possible correction by the team at least once a year or when changes take place.

Table 8.
*The product fraud mitigation plan*

| | | | | Product vulnerability risk scoring | | | | | | Supplier vulnerability risk scoring | | | | |
| Lp. | Raw material / packaging | Origin | Supplier's code | Probability of occurrence: 1 - not very likely 2 - possible 3 - quite possible 4 - probable 5 - very likely | | | Highest point value assigned | Rapid detection probability: 1 - very likely 2 - likely 3 - quite possible 4 - possible 5 - not very likely | | Highest point value assigned | Overall product risk score (column 5 x column 7) - matrix | 1 - very high confidence 2 - high confidence 3 - medium trust 4 - low trust 5 - very low trust | Total scoring (column 8 x column 9) | Current control measures High/ Medium/ Low | Decision of the Product Fraud Evaluation Team | Control measures |
| | | | | History of product fraud cases | Economic factors | Ease of cheating | | Supply chain complexity | Control measures currently in place to detect fraud | | | | | | | |
| 1 | 2 | 3 | 4 | | | | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 1 | Smoked salmon ASC | Norway/Poland | 123 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 2 | Medium | Keeping the supplier | Incoming raw material inspection, Certificate of Conformity (CoC), GFSI recognized certificates, supplier audits |
| 2 | Raw salmon ASC | Norway/Poland | 456 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 2 | Medium | Keeping the supplier | Incoming raw material inspection, Certificate of Conformity (CoC), GFSI recognized certificates, supplier audits |
| 3 | Shrimp ASC | Vietnam/Poland | 789 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 4 | 1 | 4 | Medium | Keeping the supplier | Incoming raw material inspection, Certificate of Conformity (CoC), GFSI recognized certificates, supplier audits |

During provide the vulnerability assessment, the HACCP team also takes into account raw materials and suppliers who put goods on the market with the MSC (Marine Stewardship Council)/ASC (Aquaculture Stewardship Council) logo. This means an increase in the susceptibility to adulteration both in the case of the raw material and the producer that supplies it, due to the need to meet the requirements of standards for the sustainable harvesting of wild fish and seafood and responsible aquaculture. In this case, a large responsibility rests with the Purchasing Department Director and/or Global Sourcing Director order for certified raw materials to a certified supplier in accordance with the current register of certified MSC/ASC suppliers available in the company (each time the supplier's status on the MSC/ASC is checked website). In addition, to enable identification/traceability, MSC/ASC raw materials have individual indexes (e.g. 121718 ASC Shrimp) in the computer system, under which only orders and deliveries of certified raw materials are recorded. In case certified suppliers after expanding the index, select the appropriate one (the name of the supplier and MSC/ASC certificate number will appear). As result the implemented and certified quality and safety management system for compliance with the requirements of the BRC, IFS, MSC/ASC standards and a high culture of food safety and quality, the Sushi&Food Factor company applies medium and high level controls, which ensure protection against adulteration.

## 4. Conclusions

The presented approach to supervision of food defence and food fraud area in the analyzed company ensures its continuous development depending on the environment changes and risk factors. The Sushi&Food Factor company is characterized by a high culture safety and quality of the produced food. Actions are still taken to support its development in various areas, such as communication, employee involvement, risk awareness. This is achieved thanks to periodically organized training sessions devoted to specific topic. Noteworthy is the simulation of unauthorized access to the internal area of the company. That action allows to verify the effectiveness of the applied solutions in food defence area. With regard to the functioning of the plan to reduce product fraud, the actions taken to review incidents in the area of adulteration that occurred on the market deserve attention. This approach allows you to review the validity of the current product fraud mitigation plan and, if necessary, immediately take additional preventive measures to reduce the impact of a given incident on the processes carried out in the company. It should be noted that the company used classic Microsoft Office applications to implement the adopted methodology of conduct in the field of food fraud and food defence analysis. Thanks to this, any company that wants to improve its activities in this area will not encounter technical barriers. The presented solutions have been functioning at Sushi&Food Factor for several years and are periodically assessed by retail chain auditors, certification

bodies and food safety supervisory authorities, as well as food safety and quality experts. Each company, based on the current situational analysis of the supplied raw materials or emerging crisis situations on the market, still has to keep its finger on the pulse to be ready to implement preventive actions and improve the adopted approach to supervising food fraud and food defence areas.

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# THE IDENTIFICATION OF QUALITY CONTROL METHODS USED IN THE PACKAGING PRODUCTION PROCESS

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**Purpose**: The aim of the article is to identify the quality control methods used in companies producing packaging and to obtain knowledge of the scope of the use of optical sensors.

**Design/methodology/approach:** Enterprises located in Poland in the Greater Poland Voivodeship, producing paper, board, corrugated and plastic packaging. The triangulation strategy was used in the study in which Computer Assisted Web Interview (CATI), Individual In-depth Interviews (IDIs), and Case Study were applied. The subject of research was the identification of quality control methods at individual stages of packaging production and the responsibility for carrying it out, as well as the method of presenting the control results. In addition, the use of optical sensors for quality control was assessed.

**Findings:** Digitalization of manufacturing leading to the Industry 4.0 concept provides novel tools for quality control and data storing. It enables real-time data collection and processing for even better even better management of the production process and quality control. However, the concept of Industry 4.0 (including Big Data Analysis, Internet of Things, Artificial Intelligence, Neural Networks) is not new, still many companies find it difficult to implement it and benefit from its capabilities. The surveyed packaging companies are characterized by low use of the possibilities related to the use of more advanced methods of product quality control at individual stages of the production process. The potential for improvement is the area of process and product control through the use of optical sensors/actuators, etc., and the form of keeping records of the product quality checks carried out.

**Research limitations/implications**: The results of this research are not representative, but they encourage the authors to carry out a broader and more in-depth analysis of the research subject on a national scale.

**Practical implications:** Research indicates the need to improve the quality control process in the production of packaging and a wider use of modern solutions with the use of optical sensors.

**Originality/value:** An article can be an element influencing the management to better select quality control methods at various stages of the production process.

# 1.  Introduction

Packing is one of the necessary operations in almost every production process (Wolniak, Zadura, 2012), most of the manufactured products go to the market in packaged form. Packaging is a product made of any type of material, intended for the storage, protection, transport, delivery and presentation of goods, used by moving from raw material to processed product, and so from producer to user or consumer (PN-EN ISO 14182:2005). Packaging is made of various raw materials and is still subject to innovation. Taking into account the criterion of the raw material from which the packaging is made, packaging made of paper, plastic, metal and glass is distinguished (Lisińska-Kuśnierz, 2005, pp. 9-10).

Due to the fact, that the packaging is used in various ways, they can be grouped in three types/levels:

- primary packaging (primary, unit), includes materials in direct contact with the product, it contains the product, therefor it's vital for ensuring the high quality of product.
- secondary packaging (additional, collective) is used for grouping primary packaging and facilitating their transport as well as display in retail locations.
- tertiary (transport) packaging is used for protection and shipment in the distribution process (e.g. baskets, pallets, boxes) (Leszczyński, Żbikowska, 2016, pp. 11-12).

Packaging should have the following functions:

1) protection of the product during storage, transport and use, as well as, protection of the environment against harmful effects of the product,
2) enabling and facilitating: production, wholesale and retail trade and use of products,
3) information, *inter alia*, about: the raw material composition of the product, its calorific value, method of preparation for consumption and the date of expiry or use-by date,
4) the product packaging should be attractive in terms of graphics and colors, i.e. arouse the interest of a potential consumer (Sykut, Kowalik, Droździel, 2013; Lee, Rahman, 2014; Ghaani et al., 2016).

Food packaging plays an important role because of its impact on safety and quality of the packed product. Packaging is an integral part of packed food; it serves as a protective barrier and enables the desired quality, freshness and durability to be maintained. Safe packaging should be characterized primarily by an appropriate sanitary and hygienic condition, not posing any threat to the packed food product, but should also ensure the safe use of the packaging (Szumicka, Górna, 2018; Wang, Wu, Cao, 2019).

Packaging manufacturers are responsible for controlling the production process, starting from the preparation stage of the production process, through its stages, ending with the release of finished products. The quality of packaging is determined by many factors, including quality of raw materials, materials and tools used (e.g. paints, printing base, printing forms, dies, adhesives), selection of the appropriate technology, knowledge and experience of personnel, machines and devices, hygiene in the plant, process and product control, documentation of activities (Winkowska, Winkowski, 2018). Quality control is essential for improving any manufacturing process. It encourages quality consciousness among workers, enables a more efficient utilization of resources and results in products of better quality at reduced production costs (Tusar et al., 2017). Product inspection should be strictly planned as to its place and time, method of conducting and criteria for accepting, rejecting, repairing the product and the persons responsible for carrying it out. Provisions confirming the fact of carrying out the control and its results, which confirm whether or not the specified requirements have been met, should be specified. Product monitoring is not only about measuring a specific physical property, but also about visual evaluation. Before the product is passed on to further processing steps and ultimately the customer, it must be ensured that the product has passed the inspection. Depending on the specificity of activities, it may be advisable to carry out an inter-operational and final control (Winkowska, Winkowski, 2018).

Depending on the intended use of the packaging (including whether the packages are for direct and indirect contact with the product) and customer requirements, defects are classified into critical defects, which make the use of the packaging dangerous, major defects and minor defects (slight deviations, minor or minor deviations imperceptible to the customer). The manufacturer, based on their own knowledge and experience, in combination with customer requirements, develops their own classification of quality defects and develops control plans, which are used by employees responsible for quality control in the company (Szumicka, 2021). The types of quality defects will vary depending on the type of raw material used for the production of packaging and the processing method - e.g. printing, lamination, etc. According to Regulation (EC) No. 178/2002 establishing the general principles and requirements of food law and establishing procedures in the field of food safety, packaging producers as participants in the food chain must identify, eliminate or limit safety-related hazards (Table 1). Food packaging can retard product deterioration, retain the beneficial effects of processing, extend shelf-life, and maintain or increase the quality and safety of food. In doing so, packaging provides protection from 3 major classes of external influences: chemical, biological, and physical (Marsh, Bugusu, 2007, pp. 39).

**Table 1.**
*Types of hazards in the production of food packaging*

| Hazards | Type of Raw Material | | | |
|---|---|---|---|---|
| | **Paper** | **Plastic** | **Glass** | **Metal** |
| **Physical** | Foreign bodies: glass, metal, wood, plastics, hair, jewelry components, sand and stones, pests and pest droppings | | | |
| **Biological** | bacteria, viruses, toxins, fungi | | | |
| **Chemical** | heavy metals, mineral oils, formaldehyde, PAA, Pentachlorophenol (PCP) | heavy metals, mineral oils, phthalates, formaldehyde, Primary Aromatic Amines (PAA) | cadmium, lead | metals, Bisphenol A (BPA) |
| **Quality defects** | creases, stains, scratches, cracks, leaks, deformations, color saturation, illegible information, print registration | | improper stress relief, gas bubbles, scratches, overburden, inhomogeneous thickness, improper holes, notched edges, improper bonding of the body and the bottom | cracks, leaks, defects in the quality of the paint coating, deformations, sharp edges, nicks, bad formation of the flange, low strength of the weld, no rubber gasket |

Source: (Emblem, Emblem, 2012; Caruso et al., 2017; Roohi et al. 2018, Sčetar, Barukčić, Kurek, 2019; Szumicka 2021).

Modern technological solutions such as intelligent optical sensors are contributing to the development of a new era of optimization of production processes (IoT in the Polish economy, 2019). Thanks to them, the quality of products and the quality of the production process can be monitored in accordance with the concept of Industry 4.0. The transformation to Industry 4.0 is driven by the demand for shorter delivery times, more efficient and automated processes, higher quality and customized products. Key technologies of Industry 4.0 are among others Cyber Physical Systems (CPS), Internet of Things (IoT), Smart Factories, Embedded Systems, sensors and actuators, Big Data, Cloud Manufacturing and Computing, Radio Frequency Identification (RFID), Automation, Autonomous Robots, Additive Manufacturing, Virtual Reality, Augmented Reality, Data Mining, Advanced/Smart Materials, Artificial Intelligence (AI), Machine Learning (ML), Cyber Security (Müller, Schmid, 2019; Demir, Testa, 2020; Wójcicki et al., 2022).

## 2. Method

Research has been conducted in 2021 and has been divided into two major parts – theoretical part and empirical part. The results of theoretical part have been published in the article titled Internet of Things in Industry: Research Profiling, Application, Challenges and Opportunities (Wójcicki et al., 2022). The empirical part was conducted with the application of triangulation

strategy. The triangulation strategy consist in combining various methods while examining one research problem aiming to increase the amount of collected knowledge and the value of the data. The data was collected using the combination of three methods: Computer Assisted Web Interview (CATI), Individual In-depth Interviews (IDIs), and Case Study.

Data presented in this research paper are based on the results of the first stage of empirical study. Quantitative data has been gathered based on a survey questionnaire. CATI (Computer Assisted Telephone Interview) has been used as a data collection technique. CATI is an Internet surveying technique in which the interviewee follows a script provided in a website or by telephone. The research population consisted of 132 enterprises located in Poland in the Greater Poland Voivodeship and classified under the following codes of the Polish Classification of Activities (PKD):

- 17.21.Z Manufacture of corrugated and corrugated cardboard as well as paper and cardboard packaging.
- 22.22.Z Production of plastic packaging.

68 enterprises took part in the study, which constitutes 51% of the surveyed population. Telephone interviews were conducted only with employees at selected positions within the organizations and competent to provide information on the subject matter (company owners, quality directors or managers, production directors or managers, and technologists). The survey questionnaire contained 17 questions related to quality control methods and techniques, the use of optical sensors, application of systems and Industrial Internet of Things (IIoT).

## 3. Results and discussion

Among the surveyed enterprises, the largest percentage was constituted by enterprises producing plastic packaging (44.1%), while the smallest percentage was constituted by enterprises producing multilayer packaging using three raw material groups - plastics, paper and aluminum (17,6%) (Figure 1).
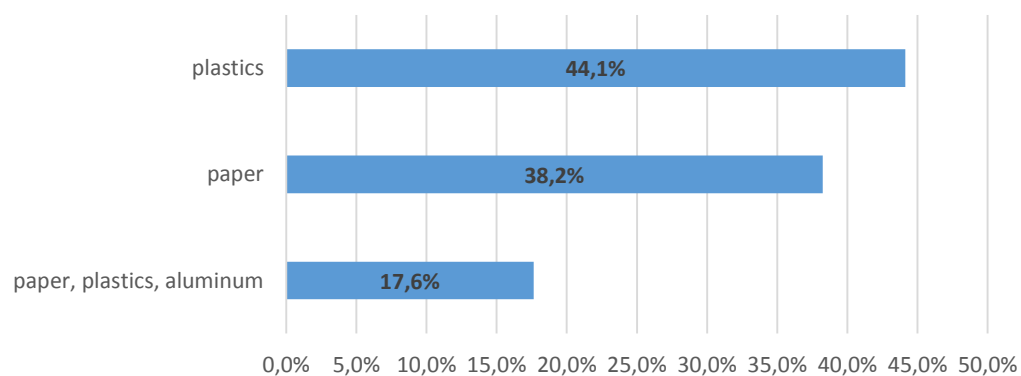


**Figure 1.** The structure of enterprises in terms of the material of manufactured packaging.

Source: Authors' own research.

Almost 59% of enterprises use packaging printing in the production process (Figure 2).
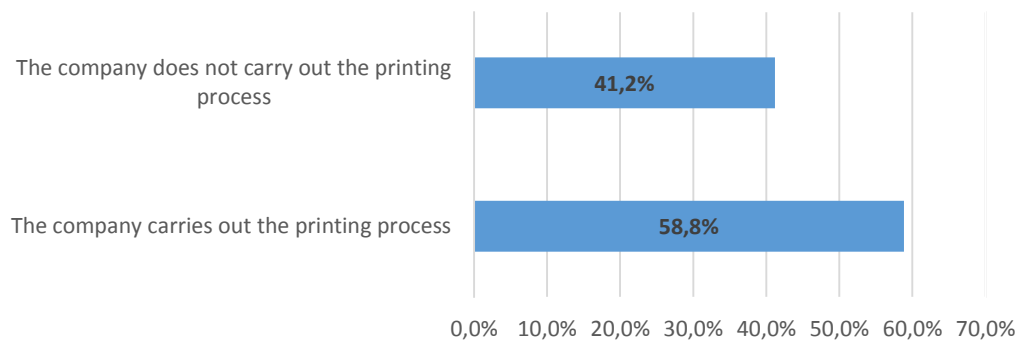


**Figure 2.** The structure of enterprises in terms of the implementation of the printing process.
Source: Authors' own research.

Most of the surveyed companies (over 50%) declared the production of packaging for contact with food (Figure 3).
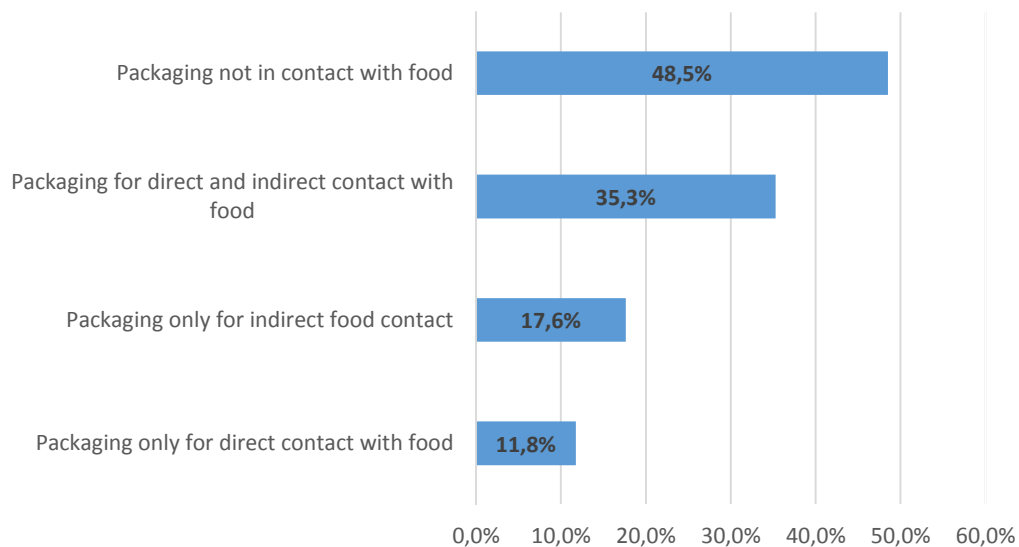


**Figure 3.** Purpose of the manufactured packaging.
Source: Authors' own research.

35.3% of the surveyed companies declared the production of packaging for direct and indirect contact with food, and 17.6% manufacture packaging only for indirect contact with food. On the other hand, 11.8% of enterprises indicated that they manufacture packaging intended for direct contact with food. In general, companies that produce packaging for direct or indirect contact with food and other hygienically sensitive products (e.g. cosmetics) are forced to comply with legal requirements regarding the supervision of the safety of these packaging, which results in the need to conduct tests of manufactured products and implement effective product quality control and the production process.

The analyzed enterprises declared that they have a certified management system (Figure 4).
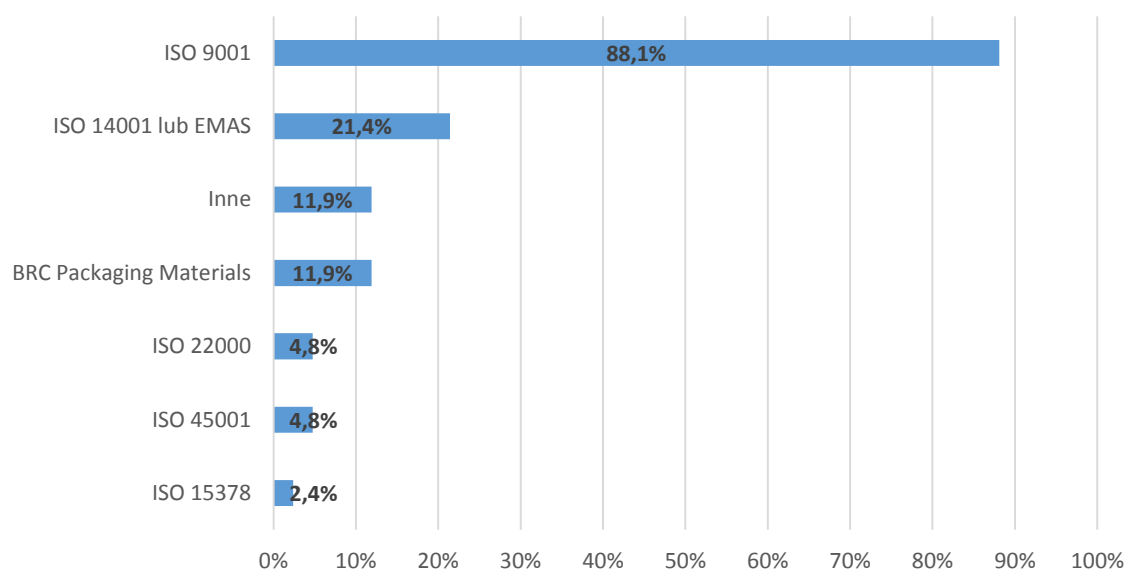


**Figure 4.** Certified management systems implemented in the enterprise.

Source: Authors' own research.

Most, i.e. almost 90% of enterprises declared having a quality management system in accordance with the requirements of ISO 9001 "Quality Management Systems – Requirements", while the least of the surveyed enterprises declared having a certified quality management system in accordance with ISO 15378 "Primary packaging materials for medicinal products — Particular requirements for the application of ISO 9001:2015, with reference to good manufacturing practice (GMP)", which is understandable, as this standard applies to a narrow group of enterprises producing direct packaging materials for medicinal products.

As a rule, the interviews were conducted only with people competent to provide information on the subject matter studied, they were company owners, directors or quality managers, production directors or managers, and technologists.

## 3.1.  Methods of raw material quality control

Raw material quality control is a key element in any manufacturing company. The use of appropriate control methods allows for the avoidance of future problems with the raw material during processing operations or the use of an already finished product. The representatives of the surveyed companies were asked about the methods of quality control used at this stage of the production process, who carries out the control and how its results are recorded. The respondents had a choice of 8 most adequate control methods and the possibility to select the option "other". However, despite indicating the option "other", they did not specify its type. 88% of respondents indicated the use of organoleptic evaluation at the stage of raw material quality verification. In most enterprises (57%) it is carried out by line employees, which proves that employees are empowered to perform tasks in this area. On the other hand, almost 100% of the surveyed companies indicated that they verify the quality specifications for a given batch

of raw material and declarations of conformity, as well as examine for example the grammage and thickness. Although, spectroscopic (68%) and chromatographic (60%) tests are carried out in the surveyed enterprises, still most common are verification of documentation regarding quality specification (94%), verification of declaration of conformity (93%), grammage control (93%), thickness control (90%) and organoleptic assessment (88%) (Figure 5).
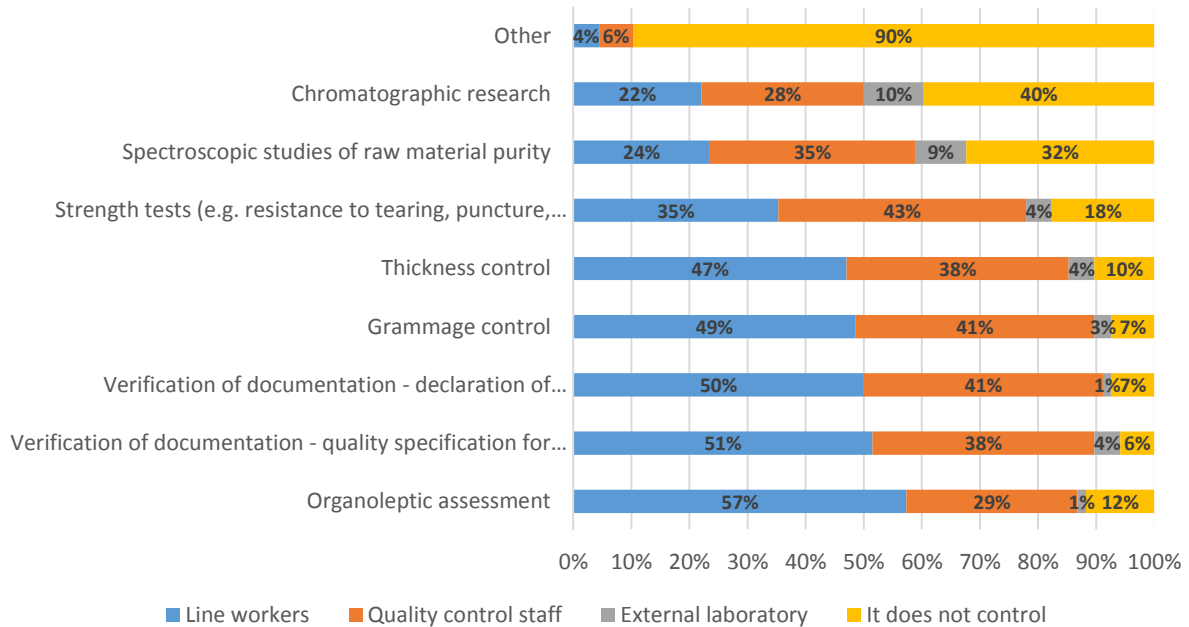


**Figure 5.** Methods of controlling the quality of raw materials and levels of responsibility.
Source: Authors' own research.

Line workers and quality control workers are most often responsible for the inspection of raw materials. A small percentage of tests are delegated to external laboratories. About 10% of the surveyed companies carry out chromatographic and spectroscopic tests in external laboratories and 50% and 59% respectively on site. Based on the survey, it can be concluded that more and more enterprises are equipped with equipment that allows qualified employees to carry out this type of research on site.
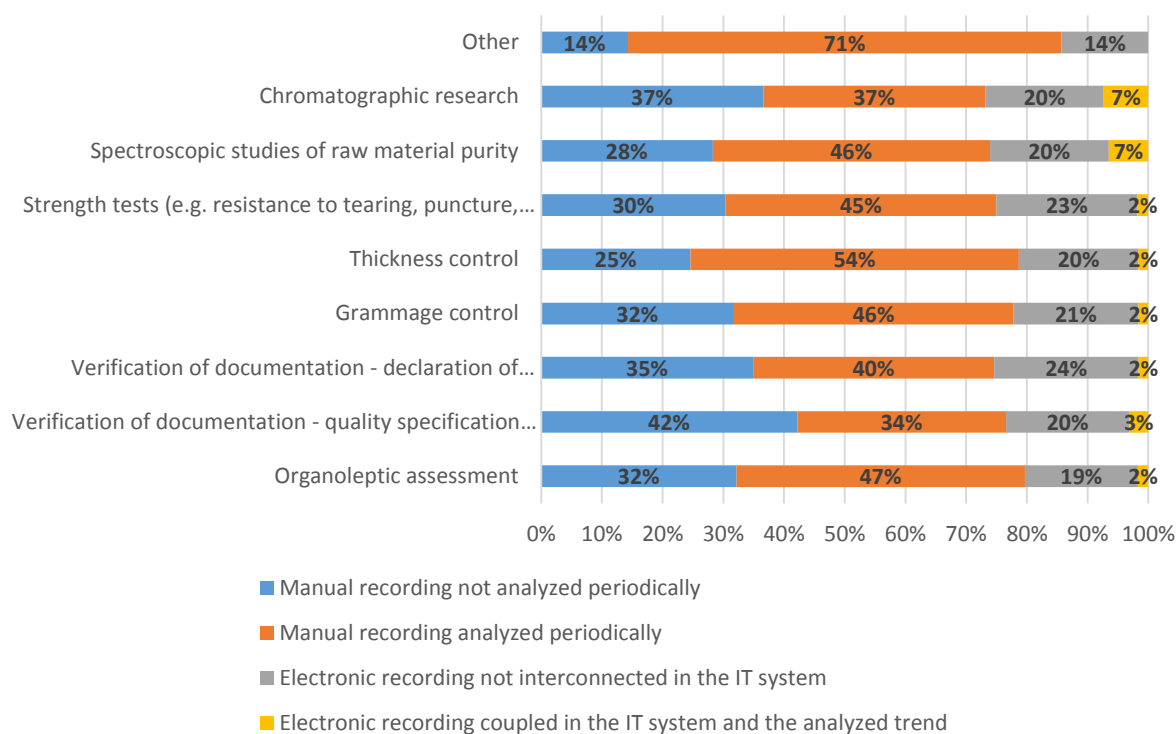
**Figure 6.** Measurement methods for quality control of raw materials and forms of records.
Source: Authors' own research.

The respondents were asked to indicate the form of records that are created after conducting a given raw material survey (Figure 6). The highest percentage of indications concerned the form of handwritten records, which are periodically analyzed. At the same time, a disturbingly large percentage are also manual entries, which are not subject to periodic analysis. Only 2-7% are electronic records coupled with the information technology (IT) system, thanks to which trends may be analyzed. In the era of Industry 4.0, it is disturbing that this form of recording the results of qualitative research is still uncommon among enterprises.

### 3.2. Product quality control during and at the end of the production process

The surveyed companies indicated which methods of product quality control they apply during the production process. The largest percentage of respondents (94%) uses visual assessment of the quality of semi-finished products in terms of compliance with color patterns (e.g. Pantone) (Figure 7). These tests are carried out in most enterprises by line employees (60%). On the other hand, the remaining tests are carried out to a comparable extent by both line employees and quality control employees. It should be presumed that the tests carried out by quality control employees will be tests verifying the correctness of tests carried out by line employees.
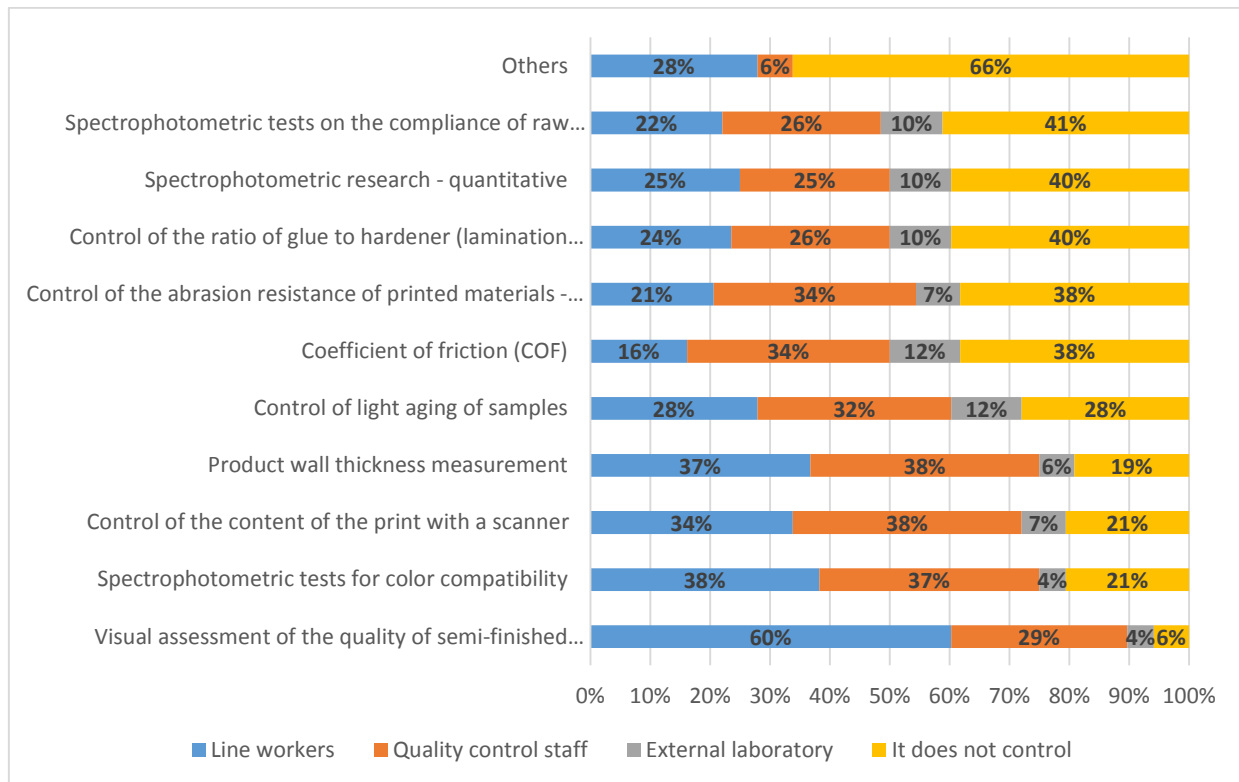
**Figure 7.** Verification of product quality control during the production process.

Source: Authors' own research.

The respondents were asked about the reasons for not carrying out product quality verification during the production process. The respondents mainly indicated that some of the surveys do not apply to their products, and do not have the appropriate infrastructure. Interestingly, about 20% of the respondents indicated that they did not carry out such tests, because customers do not require them to do so. It can be concluded that customer requirements are of key importance for the quality control methods used in the surveyed companies. Considering this, it can be assumed that this kind of activity allows for reduction of production costs.

At the end of the production process, the quality of the manufactured products is checked by 98% of the surveyed respondents through visual assessment for compliance with the finished product patterns (Figure 8). This form of control is most often performed by line workers (66%), which proves that product control is incorporated into the production line. There are no significant differences in the distribution of responsibilities for the performance of the remaining controls. It can only be pointed out that a relatively small percentage of tests is outsourced to external laboratories, which is often associated with high costs for enterprises, hence it is more advantageous to carry out these indicated forms of product control on-site at the plant.
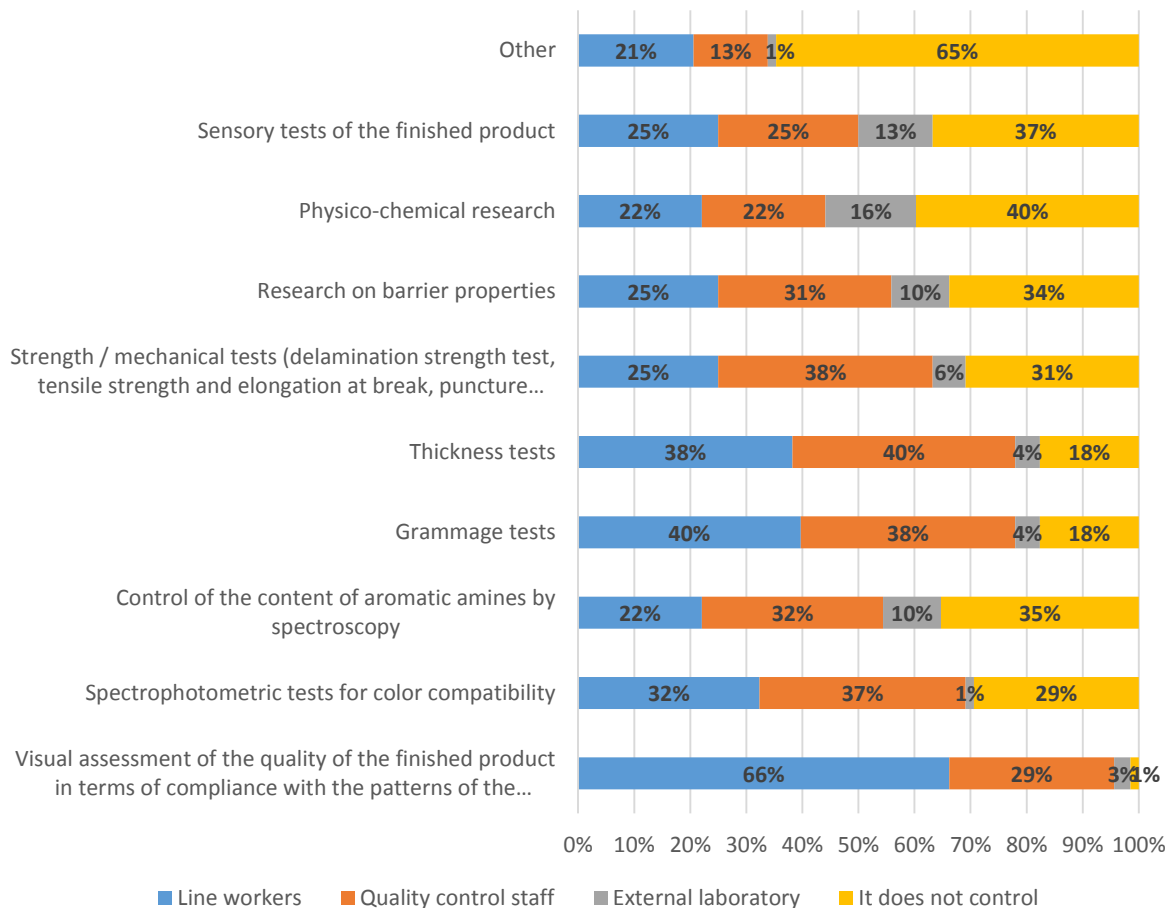
**Figure 8.** Verification of product quality control at the end of the production process.

Source: Authors' own research.

A significant percentage of the surveyed companies do not perform, among others:

- physico-chemical tests (40%),
- sensory tests of finished products (37%),
- spectroscopic analysis of the aromatic amines content (35%),
- tests of barrier properties (34%).

Considering that the research was conducted among enterprises producing food packaging, the fact that such a percentage of respondents did not undertake research on products in the above-mentioned areas is disturbing. In order to gain knowledge about the use of optical sensors / actuators in enterprises and their use in supervising the quality of products, information was obtained from respondents, which proves that the use of this type of devices in the industry under research is still very limited (Figure 9).
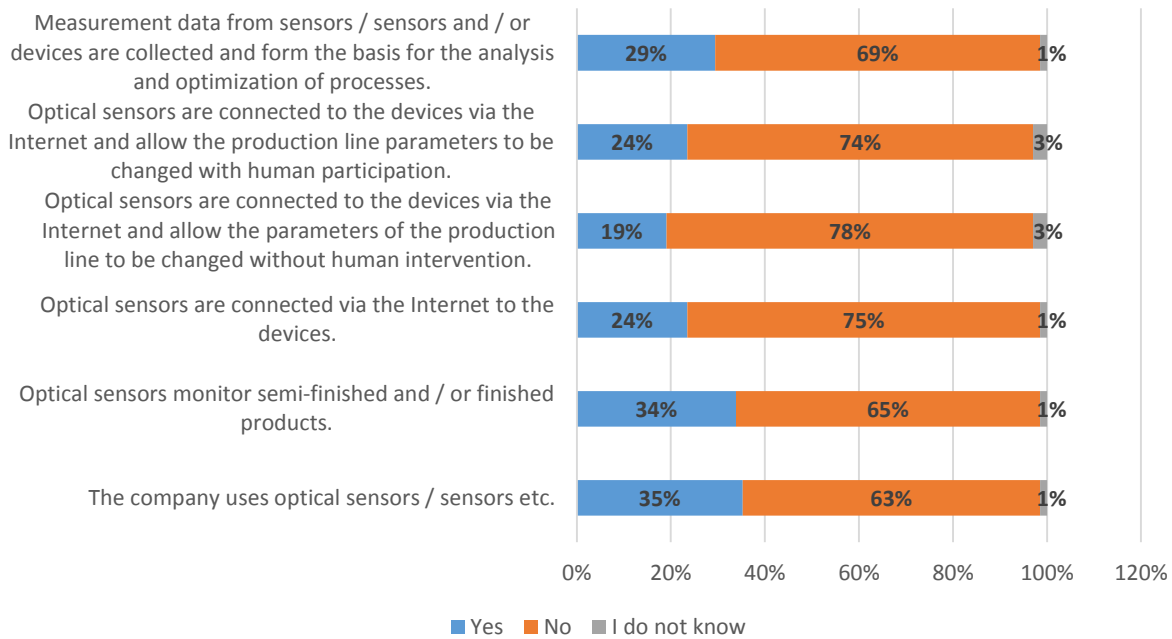
**Figure 9.** The use of optical sensors/actuators for product quality monitoring.

Source: Authors' own research.

Only 34% of the surveyed companies use optical sensors/sensors to monitor products, and 29% use the collected measurement data for process analysis and optimization. In turn, only 19% of the surveyed companies have optical sensors connected to devices via the Internet, which allows the parameters of the production line to be changed without human intervention. In the era of Industry 4.0, the collected data proves the still poor development of enterprises in this industry in the use of technology development. Over 60% of surveyed companies do not use any sensors for quality monitoring. This suggests that this process is being performed manually. Only a small percentage of companies (1-3%) is not aware of the use of optical sensors in their company.

## 4. Conclusions

The surveyed companies indicated that tests were carried out at various stages of the production process, from sensory tests, documentation verification to the use of more advanced tests. The highest percentage of respondents indicated the use of a manual entry form from the conducted quality inspections, and a negligible percentage of respondents indicated the use of electronically coupled entries to an IT system. In the era of Industry 4.0, it is disturbing that this form of recording the results of qualitative research is still not uncommon among enterprises. Moreover, the fact that over 60% of companies do not use any sensors for quality monitoring, can lead to an assumption that respondents are either not aware of their existence at the

production lines or in fact don't have them. However, it's doubtful as more and more production lines are already equipped with different sensors monitoring different parameters during production process.

Over 58% of the surveyed companies declared that they use packaging printing, while at the same time 37-40% declared that they did not carry out physico-chemical and sensory tests. Printed packaging carries a number of threats to packaged food. Lack of control in the indicated areas means that we are dealing with a high risk of chemical contamination. Printed packaging is most often laminated, and 35% of the surveyed companies do not control the content of aromatic amines. At the same time, it should be noted that during the interviews, the respondents often indicated the lack of customer requirements as the reason for not carrying out specific testing. Therefore, it can be concluded that customers are the factor influencing the application of certain methods of product control by packaging producers.

A small percentage of the surveyed companies had the implemented BRC Packaging Materials standard (11.9%), which probably also influenced the results of the research in the scope of controls carried out in the packaging production process. The requirements of this standard impose the need to control the process and the product, therefore the production plant must prove that it applies reliable control methods confirming the quality and safety of the manufactured products.

Line workers are engaged in product quality control in the surveyed companies, and most often they perform visual assessments. It is still possible to observe a significant proportion of employees of quality control departments in the performance of product tests at individual stages of the production process. Out of this group, a small percentage of the research is commissioned to external laboratories, which is probably related to the lack of customer requirement and high costs, which can still be a barrier to undertaking this type of research.

The conducted research showed little use of optical sensors / actuators etc. for product monitoring in the companies that did perform analysis. Thus, it can be indicated that the use of optical sensors/actuators is an opportunity for improvement for enterprises operating in this industry.

## Acknowledgements

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# CUSTOMER PREFERENCES OF MODERN TECHNOLOGIES (PROPTECH) ON THE PRIMARY HOUSING MARKET

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**Introduction/background**: The residential property market is in a state of constant flux, largely a consequence of the intensive development and increasing availability of modern technologies termed PropTech. Relatively resistant to change, the real estate sector is undoubtedly undergoing a technological revolution. PropTech affects the activities of entities that create both supply and services on the real estate market. In addition, it also affects the customer.

**Aim of the paper**: The aim of the paper is to identify the attitudes and preferences of primary apartments buyers regarding the use of modern technology (PropTech) by developers in the local residential property market.

**Materials and methods**: The tool was Internet survey questionnaire. Originally, a face-to-face study was planned, but due to the constraints of the pandemic, it was not possible to reach respondents directly. In some cases, the "snowball" method was also used to increase the sample size.

**Results and conclusions**: The preference surveys that have been conducted and presented are a contribution to further research work in this area. The results obtained show that the most popular solutions are those that are relatively easy to achieve and do not pose a great challenge to developers, for example. In contrast, those related to digital tools came in last place. Further questions also arise. To what extent, in a situation of relatively expensive housing, are buyers willing to pay for modern solutions. Environmental awareness, such as the use of solar energy or rainwater harvesting, may be at odds with the purchasing capacity of households. To what extent can buyers trust modern technologies without worrying about, for example, lack of energy to use appliances. These and probably other questions require further research in this area.

**Keywords**: PropTech, customer preference, residential market, housing market, real estate.

## 1. Introduction

One of the consequences of the fourth technological revolution is the implementation of modern technologies also in the real estate market (Siniak, Kauko, Shavrov, Marina, 2020). The real estate market is more resistant to change than other markets, especially with regard to the use of digital technologies. However, the use of solutions to foster its digitalisation appears to be a necessity driven by economic efficiency. Furthermore, it is a necessary response to the changing needs and preferences of customers in this market. The extensive use of digital technologies in real estate, including the Internet of Things (IoT), cloud computing, decision automation, machine learning and artificial intelligence (Starr, Saginor, Worzala, 2021) is redefining the way people live, work and invest.

The technological revolution in the real estate market is identified with the PropTech phenomenon, which is characterized by the massive implementation of emerging technologies (Siniak, Kauko, Shavrov, Marina, 2020). A narrower approach is taken by Baum and Dearsley (2017), who define PropTech as a small part of the broader digital transformation of the entire real estate industry (real estate market, construction, real estate financing), a move driving the changing mentality and its consumers in technology-driven innovation in data collection, transactions, and building and city design. PropTech definitions in the literature on the subject differ from each other, but all are based on two main elements: "property" - real estate and "technology" - technology, meaning innovative technological products and new business models for the real estate market (Baum, 2017; Siniak, Kauko, Shavrov, Marina, 2020; Shaw, 2018). In recent years, commercial entities, in the form of international consulting companies, have also taken steps to better understand the PropTech phenomenon. In this case, the term means broadly understood technological and digital, hardware and software innovations in the real estate sector, while emphasizing various aspects of the impact of digital technologies and innovations on the real estate market (KPMG,2018; PWC, 2018; Deloitte,2018).

PropTech is not a new phenomenon, but still little known in the field of academic research. Preparatory work covering an extensive overview of PropTech as an industry and providing an early definition was written by Baum in 2017. These were expanded in 2020 to include categorization of the main technologies used by PropTech, quantification of market size, and analysis of the scale of investments in various sectors and geographic markets. There are also few studies devoted to the importance of PropTech in the housing market. It is worth mentioning here Landau-Ward and Porter (2019), who examined the impact of digital innovation and PropTech technologies on the residential market in Melbourne. They discover that with the advent of PropTech and their advances in technology, the level of data available has led to increased transparency, higher land prices and greater inaccessibility of housing. The literature on the subject (Siniak et al., 2020; Clayton et al., 2019) shows that technology and innovation play an increasingly important role in the real estate industry and affect every

market participant, especially those who lack innovation. Thus, innovation and the ability to adapt to a changing environment are essential for real estate participants (e.g. investors, brokers, managers) to keep pace with the competition.

Entering into the so-called Economy 4.0 within PropTech there are several industries:

- property market - technology-based platforms that facilitate the operation and management of real estate. Platforms can provide information on the performance of buildings or urban centres, or they can directly facilitate or control construction services. This sector supports real estate management. (Baum, 2017);

- smart cities - internet portals virtualizing cities or city guides, knowledge bases corresponding to local needs, agglomerations with information and communication technologies (ICT), infrastructure attracting relocations of enterprises, general city teleinformation infrastructure providing e-services to citizens, ubiquitous environments, ICT infrastructure for ecological purposes (Anthopoulos, 2015);

- smart building - computer and intelligent technologies to achieve the optimal combination of the overall level of comfort and energy consumption (Wang et al., 2012);

- sharing economy - technology-based platforms that facilitate the use of real estate assets. Assets can be land or buildings, including offices, shops, warehouses, apartments, and other types of real estate. Platforms can simply provide information to potential users and space sellers, or they can more directly facilitate or conduct rent or fee based transactions. This sector supports real estate tenant markets (Baum, 2017);

- construction sector (ConTech) - technological innovations in the design, planning and construction phase of real estate (Unissu, 2019);

- real estate financing (FinTech) - the use of technology and innovative business models in financial services; According to the report by KPMG The Pulse of Fintech (2016), FinTech entities are divided into several key industries (industry sectors), including lending tech, payments / billing tech, personal finance / wealth management, money transfer / remittance, blockchain / bitcoin, institutional / capital markets tech, equity crowdfunding, InsurTech.

According to Baum (2017), three basic phases of the evolution of modern technologies in the real estate sector can be distinguished (Figure 1). The phases highlighted by Baum are arbitrary, and the boundaries of the emergence of PropTech 2.0 and PropTech 3.0 are blurring. The implementation of modern technological solutions on the real estate market depends on the level of market development, and thus on access to capital that could finance these changes.

**PropTech 1.0**

- development of indirect investment instruments related to the real estate market, securitization based on debt and assets, development of REITs and the derivatives market
- he rapid globalization of the real estate industry in terms of investors, capital sources and advisory services
- Excel as indispensable real estate tools

**PropTech 2.0**

- PropTech 2.0 focuses on residential real estate as a homogeneous type of real estate assets with more public information (prices and rents),
- development of the FinTech industry - in particular online payment systems, crowdfunding, equity and debt platforms as well as online exchanges

**PropTech 3.0**

- the most technologically advanced wave of PropTech, defined in 2017 at the Oxford University School of Business in Great Britain,
- blockchain, big data, artificial intelligence (AI), internet of things (IoT), cloud computing and software as a service (SaaS), drones and 3D scanning, virtual reality (VR) and augmented reality (AR)

**Figure 1.** PropTech phases.

Source: own study based on Baum (2017).

PropTech 3.0 is considered to be a phase that is to revolutionize the market, introducing a high level of changes in the entire real estate sector (Baum, 2017). Most market participants, while still in the Proptech 2.0 phase, are rapidly adapting and moving to Proptech 3.0. Proptech 3.0 is related to, among others: blockchain, big data, artificial intelligence (AI), internet of things (IoT), cloud computing and software as a service (SaaS), drones and 3D scanning, virtual reality (VR) and reality extended (AR) (Ullah et al., 2018; Baum, 2017; Shaw, 2018; JLL, 2018).

Already advances in PropTech 2.0 - including cloud and mobile computing, digital platforms, and automated, data-driven decision-making tools - are radically changing the way homeowners and investors buy and sell housing. However, it is only PropTech 3.0 that leads to a digitized global real estate market that is likely to be platform-based and transaction tokenization. Instead of lifetime investment decisions or rental contracts for years, buying, owning or renting real estate can become a seamless process mainly thanks to blockchain-based

tokens. At the same time, smart homes, equipped with countless sensors, will communicate with the owner's smartphone to optimize energy efficiency and user comfort (Braesemann, Baum, 2020).

The real estate market entities that use PropTech technology include, first and foremost, real estate brokers, developers, construction companies, and consulting companies. In shaping the PropTech market, an important role is also played by suppliers of ready-made products and solutions, developers of specialized web and mobile applications, which can generally be called technology companies (startups) (Siniak, Kauko, Shavrov, Marina, 2020) and investors who financially support the development and implementation of innovative concepts. According to a report by SkyConcept and Eurobuild (2018), 83% of real estate executives believe that PropTech technologies are the most important driving force behind the development of the modern real estate market. Entities operating in this market, both on the supply side and entities serving the market, will be forced to adapt to the customer by introducing solutions in the form of artificial intelligence (AI), Internet of Things (IoT), virtual reality (VR) and augmented reality (AR).

The possibilities offered by Proptech 3.0 technologies are enormous and they truly have the power to transform the industry. PropTech players are beginning to use various Artificial Intelligence (AI) and Machine Learning (ML) techniques to improve product visibility, productivity and accuracy. The specific applications of these tools and their potential in the real estate market are already under investigation, especially regarding the impact on how investors and other real estate professionals can incorporate technologies and new strategies into their decision-making and operational processes (Viriato, 2019). Blockchain enables secure and transparent registration of property titles and ensures faster turnaround times for real estate transactions, and improves the liquidity and indivisibility of assets (Veuger, 2017). Big Data contributes to the reduction of the risk associated with the purchase of real estate, and also enables buyers to have a better decision-making process, while eliminating subsequent regrets (Mathew et al., 2015). Cloud computing reduces IT costs in organizations. Drones increase customer attractiveness by offering top-down photos for real estate projects. The Internet of Things (IoT) keeps users more immersed and connected to the built environment. Virtual and augmented reality software and hardware make it possible to visualize real estate without physically visiting it (Casini, 2022). The digital transformation in both the area of rules and market practices to increase efficiency, flexibility and adaptability means a significant advance in the real estate market (Starr, Saginor, Worzala, 2021), both for the customer and the supply side.

## 2. Materials and methods

PropTech affects the activities of entities that create both supply and services on the real estate market. In addition, it also affects the customer. Nowadays, it would be difficult to find someone who has not felt the influence of PropTech, even unknowingly, in commercial and multi-family spaces or has spent some time looking at real estate online. From the customer's point of view, the most important and tangible area of using PropTech technology were online platforms, which made it possible to quickly search for huge amounts of information about real estate and its surroundings around the world. The COVID-19 pandemic meant that not only searches were performed online, but also finalized real estate purchase transactions.

Taking up the topic as part of PropTech on the local real estate market is aimed at joining the academic discussion in this area and determining the attitudes and preferences of the buyer of apartments on the primary market in Polish conditions. Therefore, the following goals were adopted in the research in the field of modern technologies on the local residential real estate market:

G1: identifying the sources that are taken into account in the process of acquiring an apartment, by different age groups of people.

G2: indication of the key elements that should be included on the developer's website among different age groups of people.

G3: identifying new technologies that people (of all ages) take into account when looking for a target location.

The implementation of the assumed goals was possible by conducting a survey among people potentially interested in buying a flat - the methodological assumptions are presented in Table 1.

**Table 1.**
*Basic information on research in the field of modern technologies on the local housing market*

| Itemization | Description |
| --- | --- |
| Information gathering time | 9 months - from May 2021 to January 2022. <br> When collecting the data, it was necessary to take into account the problems that arose in connection with the COVID-19 pandemic (limited access to some respondents, extended time to receive surveys) |
| Spatial scope of research | The local residential real estate market in Poznań. <br> The housing market has a local character (everyone is different, which is a characteristic feature of the real estate market). This has been proven in many domestic and foreign studies in this field (Schmitz, Brett, 2001, pp. 3-18; Stefaniak, 1997, p. 33; Bryx, 2013, p. 190; Kucharska-Stasiak, 2016, p. 59; Belniak, 2001, p. 42; Strączkowski, 2021, p. 39). |
| Material scope of the study | research subject: people from different age groups; research subject: sources of information about apartments, information important to potential buyers, what should be on developers' websites, new technologies that can be taken into account when buying apartments. <br> The aim of the paper was to take into account the views of people from different age groups on modern technologies dynamically entering the housing market. More and more people want or require modern solutions, without restrictions or inhibitions, use digital tools. |

Cont. table 1.

| Time range of the study | It coincides with the time of data collection |
|---|---|
| Research tool | Internet survey questionnaire<br>Originally, a face-to-face study was planned, but due to the constraints of the pandemic, it was not possible to reach respondents directly. In some cases, the "snowball" method was also used to increase the sample size. |
| Selection and size of the sample | non-random, random, sample size n = 702 units |

Source: own study.

Referring to the information contained in Table 1, it should be added that initially the main group of respondents to whom the questionnaire was addressed were young people, most often defined as those whose maximum age does not exceed 35 years (Kusińska, 2005). However, it was later concluded that a survey addressed to people in subsequent age groups may help to identify possible differences in the perception of modern technologies on the residential real estate market.

The ability to reach respondents was of key importance. Originally, data collection was to take place through two channels, i.e. through: (1) an auditorium survey - mainly, (2) an Internet survey - supplementary. Due to the outbreak of the COVD-19 pandemic and limitations in social contacts, collecting data through an auditorium survey turned out to be impossible, and therefore the first channel was abandoned. Ultimately, 702 respondents were reached. When it comes to the characteristics of the respondents in the study, it can be said that:

- of all the surveyed people, 54.8% were women, and men - 45.2%;
- in the age structure, the largest share was that of people aged 46 to 55 - 28.9%; the second largest group was composed of people who declared the age from 26 to 35 years - 25.7%. The third largest segment is made up of people aged up to 25 - 21.7%, followed by people aged 36 to 45 (16.0%) and over 55 (7.7%). The average age of the respondents was 38.8 years;
- they were mainly made up of farms consisting of 3-4 people (52.8% of respondents) and 1-2 persons (37.6%). 9.6% of the respondents live in larger households of 5 or more;
- these were people who most generally view parenthood favourably, as 20.4% declared having or planning to have one child, 48.6% - two children, 11.7% - three children, 4% - four or more children. Only 15.3% of all respondents did not declare the will to have children.

The respondents are dominated by two groups of people, one of whom indicated a willingness to live in a flat situated in a multi-family building - a block of flats (44.6% of all respondents), and the other in a detached building, popularly known as a house (41.2%). Life in the semi-detached or terraced house was indicated by 14.2% of people.

In the structure of responses regarding space, every fifth respondent (21.7%) indicated interest in premises with an area of up to 35 m2, every fourth (25.7%) - in a unit with an area of 36 to 50 $m^2$, 16% - from 51 to 65 $m^2$, 28.9% - from 66 to 80 $m^2$, and 7.7% - the largest apartments with an area exceeding 80 $m^2$. The responses indicate that the respondents were interested in quite large premises, as the average area of the declaration reached the level of 81.1 $m^2$.

In the case of the number of rooms, the most common desire was to have a three-room flat (44.2% of all respondents), and then a four-room flat (25.1%). On the other hand, 1% and 20.7% of the respondents showed interest in smaller one- and two-room flats, respectively. The rest (9.0%) would like to live in units with at least five rooms.

As a consequence of the information presented above, it is not surprising that the average budget for the purchase of a flat with the respondents was quite high and reached the level of 506.4 thousand. PLN. On the other hand, in the structure of responses, 26.3% of respondents declared a budget of up to PLN 350,000, 24.0% - from PLN 351 thousand to 450 thousand., 20.2% - from PLN 451 to 550 thousand. and 29.6% - over PLN 550 thousand.

Interestingly, some of the people were willing to allocate a certain amount of the budget for the purchase of premises in a building in which modern technologies would be used. On average, it would be 9.8% of the total purchase price of a flat, i.e. nearly PLN 50,000 (PLN 49.6 thousand), with 38.7% of respondents saying that they would spend up to 5% of the price of a flat for this purpose, 37.8% - up to 10% of the price, 8.6% - up to 15% of the price, 11.1% - up to 20% of the price. Only a few would be willing to allocate a higher share, exceeding 20% of the price.

## 3. Results and discussion

It is worth starting the issue of using modern technologies in the context of clients on the residential real estate market by identifying sources of information, i.e. those places that the respondents would use when looking for their own flat. Of course, there are quite a lot of sources of them - some are places that are available and common to many people (e.g. websites, billboards), and some are informal contacts (an example may be the opinions and helpful opinions of friends and family). Table 2 presents structure of information sources used in searching apartments.

**Table 2.**

*Sources of information that the respondents would use when looking for a flat – in total and by age of the respondents (percentage of responses)*

| itemization | in total | respondents aged: | | | | |
|---|---|---|---|---|---|---|
| | | up to 25 years | from 26 up to 35 years | from 36 up to 45 years | from 46 up to 55 years | over 55 years old |
| Internet portals with housing offers | 91.4% | 98.0% | 96.7% | 90.2% | 88.1% | 70.4% |
| family, friends | 71.6% | 91.4% | 71.7% | 67.0% | 59.9% | 68.5% |
| developer sites | 69.1% | 82.9% | 75.6% | 63.4% | 61.4% | 50.0% |
| banners, information on investment fences | 20.3% | 23.7% | 20.0% | 20.5% | 17.8% | 20.4% |
| real estate fairs | 19.3% | 28.3% | 20.0% | 13.4% | 16.3% | 13.0% |
| local media (daily newspapers) | 14.9% | 8.6% | 7.2% | 17.0% | 20.3% | 31.5% |
| local TV and radio | 5.6% | 3.3% | 2.8% | 3.6% | 9.4% | 11.1% |
| billboards | 5.1% | 2.0% | 1.1% | 7.1% | 9.4% | 7.4% |
| magazines | 3.0% | 3.3% | 0.0% | 3.6% | 4.5% | 5.6% |
| leaflets (e.g. in mailboxes) | 3.0% | 1.3% | 2.2% | 3.6% | 3.0% | 9.3% |

Source: own study.

Among the potential places from which one can gain knowledge about housing, the most important role can be attributed to internet portals with housing offers - this source received 91.4% of responses in total. Great importance can also be attached to family and friends (71.6% of responses), developers' websites (69.1%) as well as banners and real estate fairs (20.3% and 19.3% of responses, respectively). Interestingly, the importance of the sources varies depending on the age of the respondents. It is quite clear, as illustrated in Table 2, that young people - up to 25 years of age, and relatively older people - over 55 - approach some sources differently. For the former, internet portals with housing offers are crucial (98% of responses), for the latter, they are important, but the percentage of responses is much lower and amounted to 70.4%. It is worth noting, however, that for people aged over 55, traditional sources of obtaining information are relatively more important, such as local newspapers, television and radio, billboards or leaflets left in e.g. mailboxes. Looking at the data in Table 2, one can also draw a conclusion that confirms the general assumptions that age may determine the choice of information source and that younger people more often use modern, digital sources, older people - are open to modern methods, but they use traditional sources relatively more often.

As apartment websites and developer websites rank high in the hierarchy of information sources, it is worth looking at the key elements of developer websites - those that are important to respondents. A proper summary of them together with the importance calculated using the arithmetic mean is included in Table 3.

**Table 3.**

*Importance of items on the developer's website in the opinion of respondents – in total and by age of respondents (average values)*

| itemization | in total | respondents aged: | | | | |
|---|---|---|---|---|---|---|
| | | up to 25 years | from 26 to 35 years | from 36 to 45 years old | from 46 to 55 years old | over 55 years old |
| the ability to check the prices of apartments | 4.86 | 4.89 (1) | 4.91 (1) | 4.79 (1) | 4.82 (1) | 4.93 (1) |
| possibility to see projections of apartments | 4.69 | 4.72 (3) | 4.74 (2) | 4.66 (2) | 4.65 (2) | 4.65 (2) |
| information about the availability of individual apartments | 4.65 | 4.75 (2) | 4.71 (3) | 4.50 (3) | 4.61 (3) | 4.63 (3) |
| information about the investment environment | 4.39 | 4.36 (5) | 4.41 (4) | 4.27 (5) | 4.41 (4) | 4.56 (4) |
| investment visualization | 4.29 | 4.38 (4) | 4.27 (5) | 4.33 (4) | 4.19 (5) | 4.39 (5) |
| visualizations of individual apartments | 4.13 | 4.25 | 4.08 | 4.14 | 4.05 | 4.32 |
| apartment search engine | 3.90 | 3.93 | 4.07 | 3.83 | 3.84 | 3.70 |
| the ability to send an email via the contact form | 3.62 | 3.57 | 3.61 | 3.61 | 3.73 | 3.49 |
| the possibility of taking a virtual walk | 3.39 | 3.64 | 3.37 | 3.25 | 3.35 | 3.17 |
| virtual arrangement of space | 3.39 | 3.36 | 3.34 | 3.34 | 3.48 | 3.44 |
| online meeting with apartment sellers | 3.35 | 3.38 | 3.39 | 3.29 | 3.38 | 3.17 |
| interactive building plans | 3.32 | 3.62 | 3.37 | 3.15 | 3.26 | 2.87 |
| interactive map of the location | 3.31 | 3.49 | 3.33 | 3.11 | 3.31 | 3.15 |
| the possibility of filling in a short questionnaire and choosing the apartment to match my answers | 3.24 | 3.36 | 3.27 | 3.03 | 3.30 | 3.09 |
| photos from the progress of works on the construction site | 3.23 | 3.14 | 3.16 | 3.21 | 3.29 | 3.49 |
| social media links (Instagram, Facebook, Twitter) | 2.95 | 3.21 | 3.10 | 2.71 | 2.87 | 2.45 |
| transition from the website to the mobile application | 2.71 | 2.93 | 2.74 | 2.88 | 2.51 | 2.35 |
| QR code enabling quick access to selected parts of the offer | 2.44 | 2.63 | 2.40 | 2.36 | 2.45 | 2.20 |
| direct video transmission from the construction site | 2.24 | 2.16 | 2.17 | 2.18 | 2.32 | 2.48 |
| chat bots | 2.23 | 2.47 | 2.28 | 2.08 | 2.18 | 1.89 |

Attention! In the table in individual age groups, next to the average value, their ranking position was entered next to the average value for the five most important elements.

Source: own study.

According to the research, the key role in making a decision to buy a flat is assigned to its price (Strączkowski, 2021). Probably for this reason, the most important element of the developer's website should be the ability to check home prices - the respondents' answers gave an average of 4.86 points - compare table 3. Among the other elements, forming the so-called the top 5 of the most important ones are: the possibility to see projections of apartments (4.69), information about the availability of individual apartments (4.65), information about the investment environment (4.39) and investment visualization (4.29).

It is worth noting that, taking into account the age of the respondents, there are some differences in the perception of the importance of individual elements of developers' websites. While in the case of the possibility of checking prices in all groups, compliance was noted, i.e. it is the most important element, among the youngest respondents, the information about the availability of individual apartments was ranked second, while in the remaining groups - the possibility to see projections of apartments. There were also slight differences in the fourth and fifth items.

Differences in the assessment of individual elements were also noted in the case of the least important details of the website, i.e. links to social media (Instagram, Facebook, Twitter), the possibility of switching from a website to a mobile application (important when using smartphones to obtain knowledge), code QR enabling quick transition to selected parts of the offer, direct video transmission from the construction site or the so-called chat bots. Generally, it can be said that the elements indicated here relatively higher were appreciated by younger respondents and there was a tendency that with age the average score became lower. The exception was the possibility of viewing the construction site via the Internet, which was appreciated by respondents aged 46 to 55 and over 55.

The last part was devoted to checking which technologies currently used in housing construction were the most and least important for the respondents when choosing a flat. The list of indications is presented in table 4. And so, in the case of all respondents, the most important elements were: high thermal insulation of the apartment, alarm and monitoring system, heating control (e.g. building heating depending on the presence of residents), photovoltaic panels and lighting control (e.g. light switch when detects the presence of a person). The following can be considered the least important: weather system (adapting the building to the outside conditions), simulating the presence of household members (e.g. when going on vacation), access control (fingerprint or iris scanning).

**Table 4.**
*Technologies most and least important in choosing a flat in the opinion of the respondents - in total and by age of the respondents (percentage of responses)*

| itemization | in total | respondents aged: | | | | |
|---|---|---|---|---|---|---|
| | | up to 25 years | from 26 to 35 years | from 36 to 45 years old | from 46 to 55 years old | over 55 years old |
| high thermal insulation of the apartment | 73.0% | 61.8% | 66.1% | 77.7% | 80.2% | 90.7% |
| alarm and monitoring system | 67.7% | 64.5% | 73.9% | 74.1% | 61.4% | 66.7% |
| heating control (e.g. building heating depending on the presence of residents) | 45.0% | 39.5% | 44.4% | 42.0% | 52.0% | 42.6% |
| photovoltaic panels | 42.6% | 32.9% | 41.1% | 44.6% | 49.5% | 44.4% |
| lighting control (e.g. light sensor when it detects the presence of a person) | 37.4% | 41.4% | 38.9% | 32.1% | 35.1% | 40.7% |
| air conditioning control | 35.9% | 54.6% | 34.4% | 34.8% | 29.2% | 14.8% |
| collecting rainwater for watering green areas | 34.3% | 30.9% | 32.2% | 33.9% | 38.6% | 35.2% |
| use of solar energy to heat water | 28.9% | 30.3% | 26.1% | 28.6% | 30.7% | 27.8% |
| recuperation | 21.1% | 14.5% | 18.9% | 27.7% | 23.8% | 24.1% |
| control of electronic equipment | 17.6% | 32.9% | 20.0% | 13.4% | 8.4% | 9.3% |
| own sewage treatment plant | 12.9% | 7.2% | 12.8% | 11.6% | 17.8% | 13.0% |
| weather system (adaptation of the building to the outside conditions) | 12.1% | 16.4% | 12.2% | 9.8% | 9.4% | 14.8% |
| simulation of the presence of household members (e.g. when going on holidays) | 10.6% | 13.2% | 10.0% | 7.1% | 10.4% | 13.0% |
| access control (fingerprint or iris scanning) | 7.4% | 11.2% | 8.3% | 8.0% | 4.5% | 3.7% |

Source: own study.

It is worth noting, however, that there are differences in the declarations of younger and relatively older people. They concern both the order of individual elements and the percentage of indications. For example, for people up to 25 years of age - the most important were (in order): alarm and monitoring system, high thermal insulation of the apartment, air conditioning control, lighting control, heating control, and the least important: simulation of the presence of household members, access control, own sewage treatment plant. In turn, for people from the oldest age group, the most important were: high thermal insulation of the apartment, alarm and monitoring system, photovoltaic panels, heating control, lighting control, and the least important: simulation of the presence of household members, control of electronic equipment, access control.

It should also be noted that in some cases the order of individual elements is similar, but there are differences of a few or a dozen or so percentage points. This can be illustrated by three examples: air conditioning control, electronic equipment and standby control of high thermal insulation of the apartment. According to the indications of people up to 25 years old, air conditioning control was the third most important element that would be taken into account when choosing a flat (54.6%). Meanwhile, in the case of people from the last age group (over 55), it would not play such a big role (15% of responses). It can also be said that there is a tendency - the importance of this element decreases with the age of the respondents. A similar situation can be observed in the case of controlling electronic equipment. Here, too, the highest percentage of indications was recorded for the youngest people, and the lowest for the oldest people.

However, with regard to the high thermal insulation of the apartment - in all age groups, this element is given among the most important ones, but in young people it has 61.8% of indications, and in the oldest people - 90.7% (the difference is therefore almost 30 percentage points). Here, too, one can speak of a tendency that the importance of this element grew with the age of the respondents.

## 4. Summary

The preference surveys that have been conducted and presented, which relate to modern technologies, are a contribution to further research work in this area. Technological progress will undoubtedly force the increasing use of various solutions that can fit into sustainable construction, environmentally friendly user behavior, the sphere of well-being of residents. However, a number of questions arise about the scope of application of modern technologies in the current situation in the residential real estate market. The results obtained show that the most popular solutions are those that are relatively easy to achieve and do not pose a great challenge to developers, for example. In contrast, those related to digital tools came in last

place. Further questions also arise. To what extent, in a situation of relatively expensive housing, are buyers willing to pay for modern solutions. To what extent, for example, environmental awareness, such as the use of solar energy or rainwater harvesting, may be at odds with the purchasing capacity of households. To what extent can buyers trust modern technologies without worrying about, for example, lack of energy to use appliances. These and probably other questions require further research in this area.

In the research undertaken in the field of modern technologies on the local housing market, it can be assumed that the conducted research allowed for the achievement of the previously mentioned aims.

Undoubtedly, an important aspect of the conducted research is the question of their usefulness for various groups of entities operating on the housing market. It seems worth using them:

- development companies - due to the need to adapt the offer to the client's needs. Adjusting the offer should include not only the basic features of the apartment, such as size, number of rooms, etc., but also equipping the apartment with modern digital technologies that facilitate its use. This type of research may allow developers to increase the awareness of customer expectations, but also be an indication of the growing awareness of customers in the field of modern technologies and home furnishings;

- residential start-ups in the field of innovation in the design, implementation, sale and use of development process products;

- housing cooperatives, housing communities with a housing stock that can and will have to be modernized, meeting technical and environmental standards and the requirements of subsequent generations of apartment buyers and premises users;

- researchers and academics who should contribute to the international discussion on the importance of PropTech in local real estate markets, especially in the context of the competitiveness of developers.

Of course, there are significant research limitations including:

- the local market situation - lack of ordinary housing, developers are selling everything they build in a very short time;

- the COVID-19 pandemic - difficulty in reaching respondents;

- the local market, which may be a limitation since it is an example.

However, despite these limitations, the above study can provide a starting point for examining the sophistication of developers in local real estate markets, taking into account the needs and expectations of potential customers.

## Acknowledgements

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# IMPLEMENTATION OF MODERN TECHNOLOGIES (PROPTECH) BY DEVELOPERS ON THE LOCAL HOUSING MARKET

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**Introduction/background:** The implementation of modern technologies in the real estate market is a phenomenon that has been observed for several years in global markets. The emergence of solutions favouring the digitalisation of the relatively change-resistant real estate sector is a response to the changing needs and preferences of customers in this market. Taking up the topic within the framework of PropTech in the local real estate market aims to contribute to the discussion in this area and to identify opportunities for the uptake of new technologies in Polish conditions. The area of real estate development activity in the residential market with regard to the use of modern technologies in the business was selected for analysis.
**Aim of the paper**: The main aim of the paper is to analyse to what extent developers are aware of and interested in modern technologies. The 3 following goals were adopted: G1: assessment of the developers' state of knowledge in the field of modern technologies (PropTech); G2: identifying areas that, in the opinion of developers, have the greatest potential for implementing modern technologies; G3: perspectives for the use of modern technologies in the studied areas.
**Materials and methods:** In order to achieve the intended goals, a survey questionnaire was carried out among developers on the real estate market in Poznań.
**Results and conclusions:** As the survey shows, the development of Proptech for developers is still at a rather early stage. Despite the fact that, in their opinion, customers already have expectations in terms of modern technologies and pay attention to environmentally friendly solutions, they use the available solutions only to a small extent, as if forgetting (or not knowing) that the possibilities for implementing modern technologies are much greater and cover many more areas.

**Keywords:** real estate market, PropTech, modern technologies, housing market, developer.

## 1. Introduction

Industry 4.0, which is the digital transformation of most areas of the economy, is also entering the real estate sector that is relatively resistant to innovation (Siniak, Kauko, Shavrov, Marina, 2020). The changes observed in this area may have the hallmarks of a revolution, the effect of which will be to increase the efficiency, agility and flexibility of real estate managers, intermediaries in their turnover, but above all, entities that create the supply of new products in the form of buildings and premises. The phenomenon of mass implementation of modern technologies in the form of virtual reality (VR), artificial intelligence (AI), building information modeling (BIM), advanced data analysis tools, Internet of Things (IoT), blockchain, real estate crowdfunding, in combination with such trends such as smart city, smart home or Sharing Economy create a new environment known as PropTech.

The concept of PropTech is a combination of the two words "property" - real estate and "technology", and therefore includes innovative technology products and new business models for the real estate market. It is worth emphasizing that both in the field of science and practice, this term is relatively new on the one hand, and extremely fashionable on the other. The literature on the subject lacks a universal definition of the term PropTech, which makes it difficult to define the investments and market segments that are involved in this new trend. The concept of PropTech as the sum of technologies that affect the real estate market was introduced by Baum (2017), while defining its three basic sectors: smart real estate, shared economy and FinTech. Smart Real Estate is all technology-based platforms that facilitate the operation and management of real estate, but can also directly facilitate or control construction services (Baum, 2017). The concept of "Platform Real Estate", which includes the social engineering dynamics driving the digitization of real estate technology, was also developed by Shaw (2018). Another sector of PropTech is the Shared Economy, which includes technology-based platforms that facilitate the use of real estate assets, including land or multi-purpose buildings. In this respect, the main purpose of the platforms is to provide information to users and space managers. The final sector is FinTech, which consists of technology-based platforms that facilitate real estate trading through various financing services. In addition to the sectors indicated by Baum (2017), PropTech also includes elements of smart cities and the construction industry (ConTech). PropTech sectors are presented on Figure 1.
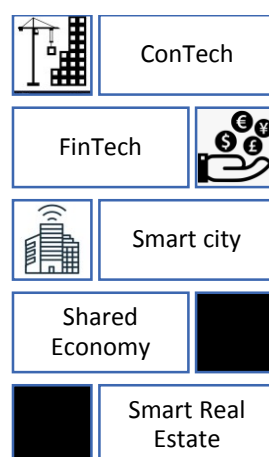
**Figure 1.** PropTech sectors.

Source: own study based on (Baum, 2017).

PropTech being the sum of all technological innovations can also be described as a movement driving the change of mentality in the real estate industry (Dearsley, 2018). Hasenmaile, Rieder (2017) mentioned the possibility of optimizing products, processes or the entire business concept in the real estate sector as a result of the implementation of modern technological achievements, i.e. PropTech. On the other hand, it is difficult to determine which technologies and entities are involved in the digitization of the real estate sector and what their innovative potential is, especially considering that some markets (e.g. US, UK) that seem to be more active than others in keeping up with the pace of change (Tagliaro, Bellintani, Ciaramella, 2020).

The dynamic development of the construction industry in Poland offers great opportunities to use innovation. In 2020, according to Central Statistical Office (GUS) data, 7% more apartments were completed than in 2019. It is the construction industry that is one of the most frequently indicated areas of PropTech use. However, it also includes solutions for office space management, IoT technologies, solutions for trade or rental of real estate, and even financing for home purchases or crowdfunding of construction projects.

The main goal of PropTech is to improve the efficiency of the real estate market, which is perceived as relatively technologically backward and very resistant to any changes. PropTech, similarly to smart city solutions, effectively changes the space in which we operate on a daily basis. The issue worth noting are the two speeds of this revolution in Poland. On the one hand, large entities from the real estate industry, and on the other hand, many small companies that are not prepared - both in terms of resources and the possibility of introducing innovations or technological experiments, thus lagging behind.

The use of modern technologies and their importance in the real estate development process is an important current of research today. Maududy, Gamal (2019) emphasize the need to introduce innovative technological solutions by developers from the residential real estate sector, interpreting real estate technology as an innovations within construction, sales, management that changes the real estate development process.

Developers on developed real estate markets operate in various segments, including commercial, office, warehouse or residential (Trojanowski, 2004). Definitions of a developer often narrow the area of his activity, e.g. only to the housing market. This interpretation is used by Kirejczyk and Łaszek (1997), who define the developer through the prism of his main task, which is to define the market segment in which there is a housing demand, and then to organize a project consisting in the construction of apartments. The developer is also identified with the investor. Bryx and Matkowski (2001) define the developer as the investor who builds facilities that are then intended for sale and rent. The perception of a developer only as an investor is an approach that limits the nature of his activity, which consists in coordinating the entire development process, starting from the initiative of the planned project, through its implementation and handing over the final product for operation or for further development (Trojanowski, 2004). Similarly, Belniak and Wierzchowski (2001) define the developer as the coordinator of the entire investment process, which leads to the creation of a new form of land development. Kozłowski (2003) also emphasizes that mobilization and coordination of resources in order to develop the area are characteristic of development activity. The literature on the subject very often emphasizes the effect of the developer's activity, which is an increase in the value of the property. Dobrowolski and Sędek (1996) recognize as a developer an entity that intends to make the best use of real estate, providing it, through investment, with the greatest value.

The essence of development activity can be considered in terms of: semantic, economic and process. In semantic terms, a developer is defined as an entity whose activity is related to the development of land real estate. In economic terms, a developer is an entrepreneur who conducts, at his own risk, the activity of investing in real estate, earning income on this account. A real estate development company focuses on investing in real estate, which increases its value. The developer acts as a coordinator and organizer of the implemented project. From the procedural perspective, developer activity should be understood as a sequence of successive activities that make up the process of implementing a development investment project, considered in a broader or narrower aspect (Gostkowska-Drzewiecka, 2007).

The development process is often considered in many dimensions, as it results in a physical, material, social and economic transformation of space (Henzel, 2004; Peca, 2009) defines a real estate development project as a process that requires a highly creative approach, during which tangible components such as land and buildings are effectively combined with financial and marketing resources to create a space where you can live, work and play. This allows for the identification of basic features, common to each type of development investment project:

- real estate development,
- high degree of creativity,
- effective combination and use of space components, such as land and buildings,
- combining financial and marketing resources.

According to this definition, only an appropriate combination of financial and marketing resources, in particular regarding market analyzes, is the key factor determining the profitability of development investments. The aspect of resource use can also be found in the definition cited by Dąbrowski and Kirejczyk (2001), in which the basis for a development investment is an appropriate combination of location, idea and capital. In any case, the starting point for a development project should be an idea tailored to the preferences of potential buyers.

At the core of the development process is the ability to effectively and sustainably shape space. In a narrower sense, the development process closes in two phases: pre-construction and implementation. In a broader sense, the development process is a three-phase process. This is the case where the developer not only carries out the project but also operates it. (Gostkowska-Drzewiecka, 2007) The development process of Dziworska and Trojanowski (2007) is completed in three basic phases: pre-investment (preparatory), implementation, and operation (operational). Karnaszewski (2000), in turn, distinguishes four stages of the construction investment process: the pre-investment phase, the investment preparation phase, the implementation phase, and the investment completion and commissioning phase. However, each development process, regardless of the division, has similar stages, starting with the initiation and ending with the sale or use of the property. Real estate development as a result of a developer's activity is a process that combines components and knowledge in order to create a specific product that meets the expectations of individual customer groups.

The developer, as a party creating supply on the housing market, and having large financial resources at its disposal, is an entity that, apart from construction companies, should be the first to try to digitize some of its activities. Innovations in terms of the presentation of the offer, the process of servicing a potential customer, as well as modernizing the product itself should be one of the main strategic goals for the developer. Maududy and Gamal (2019) emphasize that failure to use available PropTech technologies may lead to a drop in sales, deterioration of the competitive position, and eventually exit from the market.

## 2. Aim of the paper

The technological revolution is entering the real estate market and concerns various stages of developers' investment projects, starting from the design phase, through the execution, sale and operation of the property. The question, however, is to what extent developers are aware of and interested in modern technologies. In response to this question, a study was conducted for which the following goals were adopted:

G1: assessment of the developers' state of knowledge in the field of modern technologies (PropTech).

G2: identifying areas that, in the opinion of developers, have the greatest potential for implementing modern technologies.

G3: perspectives for the use of modern technologies in the studied areas.

In order to achieve the intended goals, a survey was carried out among developers on the real estate market in Poznań. The adopted spatial scope results from the specificity of this research area. And although there are no substantive grounds for major generalisations, taking into account the size of the market in Poznań, it can be assumed that in other large Polish cities the degree of use of modern technologies is similar.

## 3. Materials and methods

The research was carried out in March and August 2022, and the time scope of the research coincided with the time of collecting the information. The spatial scope of the research covered the residential real estate market in Poznań. The subjects of the research were both local and domestic developers implementing investments in Poznań and its vicinity, while the subject of the research were the areas of application of modern technologies by developers on the local real estate market. In order to conduct the study, a survey questionnaire was used, which was conducted online by sending a form to developers and in the form of a telephone survey conducted by interviewers. The sample selection was deliberate, non-random. 22 out of over 47 were examined developers operating on the Poznań market (data from platform with developers' offers Rynekpierwotny.pl). According to the data on the marketpierwotny.pl website, they are currently implementing 69 investments in Poznań and its vicinity. Basic information on the study is presented in Table 1.

**Table 1.**
*Basic information on the developer research on the areas of application of modern technologies*

| Itemization | Description |
|---|---|
| Information gathering time | 2 months in March-August 2022 |
| The spatial scope of the study | the local residential real estate market in Poznań |
| Material scope of the study | research subject: local and national developers of the residential real estate market offering investments in Poznań.<br>research subject: areas of application of modern technologies by developers on the local real estate market |
| Time range of the study | coincides with the time the information was collected |
| Research tool | survey questionnaire |
| Selection and size of the sample | sampling non-random, purposeful, sample size n = 22 entities |

Source: own study.

Metric data about the respondents:

- 86% were companies that operate in a city with more than 500,000. inhabitants, 9% were companies with activities in the city between 250-500 thousand. residents, and 5% of respondents had their headquarters in cities below 250 thousand. Residents,

- over 90% of the surveyed developers have been operating for 10 years and more, and only 10% between 5 and 9 years; among the respondents there were no developers who had been operating on the market for less than 5 years,

- among the respondents, half of the developers operated on the local real estate market in Poznań, while the other half operated nationwide as well,

- over 70% of the surveyed developers specialize in the popular housing segment (based on the standard), while approximately 30% of the respondents operate in the premium apartment segment (higher standard),

- Almost half of the respondents (45%) consider that they are a large market player in terms of turnover, about 36% describe themselves as medium-sized companies, and only 18% indicated that they are a small company.

The developers covered by the study built a total of 8,370 flats in the presented investments, of which 1,793 are currently for sale. This means that the sales ratio is 79%. The starting point for the above data was the number of offers on the marketpierwotny.pl website, while the analysis was based on the developers' websites, and therefore some data were updated. At the same time, it should be noted that among developers there are those who currently offer 1-2 available flats and those with over 400 available flats.

The survey questionnaire used closed questions. Only the metric question used open-ended questions regarding the entity's period of operation in the market and the number of employees. The developers that were selected for the survey were all entities that were making investments in the local market at the time of the survey.

## 4. Results and discussion

The first question in the conducted research was to determine the degree of familiarity by developers with the term "PropTech". This concept should be well known by them and used by them as participants of the investment process in which modern technologies are used, as well as entities taking care of the property after its use. The distribution of answers is presented in Figure 2.
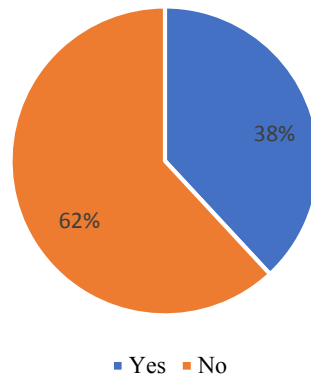
**Figure 2.** Knowledge of the concept of Proptech among developers.

Source: Own study based on the research.

As it turns out, slightly less than 2/3 of developers know or have heard of the term Proptech, while over 1/3 of developers have never come across this term. This means that despite the fact that modern technologies used in the real estate market are developing, many real estate market entities still do not know the basic concept in this regard. Perhaps this is due to the lack of interest in the trend as such, but only in individual innovative technological products.

The next questions concerned the areas that developers believe have the potential to apply modern technologies. In their responses, the respondents could indicate whether the potential for a given area already exists, whether there is an opportunity for a given area within 5 or 10 years, or whether the given area has no potential at all.

The first question concerned the area related to market research (Figure 3).
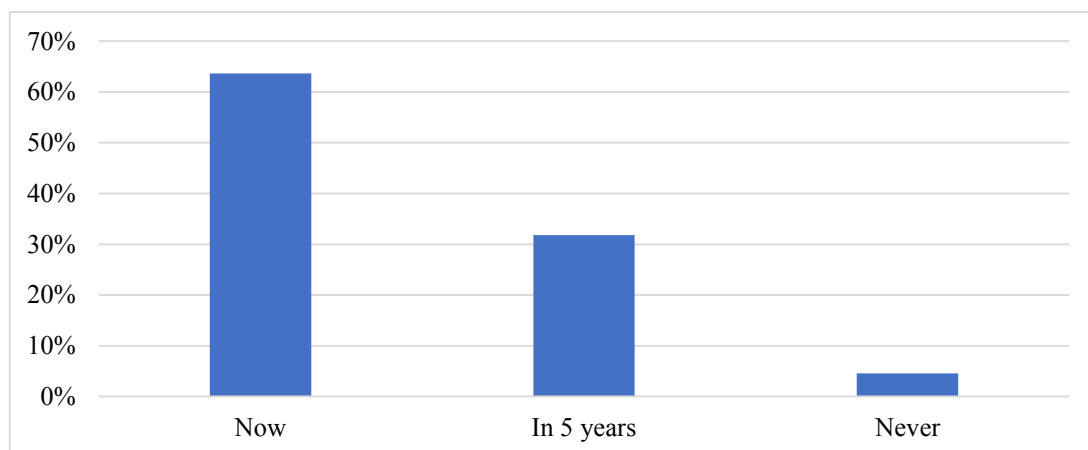


**Figure 3.** Market research as an area with the potential of using modern technologies.

Source: Own study based on the research.

Over 60% of respondents believe that market research is an area that has great potential to use modern technologies today. About 30% of the respondents considered that the right moment to use the potential of this area was about 5 years from now. None of the developers indicated the period in 10 years, while only 1 respondent, representing 5% of the entire surveyed group, believes that market research will never be an area with the potential to use modern technologies. The modern technologies used in the field of market research include: using

artificial intelligence, VR glasses, data analysis (Big Data), creating virtual and augmented reality or 3D printing to visualize projects on the basis of which customers can evaluate the project.

Another area in which modern technologies can be used is the financing of housing investments (Figure 4).
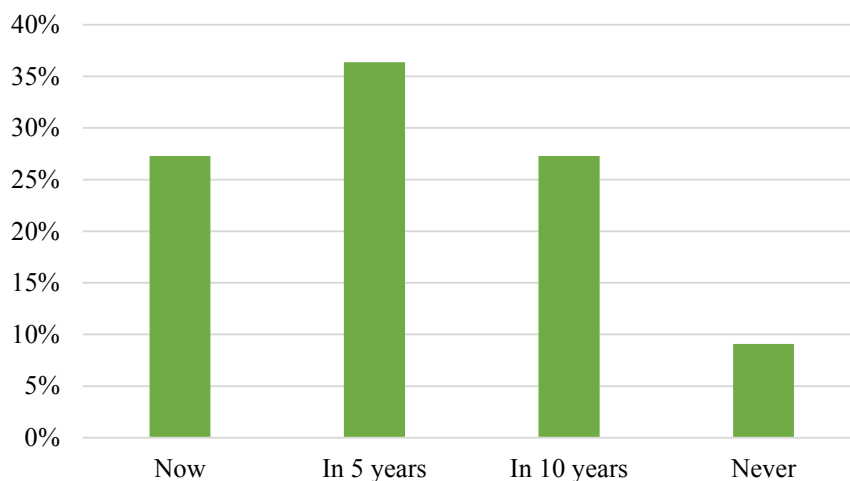


**Figure 4**. Financing of housing investments (e.g. crowdfunding) as an area with the potential of using modern technologies.

Source: Own study based on the research.

Most of the surveyed developers believe that the use of modern technologies in financing housing investments (especially through crowfunding) will have the greatest potential in the next 5 years (36% of respondents), and even 10 years (27% of respondents). On the other hand, slightly over 27% of respondents believe that it is already an area with the potential to use modern technologies. Only 9% of the developers surveyed believe that modern technologies will never have such potential in this area. Crowdfunding using online platforms allows small investors to finance large projects without taking a loan. It is a relatively safe capital investment, however, to a large extent, the problem in terms of interest may result from the small number of investment platforms on the Polish real estate market, on the other hand, the lack of physical ownership of real estate, which in the case of this type of investment may be a certain barrier for a part of the society. Perhaps the developers decided that in the next few years the awareness of investors will increase, which will result in a greater potential for using the possibilities of modern technologies in this type of investing in the future.

Another area related to the implementation of modern technologies on the real estate market is the design and construction of residential real estate.
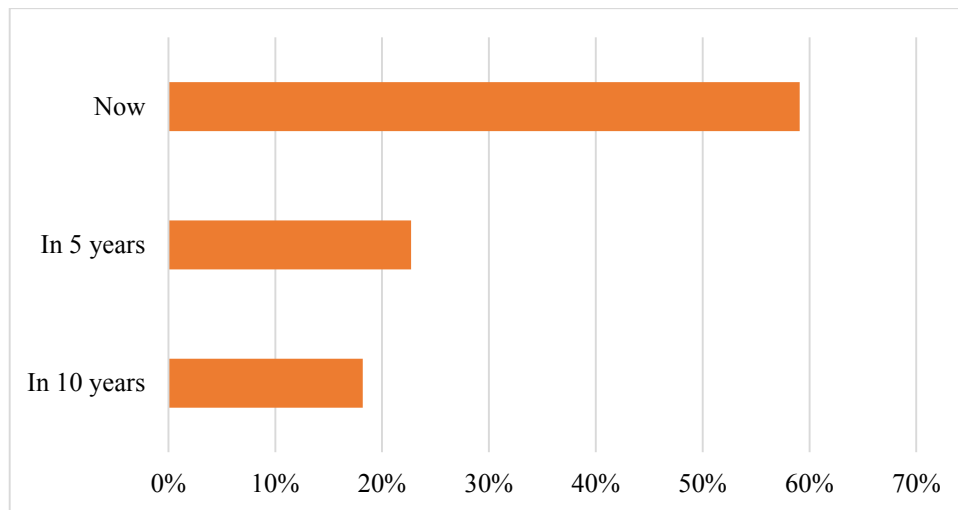
**Figure 5**. Designing and housing construction as an area with the potential of using modern technologies.

Source: Own study based on the research.

As shown in Figure 5, all respondents recognized that this is an area with great potential in terms of modern technologies. Almost 2/3 of the respondents already see the possibility of using them in the investment process, while slightly more than 1/5 see an opportunity in the next 5 years, and a little less than 1/5 in the next 10 years. None of the respondents indicated the answer that there will never be such prospects. In terms of design, the use of modern technologies largely concerns the creation of apartment visualizations, 3D models, projects in augmented reality or visualization of buildings. In the process of building residential real estate, direct video transmissions from the construction site are carried out, electronic document circulation is carried out, intelligent buildings are built or activities are carried out to optimize the construction process, among others, through digitization of work or a BIM model viewer.

The area that is considered to be the most potential in terms of using modern technologies is marketing, as shown in Figure 6.
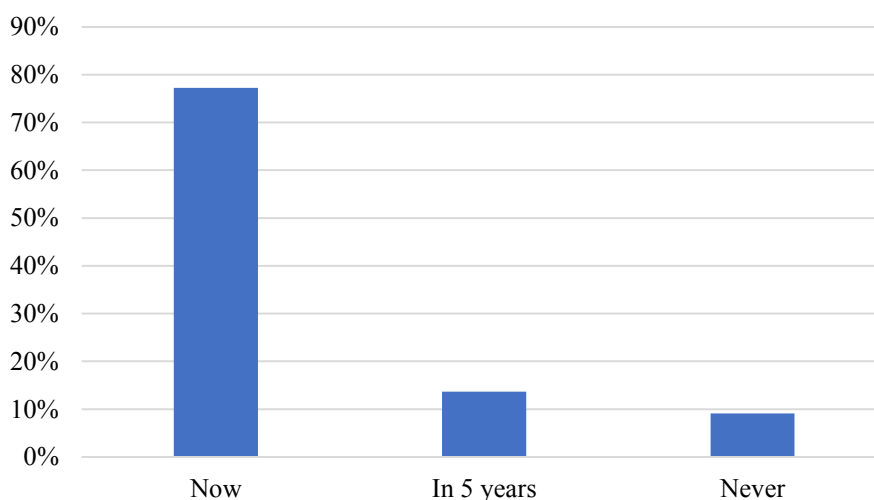


**Figure 6**. Marketing as an area with the potential of using modern technologies.

Source: Own study based on the research.

According to the survey, 77% of the surveyed developers believe that real estate marketing has the potential for modern technologies right now. Only 14% see the potential in the next 5 years, and only 9% of respondents believe that this potential will never exist. Real estate marketing is also related to other areas and so the visualizations of buildings or apartments used in the design or construction phase in terms of marketing are to promote individual investments. Other possibilities of using modern technologies include virtual walk, interactive location maps, 3D models or QR codes enabling quick transition to selected parts of the offer.

Another area with great potential, according to the respondents, is the sale or rental of real estate (Figure 7).
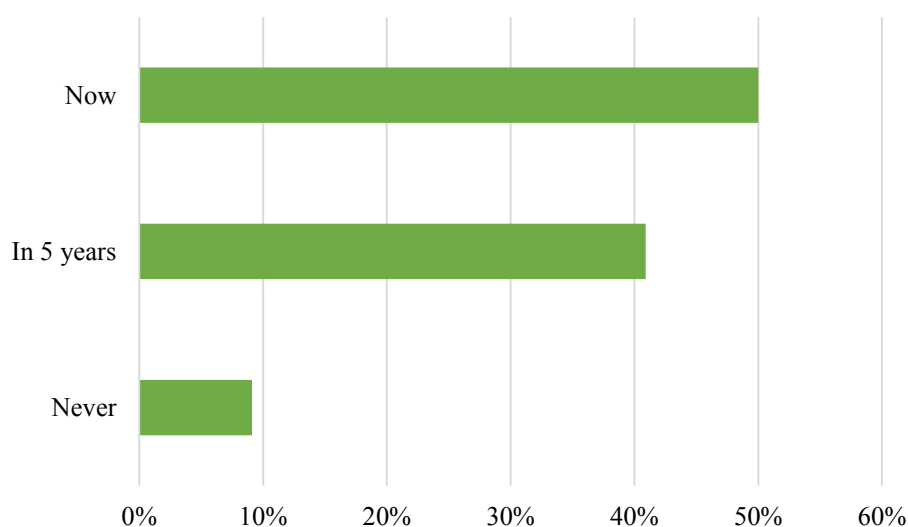


**Figure 7**. Real estate sale/rental as an area with the potential to use modern technologies.
Source: Own study based on the research.

Over 90% of the developers surveyed indicated the sale or rental of apartments as an area with potential in the use of modern technologies. Equally, half of the respondents agreed that now is the time to use them, while 41% of respondents said that there will be time in the next 5 years. Only 9% of the respondents answered that there will never be potential in this area, and none of the respondents indicated that it will happen in the next 10 years. Modern technologies in the process of selling or renting an apartment include the use of chatbots, virtual assistants for buying an apartment, apartment search engines and online meetings with sellers.
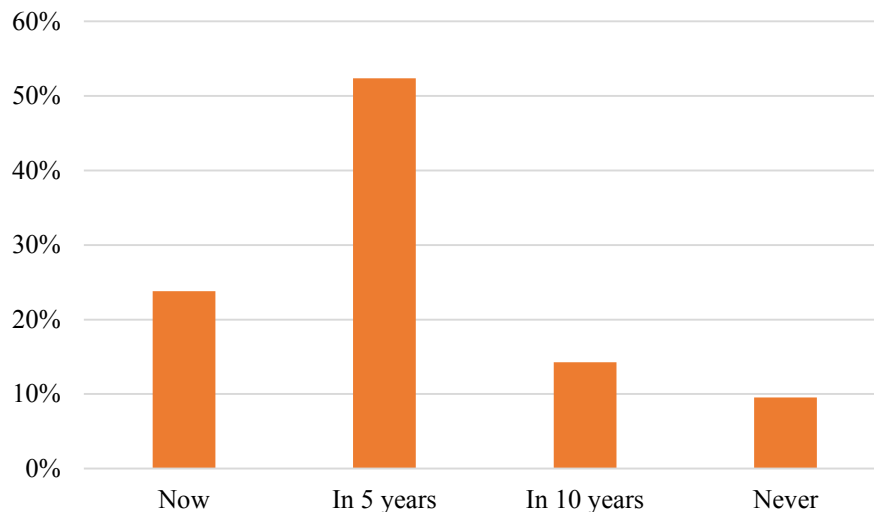
**Figure 8**. Residential real estate management as an area with the potential of using modern technologies. Source: Own study based on the research.

In addition to the issues related to the process of building and then selling real estate, the real estate management process, during which the manager supports the facility using technologies designed and implemented in the building, is of significant importance from the point of view of the use of modern technologies.

Interestingly, more than half of the respondents agreed that modern technologies in the property management process will have the greatest potential in about 5 years. Just over 20% of the respondents assumed that the potential is there today, and 14% see it in 10 years. On the other hand, 10% of respondents decided that there will never be any potential for modern technologies in this area. Perhaps this is due to the degree of application of modern technologies in residential buildings - the low level of implementation of modern technologies means that property managers do not have systems that they could use, while older buildings lack adequate funds to undertake investments in this area (Figure 8).

The last area subject to the developers' opinion was the issue of Smart Buildings (Figure 9).
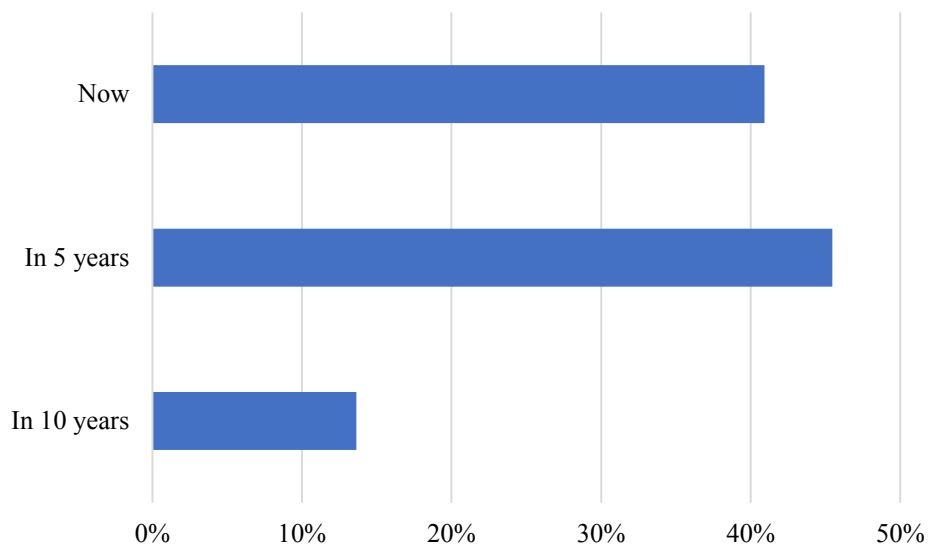
**Figure 9**. Smart buildings (so-called intelligent buildings) as an area with the potential of using modern technologies.

Source: Own study based on the research.

All surveyed developers concluded that the use of modern technologies in the creation of Smart Buildings is an area with potential. Most of the respondents (45%) believe that the greatest potential in this regard will be in about 5 years, 41% believe that the potential of this area should be exploited now, and 14% believe that despite the fact that they see the potential, it will be possible use only in about 10 years. Intelligent buildings cover many aspects related to real estate - these are systems related to controlling lighting, heating, air conditioning, electricity, roller shutters and household appliances, but also all devices that irrigate the garden, monitor objects and use solar energy.

## 5. Summary

According to the research, developers see potential in the use of modern technologies on the real estate market. It varies depending on the suggested area, but predominantly now, and in the next 5 years at the latest, they forecast that modern solutions will be introduced on the market. The areas perceived as the most promising are market research, design and construction, as well as real estate marketing. This is the result of using modern technologies in facilities that are just under construction and are at the concept or design stage. The use of modern technologies at this stage is mainly to help avoid possible design errors (e.g. through prior visualizations and 3D prints), speed up the construction process (e.g. through electronic document flow) and minimize costs (e.g. through the use of BIM models). On the other hand, the lowest potential of modern technologies was indicated in the context of financing housing investments through crowfunding or real estate management. This is probably the result of

insufficient popularity of this type of investment in the case of real estate financing and the still relatively "old" housing stock in general, in which modern technologies have not been used so far, and the prospects for their use are low due to the necessity to incur additional costs. The conducted analysis may constitute an introduction to further research related to the determination of the use of modern technologies in particular areas in the future.

The results of the research can be used in the activities of developers and entities preparing technologies and tools that can be used on the real estate market in such areas as, for example, sales and customer service.

Unfortunately, there are significant research limitations including the local market situation - lack of ordinary housing, developers are selling everything they build in a very short time; the COVID-19 pandemic - difficulty in reaching respondents; the local market, which may be a limitation since it is an example. However, despite these limitations, the above study can provide a starting point for examining the level of implementation of modern technologies on the local primary housing market.

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# DANGEROUS PRODUCTS ON THE CONTEMPORARY EU MARKET – CHARACTERISTICS OF THE NON-FOOD PRODUCTS

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**Purpose:** For most products, for example, toys, food, cosmetics, there are regulations in European law that define safety requirements. However, each year, several thousand products potentially dangerous for consumers appear on the market. Producers' organizations, as well as public institutions and consumer organizations are fighting to keep them as few as possible, yet, different market forces play a role here and they are still on the market. Therefore, consumers should be educated and knowledge about such products should be disseminated.

**Design/methodology/approach**: In the research part, the products deemed unsafe in years 2015-2021 were analyzed. Additionally, the 80 latest alerts on dangerous products were also thoroughly analyzed. Data was collected from The European Commission Safety Gate system, The comparative analysis method was used as well as the documentary analysis.

**Findings:** The aim of this article was to identify the main types of risk to consumers, related to the consumption of non-food products. The conducted analysis shows that it is mainly a risk of injury, poisoning, allergic reaction, as well as chocking and suffocation, but the risks vary greatly depending on the product group. It is significant that dangerous products are often intended for children, therefore the conscious attitude of parents is important.

**Research limitations/implications:** It should be taken into account that the situation may change over time, that may be related to new legal norms, to a change in the economic situation on international markets due to new products, to greater awareness of producers, for example. Therefore this type of research should be discussed in a broader context.

**Practical implications:** The analysis shows the need for an alert system against dangerous products. The results indicate that stereotypes about the 'safe country of origin' can change; in practice, therefore, consumers need new knowledge about dangerous products which will help them make informed decisions. Up-to-date knowledge is also needed by the sellers – they can make decisions about cooperation with suppliers that will be more favorable to them.

**Social implications:** The awareness of the presence of dangerous products on the market is important for the health of consumers, but it is also important for producers themselves due to the potential damage that can be caused to consumers and the environment.

**Keywords:** conscious consumption, consumer rights, RAPEX, safety of consumption.

**Category of the paper:** Research paper.

# 1. Introduction

Now, when the pandemic seems to be behind us, all sorts of gaps in manufacturing and security systems have emerged. Many emphasize that "business as usual" will not come back, because the changes have gone far, and there is the need to adapt to deal with complex challenges. Action is needed in the fields of technology, business, social affairs, health and science - and these require coordination to achieve policy coherence (Bragge et al., 2022). All of this also applies to the issue of unsafe products on the market. Thus, coordination tasks include facilitating a common understanding of problems and solutions, as exemplified by RAPEX. It should be emphasized that the European Union countries have been developing the warning system against dangerous products for many years. But, although European regulation aims to develop healthy societies geared to shared prosperity, there seems to be a lot of work to be done in terms of product safety. This is mainly due to the changing economic and political environment, changing technology (also new products), and new ways of purchasing. Some experts believe that commendable efforts have been made, but there has been a lack of coordination and solid partnerships in the public, private and pluralist (civil society) sectors, which results, inter alia, in the problems with the quality of products available on the market (Saxena, 2021).

Consumer safety should be secured on two sides: from the side of producers and sellers, and from the side of relevant state authorities. Of course, companies are required to only place on the market products that are safe, and to inform consumers of any risks associated with the products they supply, and to make sure that any unsafe products on the market can be traced. At the EU level, it is regulated by The general product safety directive (Directive 2001/95/EC).

Within the EU, there are two alert systems for dangerous products: RASFF – the rapid alert system for food and feed and RAPEX – the EU rapid alert system for dangerous non-food products. Both operate under the Directorate-General for Justice and Consumers of European Commission. Due to the huge amount of data and the complexity of the issues, as well as separate regulations, in this article only the non-food products present on the European market will be discussed. It is worth noting that there are new areas that require regulations, such as artificial intelligence, autonomous vehicles or robots, which will soon be used on an equal footing with other products of everyday use. Thus, the safety of products available on the market is an up-to-date and important issue.

Dangerous products can be defined in various ways - in this article we assume the perspective of consumers, so a dangerous product is primarily one that may endanger health or life of the user. Against this background the aim of the article is to identify the most common types of risks for consumers and to establish links between unsafe products and the countries of origin. We believe that, apart from low-quality products from China, also European companies have difficulties in maintaining appropriate safety standards, which will be analyzed

in the empirical part. The research was carried out in two paths: in one part the data prepared by RAPEX was obtained, in the other part, the own analysis of alerts from 2022 was performed. In this part the content analysis method was used.


## 2.  Literature review


From the point of view of the number of publications, the safety of product consumption reached its peak in the mid-70s. of XX c. At that time, for example, the situation in the hairdressing industry, which did not agree to legal regulations regarding the safety of hair dyes, was widely discussed. The hairdressing industry motivated its resistance with the vision of bankruptcies and the closure of hairdressing salons (Cancer-causing chemicals, 1978). However, studies showed that the ingredients in cosmetics are carcinogenic and the necessary changes must be introduced immediately. Therefore, in the early 1970s, the then EU Member States decided to harmonize their national cosmetics legislation to protect consumers, while allowing cosmetic products to circulate freely within the Community. As a result of numerous discussions among experts from all Member States, the Cosmetics directive of the Council no. 76/768/EEC was adopted. The rules set out in the Cosmetics Directive took into account the needs of the consumer, with the introduction of the principle that if a product is to move freely within the EU, the same labeling, packaging and safety systems must apply (Hodges, 2005; Pauwels, Rogiers, 2010). Similar discussions and regulations have arisen in the United States, as evidenced by the cosmetic safety hearings in front of the Congress. Also in the 1970s, problems were noticed regarding the poor quality of footwear, TV sets, toys, Christmas decorations or flammable fabrics imported then from Taiwan and Hong Kong. Therefore, the necessity to introduce broader regulations was emphasized, and the point of view of consumers was also stressed, especially that they are always in a weaker position than a producer and a seller (Dine, Fagan, 2006). These issues have received more and more attention as international trade, globalization, and the internet and online commerce expand. As a result, in 2001, the European Union introduced common product safety regulations, as well as an international system for the rapid exchange of information (Purves, Echikson, 2021). Of course, not only cosmetics are regulated, but also various groups of products, such as medical and food products, for example. Although European and American regulations and those in force in other countries are not identical, it should be emphasized that consumer safety has become one of the key social and economic issues, especially during the covid-19 pandemic. J. Ruohonen (2022) emphasizes that from the 1960s to the present day new safeguards are created, allowing consumers to minimize their weaker position vis-à-vis producers and sellers. The literature also emphasizes the importance of a holistic view of the security problem – not only consumption should be safe, but also the production, and later disposal of waste (Hall, 2019).

## 3.  Dangerous products - definition and rules of conduct

The presence of dangerous products on the market is restricted in four areas: 1) labeling, packaging, waste; 2) accident prevention; 3) transport and 4) liability for damage (Pozzo, 2009). Nevertheless, dangerous substances are around us. Although, as already mentioned, the product cannot be dangerous for its user, however, there are many natural substances that may pose such a threat - they are listed in Fig. 1. Dangerous substances are, for example: explosive ones present in car batteries; exhaust gases (such as nitrogen oxide) from internal combustion engines; oxidizing substances, such as sulfuric acid and nitric acid, used in the plastics industry; an example of a toxic substance is also hexane – a solvent used in the food industry (Zhang et al., 2022). Dangerous substances are not the only source of risks for consumers. One should add here defective technical solutions that may cause damage to the body, eyesight or hearing, burns, poisoning, or even fertility problems. Such effects may result from the use of too strong light or sound emitters, from faulty workmanship of parts, bad security and insulation, which, in combination with electricity or the previously mentioned harmful substances, has negative effects on health.
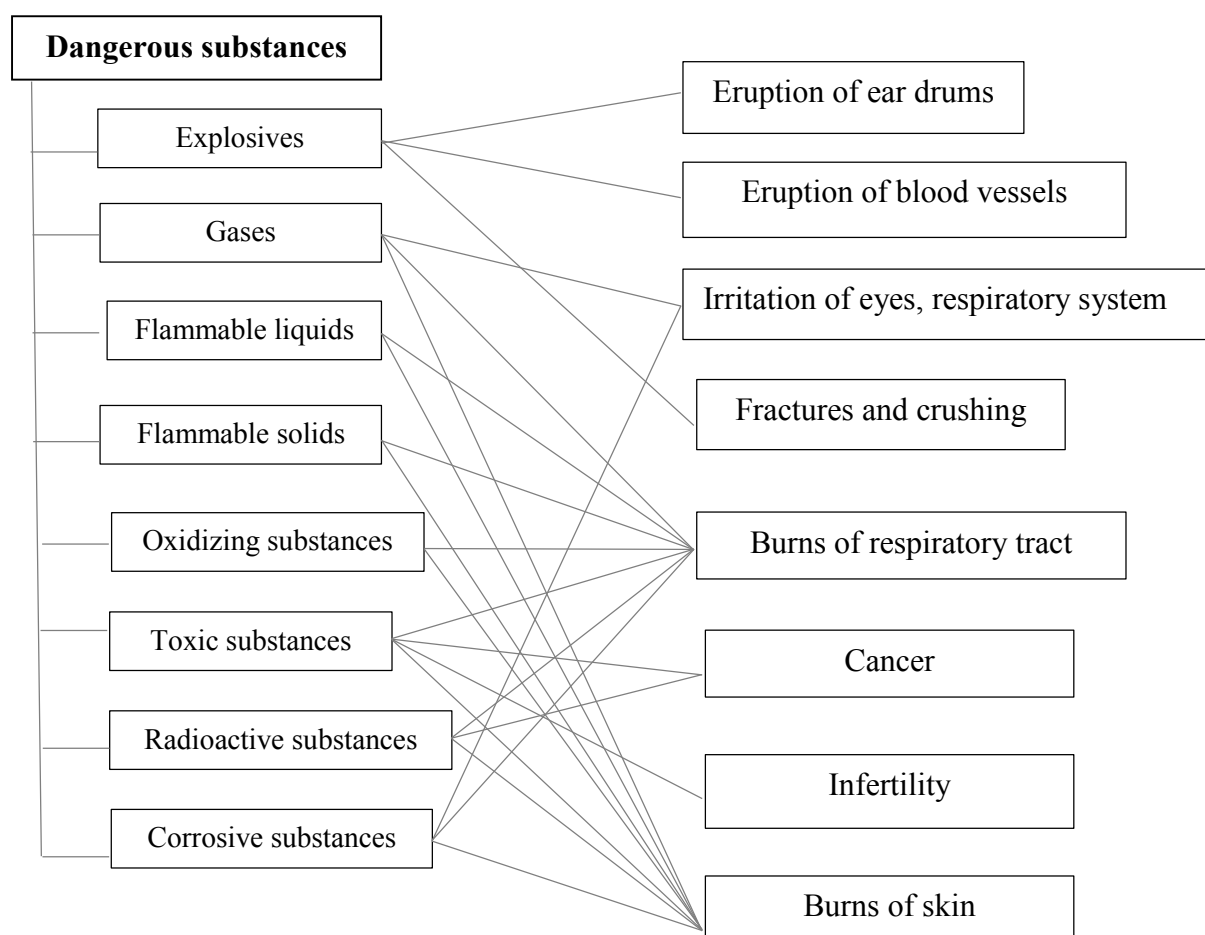


**Figure 1.** Substances and processes that affect product safety.

Source: Own study based on: https://blog.storemasta.com.au/risks-dangerous-goods.

In EU legislation, dangerous products are primarily defined by the aforementioned The general product safety directive (Directive 2001/95/EC), which considers as a dangerous product anything that does not provide safety that can be expected given the normal use of the product. A similar approach to defining products dangerous for the consumer is in force in other EU countries, and thus also in Poland (it is regulated by Art. 449 of the Civil Code). Whether a product is safe is determined by the circumstances at the time of placing it on the market, in particular the way it is presented and the information about its properties provided to the consumer. Thus, a product is dangerous, if in normal conditions of its use poses a threat to the health or life of consumers, as well as a threat to the natural environment. In other words, a safe product may not carry any risk, or only the minimum risk corresponding to the use of the product and related to its proper operation. The potential consequences of using hazardous products may be as follows:

- choking, suffocation,
- skin infections,
- bruises, wounds, fractures,
- internal organ disorders,
- damage or loss of vision /hearing,
- nervous system disorders,
- fertility disorders,
- poisoning,
- burns,
- death.

The likelihood of negative consequences for the product user is not easy to estimate. Therefore, workflows have been developed, which take into account the type of users, their knowledge of the risk and possible precautions. As a result, there are three levels of negative effects of using the product: low, medium and high risk. In the case of medium and high risk, the entrepreneur is obliged to report this fact to the relevant authorities.

The already mentioned RAPEX system enables the exchange of information on non-food and non-medical products, which was released in 2003 pursuant to the provisions of the General Product Safety Directive. Currently, the system includes 30 participating countries – EU27 plus Iceland, Liechtenstein and Norway (Safety Gate 2021 results, European Commission, 2022). The RAPEX notification is filled in by the entrepreneur responsible for the product and contains, inter alia, risk type, name of notifying country, information about the packaging and brand of a product, bar code, as well as the country of origin of the product. The notification also includes information on the corrective measures taken (most often it is 'Withdrawal of the product from the market' or 'Recall of the product from end users').

As a rule, the producer is responsible for the effects caused by a dangerous product, however entities that may be responsible for a dangerous product also include co-producers of the product, importers and sellers. The key legal act here is the 'The general product safety directive', which says that within the limits of their typical activities, manufacturers provide consumers with appropriate information to enable them to assess the risk associated with the product throughout its reasonably foreseeable period of use. When the overall risk is assessed by the manufacturer as medium or high – so it goes beyond the permissible framework – he must inform the relevant market surveillance authorities by providing them with information such as: all available data on product identification, a full description of the risk associated with the product and a description of the measures taken (and planned) to protect consumers. Importantly, producers and distributors should inform the relevant authorities in each of the EU member states where their products are sold, which is why the RAPEX platform is so important.

An entrepreneur burdened with placing a dangerous product on the market is obliged to take corrective actions aimed at eliminating the risk. Apart from withdrawing the product from the market, it may also include: modification of product design, sending information and warnings to consumers regarding the proper use of products, modification of products at consumers' premises or elsewhere, replacement of the product at the consumer. If the entrepreneur is based in the EU, the costs of product recall and other corrective actions shall be borne by him and jointly by other entities involved in the sale. In the case of products originating outside the EU, the costs of withdrawing the product from the market and its re-export or destruction are borne jointly and severally by the person who took responsibility for its import and the person who brought the product into the European customs territory, i.e. the importer and the seller. Each RAPEX country has notified an authority responsible for monitoring dangerous products. In Poland, such a national institution is the Office of Competition and Consumer Protection (Market Surveillance Department), in Bulgaria, for example, it is the Commission for Consumer Protection, and in Estonia it is the Consumer Protection and Technical Regulatory Authority.

## 4. RAPEX notifications of dangerous products

RAPEX alerts may come from relevant national institutions responsible for product safety, but above all from the entrepreneurs themselves involved in corrective actions. In 2021, from all countries belonging to the system RAPEX received 2,142 notifications – the dynamics of these notifications in 2010-2021 is shown in Fig. 2.
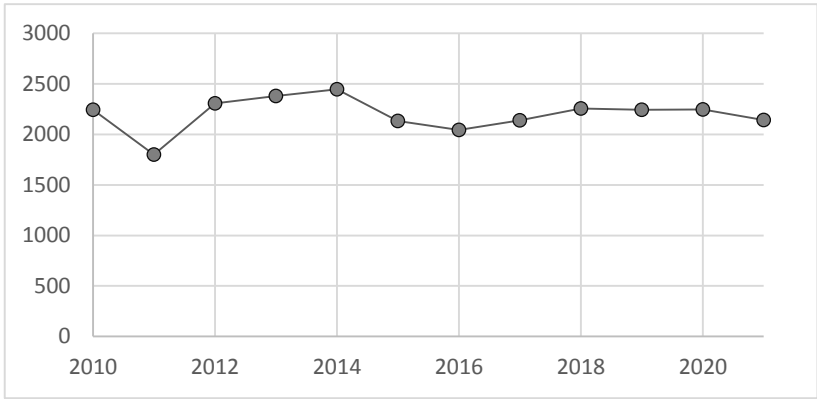
**Figure 2.** Alerts in the RAPEX system in 2010-2021.

Source: Safety Gate 2021 results, European Commission 2022.

In 2021, 26% of all alerts came from Germany and they most often related to cars, which will be discussed later in this article. The next places in terms of the number of alerts were followed by France, Sweden and Poland. In 2019-2020, particular emphasis was placed on products sold online and common procedures were developed for the countries participating in RAPEX. This is extremely important as 71% of consumers made online purchases in 2020, according to Eurostat (Key Consumer Data, 2020).

The most frequently reported products are toys, car parts, jewellery, and textiles (Fig. 3). As can be seen from the comparison of data for 2021 – reports on passenger cars have become the dominant product category (550 alerts). Toys are second, followed by electrical appliances. A more detailed analysis of the alerts is presented in the following section, however, a change in the dominant product category should be noted here – for the first time, most notifications concerned passenger cars.
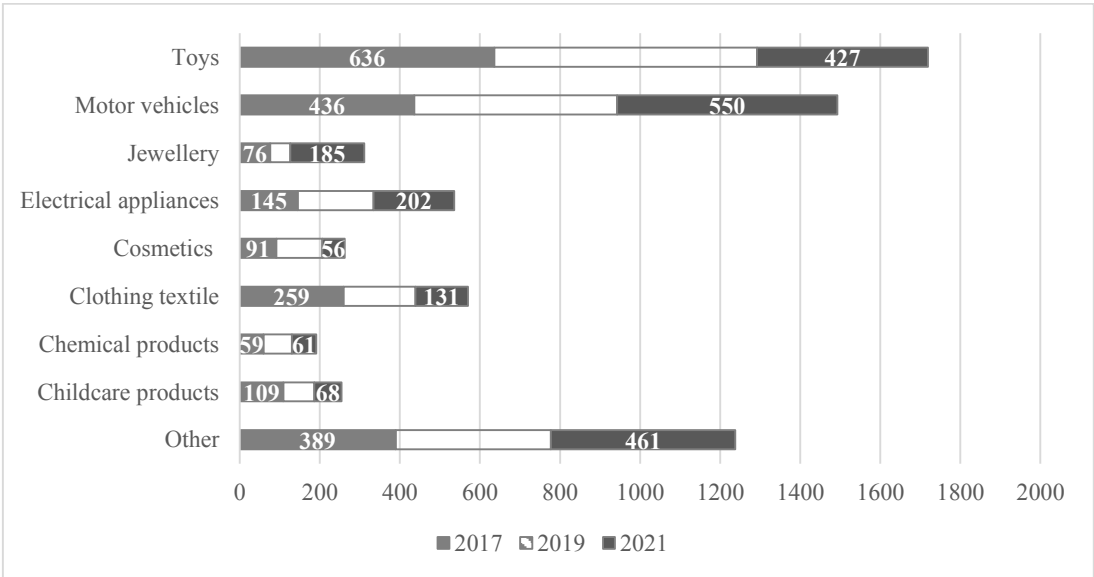


**Figure 3.** The most frequent product categories alerts in 2017, 2019 and 2021.

Source: own work based on: Safety Gate 2021 results. Modelling cooperation.

The RAPEX platform provides a lot of aggregate information, but does not describe the nature of the threats detected, therefore the 80 most current notifications, which were described as 'recent' (all from 2022), were carefully analyzed. In this group, exactly half of the analyzed cases concerned passenger cars and, significantly, only 27.5% (i.e. 11 out of 40 notifications) concerned cars from outside the EU. This means that the main category of hazardous products are passenger cars, largely produced in EU countries. Therefore, the sample of 80 reports was divided into two parts: 1) alerts concerning passenger cars, 2) other alerts – each group includes 40 cases.

As for the sources of risk identified in group 1 (passenger cars), these were poorly secured or unsecured cables, inoperative airbag sensors, overheating or falling off parts, fuel leaks from pipes, inoperative brake assist and many others. According to the description of potential consequences, it can be said that the revealed defects posed the risk of an accident, injury, fire and even death of users (Fig. 4).
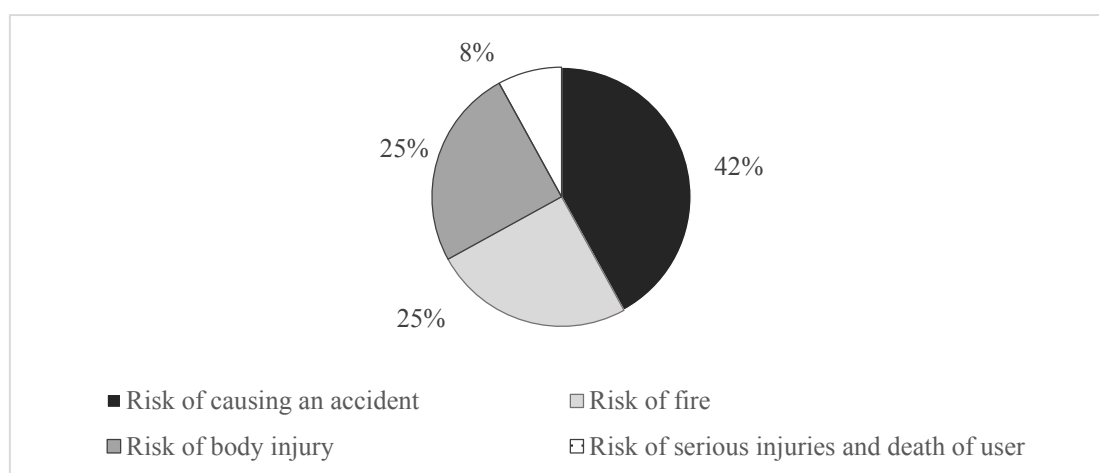


**Figure 4.** Types of threats to consumers in group 1 - passenger cars (n = 40).

Source: own study based on the analysis of the content of notifications at RAPEX, https://ec.europa.eu/safety-gate-alerts/screen/webReport.

The country of origin of the faulty car part is a surprising issue as most of the faults were reported in Germany. The development of the automotive industry in this country is probably important here, but on the other hand, no one associates Germany with faulty cars. The data presented in the comparison seem to be different, because Germany was indicated as the country of origin of the defective product (Fig. 5).
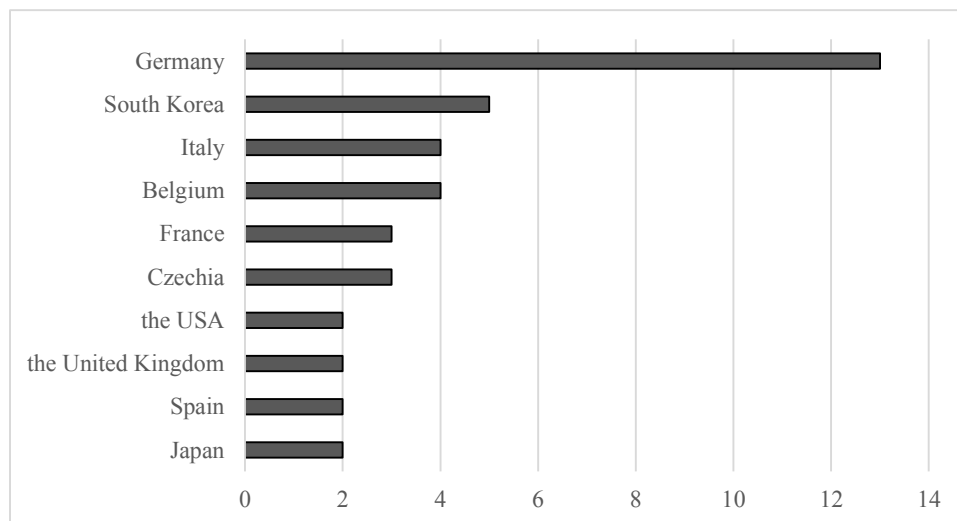
**Figure 5.** Country of origin of the faulty car part (n = 40).

Source: own study based on the analysis of the content of notifications at RAPEX, https://ec.europa.eu/safety-gate-alerts/screen/webReport.

It is very interesting that the alerts often concerned very reputable car brands, such as Mercedes (as much as 22.5% of the notifications concerned this brand), as well as Opel, Skoda, Toyota, KIA, and also Volvo, McLaren, and BMW. This means that even trustworthy manufacturers have problems with maintaining safety standards. The product alerts indicate the country of origin of the defective product and the reporting country – in the analyzed sample, 67.5% of reports came from Germany, 10% were reported by Bulgaria and Poland, 5% were from France and Portugal, and 2.5% from Spain. It means that predominantly German entrepreneurs reported a defective product produced by German contractors.

The second part of the analyzed notifications (also 40, but excluding passenger cars – Fig. 6) was more diverse – from the product category point of view, there were mainly toys (32.5%), followed by children's articles (15%), motorcycles and jewellery (each group of 4%). An interesting category are chemical products, which mean electronic cigarettes here.
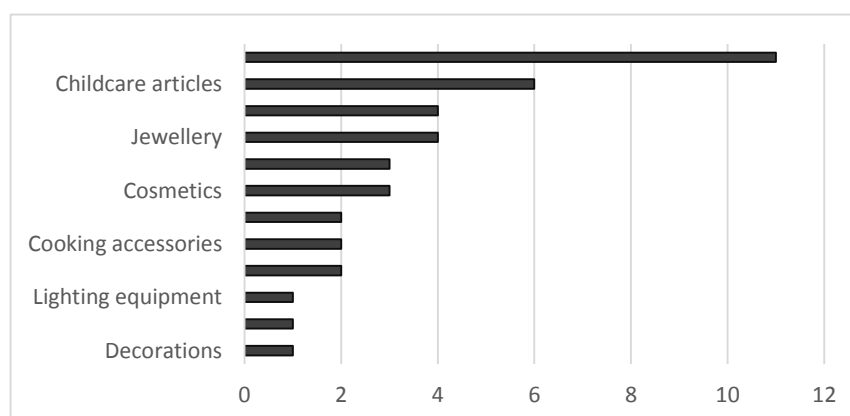


**Figure 6.** Groups of notified products, excluding cars (n = 40).

Source: own study based on the analysis of the content of notifications at RAPEX, https://ec.europa.eu/safety-gate-alerts/screen/webReport.

Due to the variety of products, there are many different risks as well, such as injuries, poisoning and infections, choking and suffocation or burns. Sometimes, of course, several hazards can occur simultaneously, such as burns and damage to internal organs in explosions. For toys, the most common hazard was 'small parts that may be swallowed', which poses a choking or suffocation risk. Excessive concentration of lead and cadmium was also mentioned, which can have wide-ranging effects on health, such as, for example, infertility. For childcare articles – cots, high chairs – there was a fall and injury hazard, which was also a major risk in the motorcycle category. In turn, in the case of jewellery, it was a risk of an allergic reaction caused by an excessive amount of nickel (Fig. 7).

In the second group of notifications, the products came from 13 countries, but as much as 57.5% came from China. This is where the issue of cheap, low-quality products becomes apparent. Only single cases concerned products from Austria, Turkey or Poland (5% each). This issue is referred to in Fig. 8.
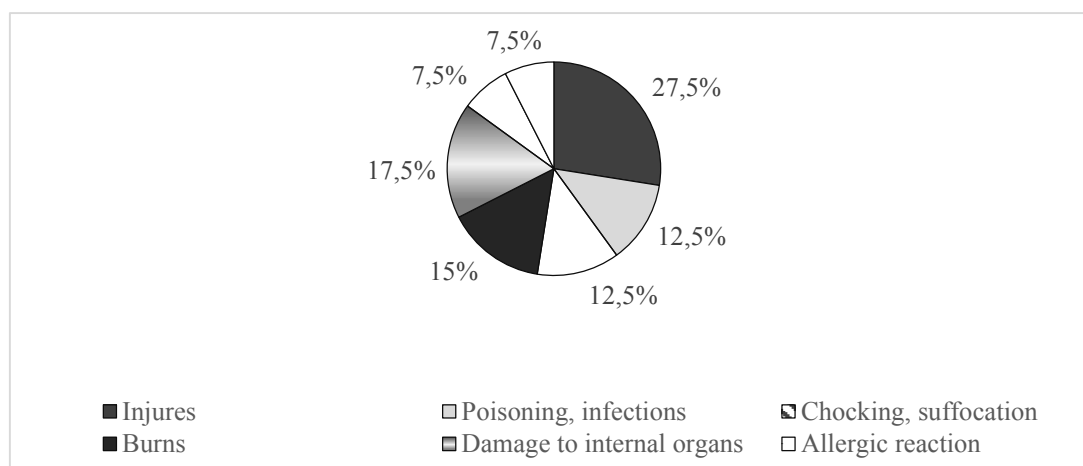


**Figure 7.** Types of threats to consumers - group 2 (excluding cars, n = 40).

Source: own study based on the analysis of the content of notifications at RAPEX, https://ec.europa.eu/safety-gate-alerts/screen/webReport.
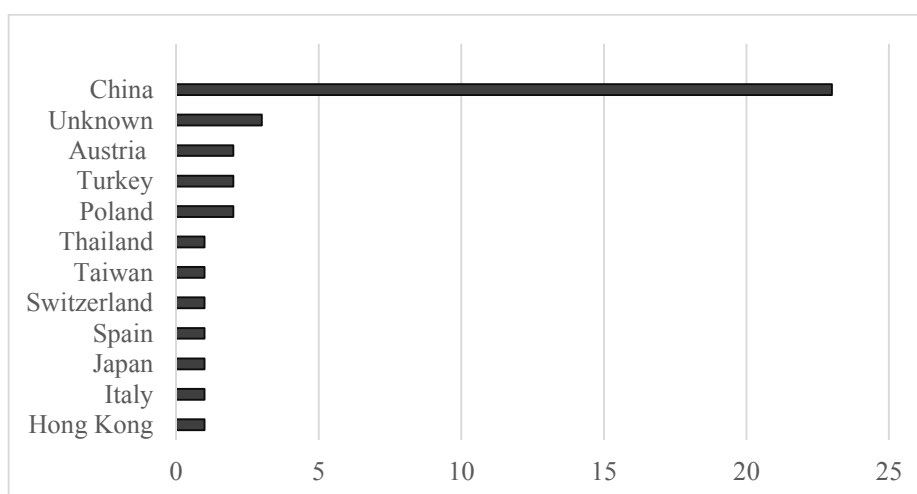


**Figure 8.** Country of origin of defective products (excluding cars, n = 40).

Source: own study based on the analysis of the content of notifications at RAPEX, https://ec.europa.eu/safety-gate-alerts/screen/webReport

By relating the results of the analysis to the entire group of tested alerts (n = 80), it can be said that:

- in the case of cars, most notifications about dangerous products concerned Germany as the country of origin (16,25%); and China does not appear in this group at all,
- there seems to be quality and safety issues in the passenger car industry,
- although we are all aware of the importance of child safety, many reports concern toys and childcare products; in this group, 28,75% of the notifications referred to China as the country of origin. Fig. 9 addresses this issue.
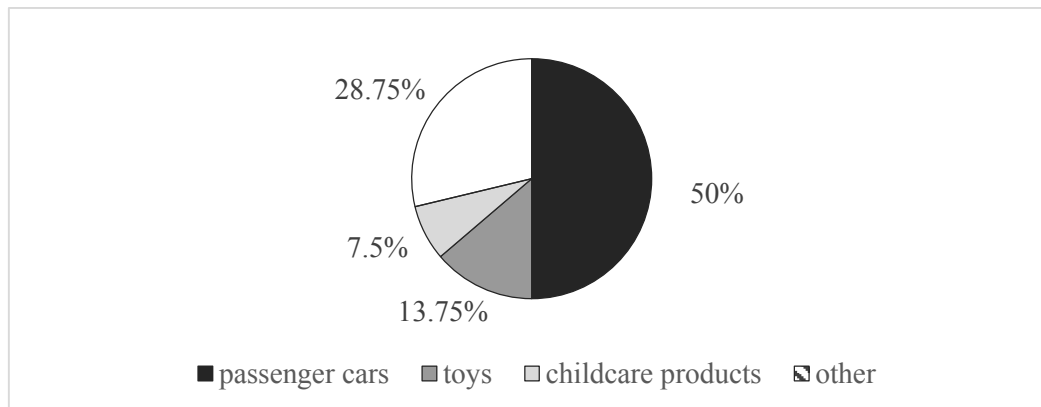


**Figure 9.** Major product groups reported as unsafe (n = 80).

Source: own study based on the analysis of the content of notifications at RAPEX, https://ec.europa.eu/safety-gate-alerts/screen/webReport.

It should be added that the above-mentioned 80 notifications concerned 18 countries of origin of the product, and nearly half of which are European Union members. As already mentioned, the group of reported countries includes Germany, but also Austria, Belgium, Poland, Italy, Spain, France, and Czechia. China is of course included in the group of countries outside the European Union, and next to it there is Japan, South Korea, Taiwan, Thailand and Hong Kong, but also the USA, the UK, Turkey and Switzerland. So it is clear that many countries have problems with maintaining product safety.

## 5. Discussion and conclusions

The aim of this article was to identify the main types of risk to consumers, related to the consumption of non-food products. The conducted analysis shows that it is mainly a risk of injury, poisoning, allergic reaction, as well as chocking and suffocation, but the risks vary greatly depending on the product group. In the case of toys, small parts that can be easily torn off and swallowed carry a risk, as well as an excess of harmful chemicals, such as lead. In the case of passenger cars, for example, the most common risks are burns from fire, injury and death of the user.

The second aim was to establish a list of countries of origin of dangerous products. Here we put into question the claim that only dangerous products come from China. Once again it can be said that it all depends on the product category – in the case of passenger cars, there are no dangerous parts imported from China at all. Moreover, it was quite surprising that a large proportion of the dangerous parts came from Germany. The situation is very different for other product groups, as there a large proportion of the dangerous items actually come from China. It should be noted, however, that in the sample of 80 notifications there were as many as 18 countries of origin of the product. This means that not only China has problems with maintaining product safety and meeting production standards.

A few years ago, in the trade press appeared information that German cars are among the most defective (Milligan, 2015). So it turns out that the long-standing tradition of solid German products is a thing of the past. Moreover, the quality of cars produced in Asia has improved a lot, while the German car industry is stagnating. This can be seen in the results of the analysis carried out, as most of the reported defective cars came from Germany. Many industries, especially transport sector, develop technologies, introduce innovations, improve quality in order to provide travelers with the greatest possible safety (Hernik, Mazur, 2018). It turns out that the German automotive industry has problems with this. Despite the fact that German cars have long enjoyed a reputation ahead of their time, there are now problems with quality apparently. Manufacturers for decades have justified their high prices on the grounds of unprecedented safety features, which may now be up for discussion.

The study also found another alarming thing: many unsafe products are made for children. Despite the regulations in force, manufacturers still produce, and importers introduce, products that may suffocate, choke, accident, damage the body, so they are definitely not for children. It turns out, therefore, that warning systems are very important to protect the rights of consumers to safe consumption. When it comes to products other than cars, the country from which dangerous products are imported is China. According to the statistics of the Chinese Statistical Office, the Chinese consumer market is the second largest in the world after the USA (Xinhua, 2021). Consumption is growing especially in the luxury segment. But, the old habits of Chinese producers significantly reduce the demand for domestic products, as they do not meet the consumers' requirements. A similar situation can be observed on the international market.

Safety issues of product consumption can be related to many areas: they can be analyzed from the point of view of sustainable development, from the consumer rights point of view, as well as the best production management standards, or human health and wellbeing. Collected data allow for the development of each of the mentioned paths. However, it is worth noting that the key here is information for the consumer who is in a weaker position than producer and seller. Therefore, information about the type of risks during consumption and the country of origin of the product should be widely disseminated in order to prepare consumers for conscious shopping and safe consumption.

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# SHAPING PRO-ENGINEERING ATTITUDES OF YOUNG PEOPLE – RESEARCH RESULTS

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**Research background:** For many years, the authors have been dealing with the issues of student inventiveness and the related innovation and creativity. The presented work refers to the sources, understood as shaping the pro-engineering attitudes of young people, which in effect translates into the creation of new, often innovative solutions in the field of technology.

**Purpose:** The aim of the research is to identify activities related to knowledge in the field of science and technology during the period of attendance at secondary school. These activities include knowledge and skills acquired at school and other relationships between young people and science and technology resulting from passions and passions. An additional goal is to indicate proposals for development in this area, mainly concerning the teaching process.

**Methodology:** The source of data for the conducted analyses are the results of surveys conducted in 2021. The analysis of the acquired data was carried out using the AHP (Analytic Hierarchy Process) method. The AHP method, by incorporating expert opinions, allows you to achieve an additional goal. This is an original approach to the analysis and interpretation of survey results. It will not replace classical statistical analyses of varying complexity, but it can be a kind of complement.

**Findings**: The implementation of the research indicated a significant interest of young people in the issues of science and technology, and the obtained data allowed to take a comprehensive look at the education of young people in this area and present suggestions for the modification of teaching forms. This may contribute to reducing the shortage of engineering staff and researchers creating new innovative solutions in many countries. This will be an important factor in economic development based on innovative technologies.

**Keywords:** Youth education, science and technology, survey research, innovative solutions, AHP method.

**Category of the paper:** research paper.

## 1.  Introduction

The time spent at a university is very important for the development of young people entering their adult life. In addition to acquiring knowledge and skills, interests and passions are developed. They form the basis for later activities in professional life, which ultimately affects the personal material status and economic development of regions. In this aspect, an important area of interest is issues related to science and technology. They are important for engineering activities that are the basis of economic development, as well as for conducting scientific research in many cases linked to creativity, which sometimes results in inventions (https://tu.kielce.pl/start/wspolpraca/ksw). Associated with this interesting issue is the acquisition of knowledge about students' interest in issues related to issues of science and technology, also considering the influence of the university on this process. One way to learn about students' connections to science and technology is through surveys. The completed questionnaires contain data, the processing of which gives a set of information concerning the analyzed issues. Then, using imagination, the ability to think abstractly while maintaining the logic of inference, acquired information can be transformed into knowledge, the essential element of which is the diagnosis taking into account the context understood as the relationship with the environment (Trajer, Paszek, Iwan, 2012; Gierulski, Santarek, Winiewska, 2020).

The survey was conducted in 2021 using an online form on students' relationship with science and technology. The target population for the study was university students and recent graduates. The results of the study, mainly as frequencies of occurrence, which is a form of research report, are presented in (Kaczmarska, Gierulski, 2022b). Transforming the information thus obtained into knowledge requires further analysis, which often relies on advanced statistical methods. In the presented work, traditional statistical methods were abandoned, instead, the method of AHP (*Analytic Hierarchy Process*) was used (Prusak, Stefanów, 2014), with the conviction that this will allow to extend the knowledge of the analyzed issue with elements beyond the information directly obtained in the research.

## 2.  Analytic Hierarchy Process – the essence

Among the multi-criteria decision support methods, AHP (*Analytic Hierarchy Process*), developed in 1970 by Thomas L. Saaty (Saaty, 1980, 1990), occupies a significant position. Its great versatility, simplicity, and accessibility result in it finding use in many areas of science and practice, also by users without specialized mathematical education. In addition to direct decision support, it is also used for cognitive purposes, to better knowledge and understand the problem being analyzed.

In the first step, a model of a hierarchical structure is created, with the decision or cognitive goal at the top, the influencing criteria below it, and the decision options at the bottom of this arrangement. Figure 1 shows an example of an elaborate hierarchical structure with additional lower-level criteria (sub-criteria) in addition to the main criteria and the options necessary to achieve the objective of the decision. The number of main criteria, additional criteria, and decision options depends on the complexity of the problem being analyzed.
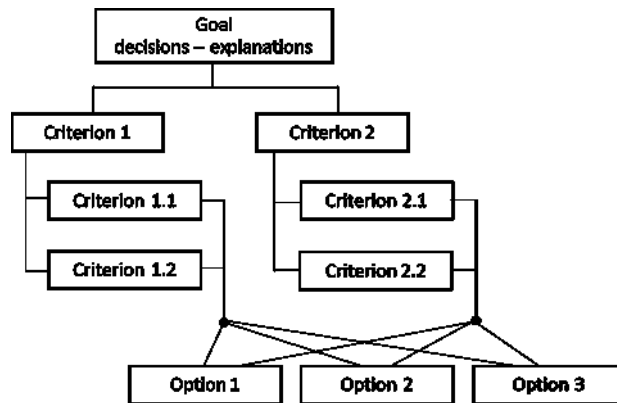


**Figure 1.** Example of hierarchical structure.

Source: Own elaboration.

In a second step, a pair of criteria and options are compared using a relative rating scale. A nine-point comparison scale is used to determine the relationship between the factors being evaluated (Table 1), called the Saaty's Fundamental Scale.

**Table 1.**
*Scale of comparison in the AHP method*

| Verbal – qualitative evaluation | Numerical evaluation |
|---|---|
| Complete advantage | 9 |
| Very large advantage | 7 |
| Large advantage | 5 |
| Small advantage | 3 |
| Same meaning. | 1 |

Source: Own elaboration based on (Prusak, Stefanów, 2014).

If there is difficulty in evaluation using the basic set (1, 3, 5, 7, 9) then intermediate values (2, 4, 6, 8) are also used in special cases.

The results of pairwise comparisons are entered into a matrix in mathematical notation or a corresponding array symbolically representing that matrix. Fig. 2 shows an example matrix in symbolic form for the three factors being compared ($x_1, x_2, x_3$).

| $X$ | $x_1$ | $x_2$ | $x_3$ |
|---|---|---|---|
| $x_1$ | $1$ | $a_{12}$ | $a_{13}$ |
| $x_2$ | $a_{21}$ | $1$ | $a_{23}$ |
| $x_3$ | $a_{31}$ | $a_{32}$ | $1$ |

| $X$ | $x_1$ | $x_2$ | $x_3$ |
|---|---|---|---|
| $x_1$ | $1$ | $a_{12}$ | $a_{13}$ |
| $x_2$ | $1/a_{12}$ | $1$ | $a_{23}$ |
| $x_3$ | $1/a_{13}$ | $1/a_{23}$ | $1$ |

**Figure 2.** Example matrix for pairwise comparison.

Source: Own elaboration.

Fig. 2. shows an example matrix in symbolic form for the three factors being compared (x1, x2, x3) including the relationship between the scores:

$$a_{21} = \frac{1}{a_{12}} \quad a_{31} = \frac{1}{a_{13}} \quad a_{32} = \frac{1}{a_{23}}$$

In the third stage, a formal verification is performed to check whether the pairwise comparison matrix is inconsistent, which is also referred to as inconsistency. It only makes sense to formulate a conclusion if all pairwise comparisons have been made obeying the laws of logic. An example of not maintaining logic in defining relationships is:

$$x_1 > x_2 \wedge x_2 > x_3 \wedge x_3 > x_1$$

It follows from this relation that x3 is both smaller and larger than x1, which leads to a contradiction. The consistency testing is done individually for each matrix using a special measure called consistency ratio (CR) (Prusak, Stefanów, 2014). It is assumed that a value of this coefficient above 10% indicates a lack of consistency resulting from a contradiction in the pairwise comparison matrix.

In the fourth step of the analysis, the weighting factors are determined for each pairwise comparison matrix. For this purpose, methods are used that employ the following in the calculations:

– matrix calculus,
– geometric mean,
– arithmetic mean.

The results obtained by each of these methods are slightly different, with differences occurring only beyond two significant digits in the decimal. A good solution is to use specialized computer programs that determine the value of the CR compliance coefficient in addition to the weighting coefficients. However, it is necessary to learn the functionality of these programs, and their use does not allow us to follow the intermediate steps of the calculations.

Figure 3 shows the calculations, for example, numerical values of the comparison matrices of the three factors (x1, x2, x3). In the pairwise comparison matrix, the following relationships (T1) were defined:

- $x_1$ shows a complete advantage over $x_2$ ($x_1 = 9*x_2$),
- $x_1$ shows a large advantage over $x_3$ ($x_1 = 5*x_3$),
- $x_3$ shows a small advantage over $x_2$ ($x_3 = 3*x_2$).

The last row of this table contains the sums of the values in each column.

| T1 - Pairwise comparison | | | | T2 - Normalization and weighting coefficients | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $X$ | $x_1$ | $x_2$ | $x_3$ | $X$ | $x_1$ | $x_2$ | $x_3$ | weights | weights % |
| $x_1$ | 1 | 9 | 5 | $x_1$ | 0.7627 | 0.6923 | 0.7895 | 0.7482 | 74.8% |
| $x_2$ | 0.1111 | 1 | 0.3333 | $x_2$ | 0.0847 | 0.0769 | 0.0526 | 0.0714 | 7.1% |
| $x_3$ | 0.2 | 3 | 1 | $x_3$ | 0.1525 | 0.2308 | 0.1579 | 0.1804 | 18.0% |
| Total: | 1.3111 | 13 | 6.3333 | Total: | 1 | 1 | 1 | 1 | 100% |

**Figure 3.** Example calculation of weighting factors.

Source: Own elaboration.

The next matrix (T2) is the normalization and weighting factors. The values in successive cells of the T1 matrix are divided by the sum of the values of each column. The weighting factors (weights), on the other hand, are the average values from each row (T2) – presented as a number or percentage. The consistency coefficient takes a small value of CR = 2.8% (the computational procedure is not shown here) which indicates that the pairwise comparison matrix is not contradictory.

For an extended hierarchical structure, this kind of calculation is performed repeatedly, and the determined weights are treated as local. From these, global weights relating to the whole issue are determined.

## 3. Implementation of research

A survey was conducted in 2021 using an online form on students' connection to science and technology issues. 190 respondents, students and recent graduates, took the survey. The results of the survey, mainly as frequencies of occurrence, are presented in (Kaczmarska, Gierulski, 2022b), which should be regarded as information only. 190 respondents took part in the survey, mostly engineering students (85%), while graduate participation in the survey did not exceed 3%.

The survey form (Table 2) contains three groups of questions. Two of them deal with sources of knowledge about history and the current level of development of science and technology. The third group concerns information on practical activities that confirm students' connection to technology.

**Table 2.**
*Survey form*

| Survey form | Evaluation scale | | | | |
|---|---|---|---|---|---|
| **Questions: groups A – B – C** | *1* | *2* | *3* | *4* | *5* |
| **A. Interest in the history of science and technology – sources of knowledge** | | | | | |
| A.1. Books – biographies of the creators | | | | | |
| A.2. Internet – biographies of the creators | | | | | |
| A.3. Museums of technology and exhibitions | | | | | |
| A.4. Copernicus Science Center. Leonardo da Vinci Center and others | | | | | |
| A.5. Science fiction literature | | | | | |
| **B. Current level of development of science and technology – sources of knowledge** | | | | | |
| B.1. Literature on new technological solutions | | | | | |
| B.2. Internet – searching for and following new solutions | | | | | |
| B.3. TV shows – e.g. How Things Work | | | | | |
| B.4. University – lectures, online forum, Facebook, etc. | | | | | |
| B.5. Enterprises – employment or study visits | | | | | |
| **C. Practical measures** | | | | | |
| C.1. Disassembling devices to learn how they work | | | | | |
| C.2. Build various devices and mechanisms on one's own | | | | | |
| C.3. Repairing home appliances and other devices on one's own | | | | | |
| C.4. Interest in computer science beyond the curriculum | | | | | |
| C.5. University – science clubs and practice, e.g. SolidWorks, FlexSim | | | | | |

Source: Own elaboration.

The form uses a five-point rating scale (Likert scale). For each group, the cumulative shares of the answer options to the following questions were determined $(\gamma_i)_k$ calculated with weighting factors corresponding to the Likert scale according to the formula (development paths):

$$(\alpha_i)_k = 1 \cdot (n_{i,1})_k + 1 \cdot (n_{i,2})_k + 1 \cdot (n_{i,3})_k + 1 \cdot (n_{i,4})_k + 1 \cdot (n_{i,5})_k$$

$$\beta_k = \sum_{i=1}^{5} (\alpha_i)_k \quad (\gamma_i)_k = \frac{(\alpha_i)_k}{\beta_k}$$

And the cumulative shares for each group of questions:

$$\delta_k = \frac{\beta_k}{\sum_{k=1}^{3} \beta_k}$$

where:

$k$ – number of the subsequent group of questions ($k$ = 1, 2, 3),

$i$ – number of question in the group ($i$ = *1, 2, 3, 4, 5*),

$n_{i,1}, n_{i,2} \ldots \ldots n_{i,5}$ – the Likert scale scores for questions in subsequent groups.

**Table 3.**
*Cumulative shares*

| Groups | A | | | | | B | | | | | C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\delta_k$ % | 30.3 | | | | | 37.2 | | | | | 32.5 | | | | |
| Questions | A1 | A2 | A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | C1 | C2 | C3 | C4 | C5 |
| $(\gamma_i)_k$ % | 15.8 | 23.5 | 18.2 | 21.5 | 21.0 | 17.4 | 23.6 | 19.9 | 21.5 | 17.6 | 21.1 | 18.9 | 23.8 | 19.5 | 16.7 |

Source: Own elaboration.

The main purpose of the research conducted was to gain an understanding of the interest of students in issues related to science and technology. An additional goal is to identify the selected measures that increase student interest in these issues. These measures relate to the curriculums understood as proposals for students regarding the subjects and forms of courses to be implemented.

The indicated secondary objective will be implemented using the AHP method. This requires that the issue under study be presented as a hierarchical structure (Figure 4). Groups of questions A, B, C are the main criteria, while further questions assigned to groups A, B, C are additional criteria. The primary and secondary criteria correspond to the questions in the survey form (Table 2). The additional element consists of options (W.1, W.2, W.3) defining additional activities related to the realization of the goal – increasing students' interest in issues related to science and technology.
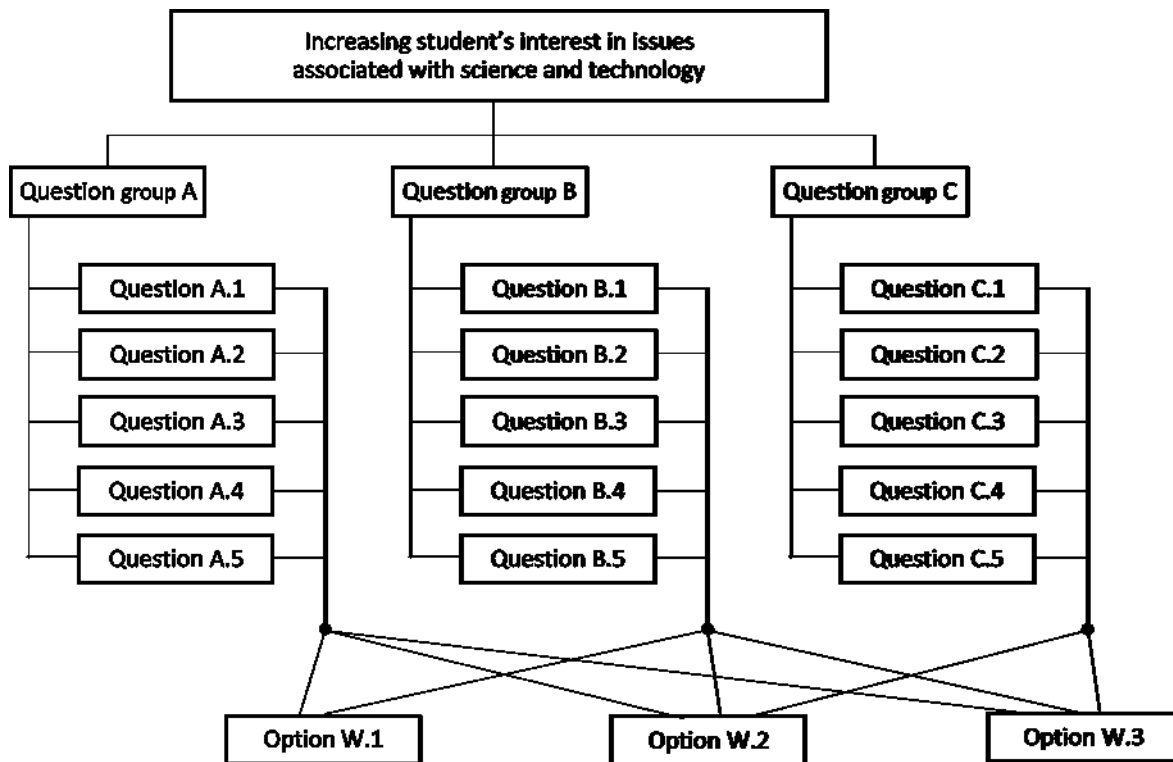


**Figure 4.** Hierarchical structure for the issue under study.
Source: Own elaboration.

Additional options address changes to the study system by increasing the role of the following elements:

W.1. Theoretical papers – interdisciplinary projects with a choice of topics in the area of technical sciences.

W.2. Experimental work – laboratories with workshop facilities with choice of research plan in the area of technical sciences.

W.3. Choice – reducing the number of compulsory subjects and increasing choice, also in other faculties and fields of study.

With these changes, students are able to shape their path of development to a greater extent according to their interests and passions. There will be an increased chance that the projects developed and the work done in the labs will actually be of a practical and research nature and not just a way to pass another mandatory course.

## 4. Analysis using the AHP method – pairwise comparisons

According to the procedure of the AHP method, the pairwise comparison process involves several steps. The first stage concerns the group of questions A-B-C. Taking into account the values of the coefficients $\delta_k$ (Table 3), which determine the relationship between the compared groups $(B > C > A)$ , an evaluation was made using Saaty's fundamental scale in its full version, including even values (Table 4).

**Table 4.**
*Pairwise comparisons A-B-C*

| ABC | A | B | C | weights | weights% |
|-----|---|---|---|---------|----------|
| A | 1 | 0.3333 | 1 | 0.2106 | 21.06% |
| B | 3 | 1 | 2 | 0.5485 | 54.85% |
| C | 1 | 0.5 | 1 | 0.2409 | 24.09% |

Source: Own elaboration.

The next step was the calculation of the weighting coefficients and the compliance coefficient (CR = 1.8%) whose small value confirms that the matrix is not contradictory.

The second stage involves questions in each of the three groups. The relationships between the compared questions for each group are determined by the coefficients $\gamma_i$ (Table 3) and are as follows:

$$A2 > A4 > A5 > A3 > A1 \ B2 > B4 > B3 > B5 > B1 \ C3 > C1 > C4 > C2 > C5$$

The pairwise comparison used Saaty's fundamental scale without even values, then the weighting factors were calculated (Table 5, 6, 7). The CR compliance coefficients did not exceed the value of 5.5% which indicates that the matrix is not contradictory.

Table 5.
*Pairwise comparisons – group A*

| Group A | A1 | A2 | A3 | A4 | A5 | weights | weights% |
|---------|-----|--------|--------|--------|--------|---------|----------|
| A1 | 1 | 0.1111 | 0.3333 | 0.1429 | 0.2 | 0.0435 | 4.35% |
| A2 | 9 | 1 | 7 | 3 | 5 | 0.6285 | 62.85% |
| A3 | 3 | 0.1429 | 1 | 0.2 | 0.3333 | 0.0847 | 8.47% |
| A4 | 7 | 0.3333 | 5 | 1 | 3 | 0.3253 | 32.53% |
| A5 | 5 | 0.2 | 3 | 0.3333 | 1 | 0.1679 | 16.79% |

Source: Own elaboration.

**Table 6.**

*Pairwise comparisons – group B*

| Group B | B1 | B2 | B3 | B4 | B5 | weights | weights% |
|---|---|---|---|---|---|---|---|
| B1 | 1 | 0.1111 | 0.2 | 0.1429 | 0.3333 | 0.0435 | 4.35% |
| B2 | 9 | 1 | 5 | 3 | 7 | 0.6285 | 62.85% |
| B3 | 5 | 0.2 | 1 | 0.3333 | 3 | 0.1679 | 16.79% |
| B4 | 7 | 0.3333 | 3 | 1 | 5 | 0.3253 | 32.53% |
| B5 | 3 | 0.1429 | 0.3333 | 0.2 | 1 | 0.0847 | 8.47% |

Source: Own elaboration.

**Table 7.**

*Pairwise comparisons – group C*

| Group C | C1 | C2 | C3 | C4 | C5 | weights | weights% |
|---|---|---|---|---|---|---|---|
| C1 | 1 | 5 | 0.3333 | 3 | 7 | 0.3253 | 32.53% |
| C2 | 0.2 | 1 | 0.1429 | 0.3333 | 3 | 0.0847 | 8.47% |
| C3 | 3 | 7 | 1 | 5 | 9 | 0.6285 | 62.85% |
| C4 | 0.3333 | 3 | 0.2 | 1 | 5 | 0.1679 | 16.79% |
| C5 | 0.1429 | 0.3333 | 0.1111 | 0.2 | 1 | 0.0435 | 4.35% |

Source: Own elaboration.

Pairwise comparisons require expert evaluation. Ratings for groups and questions within each group were determined using survey results (coefficients $\delta_k, \gamma_i$) which increases the degree of objectivity.

In the third stage, pairwise comparisons included options (W.1, W.2, W.3) for the following group A, B, and C questions. As before, Saaty's fundamental scale without even values was used, then the weighting factors were calculated (Table 8, 9, 10).

The highest value of the compliance coefficient for pairwise comparisons in stage three was CR = 6.3%, so it was less than the cut-off value (CR = 10%) which indicates that the matrix was not contradictory. In this case, the evaluations, concerning the connection of the variants (W.1, W.2, W.3) with the following questions, were determined by the experts without the support of the survey results.

**Table 8.**

*Pairwise comparisons: group A questions – options W.1, W.2, W.3*

| A.1. | W1 | W2 | W3 | weights | weights% |
|---|---|---|---|---|---|
| W1 | 1 | 3 | 0.3333 | 0.2605 | 26.05% |
| W2 | 0.3333 | 1 | 0.2 | 0.1062 | 10.62% |
| W3 | 3 | 5 | 1 | 0.6333 | 63.33% |

| A.2. | W1 | W2 | W3 | weights | weights% |
|---|---|---|---|---|---|
| W1 | 1 | 3 | 0.3333 | 0.2431 | 24.31% |
| W2 | 0.3333 | 1 | 0.1429 | 0.0882 | 8.82% |
| W3 | 3 | 7 | 1 | 0.6687 | 66.87% |

| A.3. | W1 | W2 | W3 | weights | weights% |
|---|---|---|---|---|---|
| W1 | 1 | 3 | 1 | 0.4286 | 42.86% |
| W2 | 0.3333 | 1 | 0.3333 | 0.1429 | 14.29% |
| W3 | 1 | 3 | 1 | 0.4286 | 42.86% |

| A.4. | W1 | W2 | W3 | weights | weights% |
|---|---|---|---|---|---|
| W1 | 1 | 3 | 0.3333 | 0.2431 | 24.31% |
| W2 | 0.3333 | 1 | 0.1429 | 0.0882 | 8.82% |
| W3 | 3 | 7 | 1 | 0.6687 | 66.87% |

| A.5. | W1 | W2 | W3 | weights | weights% |
|---|---|---|---|---|---|
| W1 | 1 | 3 | 0.3333 | 0.2605 | 26.05% |
| W2 | 0.3333 | 1 | 0.2 | 0.1062 | 10.62% |
| W3 | 3 | 5 | 1 | 0.6333 | 63.33% |

Source: Own elaboration.

**Table 9.**

*Pairwise comparisons: group B questions – options W.1, W.2, W.3*

| B.1. | W1 | W2 | W3 | weights | weights% | B.2. | W1 | W2 | W3 | weights | weights% |
|------|----|----|----|---------|----------|------|----|----|----|---------|----------|
| W1 | 1 | 3 | 1 | 0.4286 | 42.86% | W1 | 1 | 5 | 0.3333 | 0.2828 | 28.28% |
| W2 | 0.3333 | 1 | 0.3333 | 0.1429 | 14.29% | W2 | 0.2 | 1 | 0.1429 | 0.0738 | 7.38% |
| W3 | 1 | 3 | 1 | 0.4286 | 42.86% | W3 | 3 | 7 | 1 | 0.6434 | 64.34% |

| B.3. | W1 | W2 | W3 | weights | weights% | B.4. | W1 | W2 | W3 | weights | weights% |
|------|----|----|----|---------|----------|------|----|----|----|---------|----------|
| W1 | 1 | 0.3333 | 1 | 0.2000 | 20.00% | W1 | 1 | 3 | 1 | 0.4055 | 40.55% |
| W2 | 3 | 1 | 3 | 0.6000 | 60.00% | W2 | 0.3333 | 1 | 0.2 | 0.1150 | 11.50% |
| W3 | 1 | 0.3333 | 1 | 0.2000 | 20.00% | W3 | 1 | 5 | 1 | 0.4796 | 47.96% |

| B.5. | W1 | W2 | W3 | weights | weights% |
|------|----|----|----|---------|----------|
| W1 | 1 | 0.2 | 3 | 0.1932 | 19.32% |
| W2 | 5 | 1 | 7 | 0.7235 | 72.35% |
| W3 | 0.3333 | 0.1429 | 1 | 0.0833 | 8.33% |

Source: Own elaboration.

**Table 10.**

*Pairwise comparisons: group C questions – options W.1, W.2, W.3*

| C.1. | W1 | W2 | W3 | weights | weights% | C.2. | W1 | W2 | W3 | weights | weights% |
|------|----|----|----|---------|----------|------|----|----|----|---------|----------|
| W1 | 1 | 1 | 3 | 0.4055 | 40.55% | W1 | 1 | 0.3333 | 3 | 0.2431 | 24.31% |
| W2 | 1 | 1 | 5 | 0.4796 | 47.96% | W2 | 3 | 1 | 7 | 0.6687 | 66.87% |
| W3 | 0.3333 | 0.2 | 1 | 0.1150 | 11.50% | W3 | 0.3333 | 0.1429 | 1 | 0.0882 | 8.82% |

| C.3. | W1 | W2 | W3 | weights | weights% | C.4. | W1 | W2 | W3 | weights | weights% |
|------|----|----|----|---------|----------|------|----|----|----|---------|----------|
| W1 | 1 | 0.3333 | 5 | 0.2674 | 26.74% | W1 | 1 | 0.3333 | 0.1429 | 0.0833 | 8.33% |
| W2 | 3 | 1 | 9 | 0.6689 | 66.89% | W2 | 3 | 1 | 0.2 | 0.1932 | 19.32% |
| W3 | 0.2 | 0.1111 | 1 | 0.0637 | 6.37% | W3 | 7 | 5 | 1 | 0.7235 | 72.35% |

| C.5. | W1 | W2 | W3 | weights | weights% |
|------|----|----|----|---------|----------|
| W1 | 1 | 1 | 3 | 0.4055 | 40.55% |
| W2 | 1 | 1 | 5 | 0.4796 | 47.96% |
| W3 | 0.3333 | 0.2 | 1 | 0.1150 | 11.50% |

Source: Own elaboration.

In all evaluations, experts were the authors of the article – experienced academics involved in student invention (Kaczmarska, 2020; Kaczmarska, Gierulski, 2018a; Kaczmarska, Gierulski et al., 2018b). The evaluation process used a logical analysis and construction method supported by interviews with students and consultation with other university staff.

The method of analysis and logical construction also supports the interpretation of the results obtained. An example interpretation of three selected cases for this stage of pairwise comparisons is shown in the following examples:

**Example 1, question A.1: Books – biographies of the creators**

Interpretation: Reducing the number of compulsory subjects and increasing the number of choices, also in other faculties and fields of study (Option W.3) to the greatest extent among the three options (weight = 63.33%) will contribute to increasing the importance of books as a source of knowledge regarding the history of science and technology (Question A.1).

**Example 2, question B.5: Enterprises – employment or study visits**

Interpretation: Performing experimental work in laboratories with workshop facilities with the possibility of creating one's own research plan in the field of technical sciences (Option W.2) will contribute to the greatest extent among the three options (weight = 72.35%) to

increasing the importance of contact with enterprises (employment or study visits) as sources of knowledge about the current level of science and technology development (Question B.5).

**Example 3, question C.4: Interest in computer science beyond the curriculum**

Interpretation: Performing interdisciplinary projects in the form of theoretical papers with a choice of topics in the area of technical sciences (Option W1) will contribute the least among the three options (weight = 8.33%) to increasing interest in computer science issues beyond the standard curriculum (Question C.4).

## 5. Analysis using the AHP method – final results

The AHP-pairwise comparison analysis presented in chapter 4 yields results of a local nature for 3 groups of questions, for 5 questions in each group, and 3 variants associated with 15 questions. The results are local weighting factors (weights), which does not take into account the interrelationships shown in the hierarchical structure diagram (Fig. 4). The next step is to determine the global weighting factors as products of the corresponding local factors (Table 11). Column k5 of this table shows the calculated global coefficients for the two stages of pairwise comparisons: groups of questions (A-B-C) and consecutive questions (Ai-Bi-Ci). The values of these global coefficients (column k5) are equal to the product of the local coefficients in column k2 and the local coefficients in column k4. They illustrate the survey results in terms of AHP analysis (explanatory purpose) rather than standard statistical analyses. Global coefficients that include options W.1, W.2, W.3 are shown in columns k9, k10, and k11. They are calculated as the products of the global coefficients for the surveys (column k5) and the local coefficients for options W.1, W.2, W.3 (columns k6, k7, k8). These coefficients, in addition to the survey results, take into account the experts' evaluations of options W.1, W.2, W.3 and realize the decision-making objective of the AHP analysis. They can support decisions about modifications to the study system that promote the goal of increasing student interest in science and technology issues.

**Table 11.**
*AHP method – final results*

| k1 | k2 | k3 | k4 | k5 | k6 | k7 | k8 | k9 | k10 | k11 |
|---|---|---|---|---|---|---|---|---|---|---|
| Question groups | local | Question | local | global | local | local | local | global | global | global |
| | A - B - C | | $A_i$ - $B_i$ - $C_i$ | $A_i$ - $B_i$ - $C_i$ | W1 | W2 | W3 | W1 | W2 | W3 |
| A | 0.2106 | A1 | 0.0435 | 0.0092 | 0.2605 | 0.1062 | 0.6333 | 0.0024 | 0.0010 | 0.0058 |
| | 0.2106 | A2 | 0.6285 | 0.1324 | 0.2431 | 0.0882 | 0.6687 | 0.0322 | 0.0117 | 0.0885 |
| | 0.2106 | A3 | 0.0847 | 0.0178 | 0.4286 | 0.1429 | 0.4286 | 0.0076 | 0.0025 | 0.0076 |
| | 0.2106 | A4 | 0.3253 | 0.0685 | 0.2431 | 0.0882 | 0.6687 | 0.0167 | 0.0060 | 0.0458 |
| | 0.2106 | A5 | 0.1679 | 0.0354 | 0.2605 | 0.1062 | 0.6333 | 0.0092 | 0.0038 | 0.0224 |
| B | 0.5485 | B1 | 0.0435 | 0.0239 | 0.4286 | 0.1429 | 0.4286 | 0.0102 | 0.0034 | 0.0102 |
| | 0.5485 | B2 | 0.6285 | 0.3447 | 0.2828 | 0.0738 | 0.6434 | 0.0975 | 0.0254 | 0.2218 |
| | 0.5485 | B3 | 0.1679 | 0.0921 | 0.2000 | 0.6000 | 0.2000 | 0.0184 | 0.0553 | 0.0184 |
| | 0.5485 | B4 | 0.3253 | 0.1784 | 0.4055 | 0.1150 | 0.4796 | 0.0723 | 0.0205 | 0.0856 |
| | 0.5485 | B5 | 0.0847 | 0.0465 | 0.1932 | 0.7235 | 0.0833 | 0.0090 | 0.0336 | 0.0039 |
| C | 0.2409 | C1 | 0.3253 | 0.0784 | 0.4055 | 0.4796 | 0.1150 | 0.0318 | 0.0376 | 0.0090 |
| | 0.2409 | C2 | 0.0847 | 0.0204 | 0.2431 | 0.6687 | 0.0882 | 0.0050 | 0.0136 | 0.0018 |
| | 0.2409 | C3 | 0.6285 | 0.1514 | 0.2674 | 0.6689 | 0.0637 | 0.0405 | 0.1013 | 0.0097 |
| | 0.2409 | C4 | 0.1679 | 0.0405 | 0.0833 | 0.1932 | 0.7235 | 0.0034 | 0.0078 | 0.0293 |
| | 0.2409 | C5 | 0.0435 | 0.0105 | 0.4055 | 0.4796 | 0.1150 | 0.0043 | 0.0050 | 0.0012 |
| | | | | | | | | Total W1 | Total W2 | Total W3 |
| | | | | | | | Final evaluation: | 0.3604 | 0.3286 | 0.5610 |
| | | | | | | | Final evaluation %: | 28.83% | 26.29% | 44.88% |

Source: Own elaboration.

The sums of the global coefficients W.1, W.2, W.3 for the set of 15 questions (Table 11) are the final measure of the AHP analysis. These results show a clear dominance of option W.3, which is confirmed by the relationships:

$$W3 = 0.5610 \gg W1 = 0.3604 > W2 = 0.3286$$

Or after normalization with percentages included:

$$W3 = 44.88\% \gg W1 = 28.83\% > W2 = 26.29\%$$

It follows that the introduction of changes compliant with option W.3 – "Choice – reducing the number of compulsory subjects and increasing choice, also in other faculties and fields of study" is definitely a priority action.

The results in numerical notation for the global coefficients (Table 11) were recalculated to show percentages (Table 12). Here, too, normalization was performed by relating the values of successive indicators to the sum of indicator values in the corresponding column.

**Table 12.**
*AHP method – final results %*

| k1 | k3 | k9 | k10 | k11 |
|---|---|---|---|---|
| Question groups | Question | global W1 | global W2 | global W3 |
| A | A1 | 0.66% | 0.30% | 1.03% |
| | A2 | 8.93% | 3.55% | 15.78% |
| | A3 | 2.12% | 0.78% | 1.36% |
| | A4 | 4.62% | 1.84% | 8.17% |
| | A5 | 2.56% | 1.14% | 3.99% |
| B | B1 | 2.84% | 1.04% | 1.82% |
| | B2 | 27.05% | 7.74% | 39.54% |
| | B3 | 5.11% | 16.82% | 3.28% |
| | B4 | 20.07% | 6.24% | 15.25% |
| | B5 | 2.49% | 10.23% | 0.69% |
| C | C1 | 8.82% | 11.44% | 1.61% |
| | C2 | 1.38% | 4.15% | 0.32% |
| | C3 | 11.23% | 30.82% | 1.72% |
| | C4 | 0.94% | 2.38% | 5.22% |
| | C5 | 1.18% | 1.53% | 0.21% |

Source: Own elaboration.

The global coefficient rankings W1, W2, W3 were drawn from the data (Table 12, Fig. 5, 6, 7). This allows us to assess the importance of the measures identified as options W1, W2, and W3 for the realization of the goal – to increase student interest in issues related to science and technology.
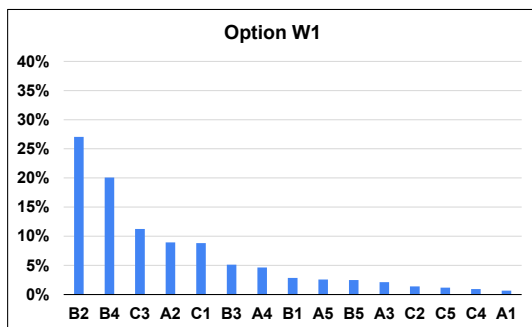


**Figure 5.** Ranking of global coefficients W1.
Source: Own elaboration.
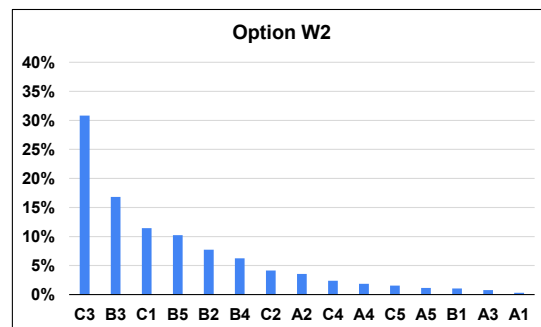


**Figure 6.** Ranking of global coefficients W2.
Source: Own elaboration.
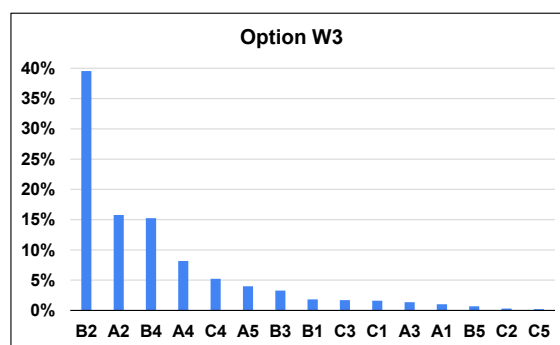


**Figure 7.** Ranking of global coefficients W3.
Source: Own elaboration.

The presented rankings show the connection of the variants (W1, W2, W3) with the questions Ai, Bi, Ci, which in the conducted AHP analysis play the role of additional criteria. They show to what extent the changes presented in subsequent options will increase students' interest in issues related to science and technology, and, in particular, in sources of knowledge and practical activities. Therefore, it is an additional element supporting decisions concerning the implementation of activities presented in options W1, W2, W3, or the development of other proposals supporting the realization of the set objective.

## 6. Conclusions

Conducting surveys in many cases is designed to identify the current state of affairs. Classical statistical methods (Kaczmarska, Gierulski et al., 2021) from simple ones like frequency of occurrence, cross-correlations to more complex ones that include association analysis (Gierulski, Kaczmarska et al., 2018a), or factor analysis (Gierulski, Kaczmarska, 2020) are used to analyze the collected data. It can also be a completely different type of analysis, for example, using Data Envelopment Analysis (DEA) (Gierulski, Kaczmarska, 2012; Kaczmarska, 2010), or AHP, sometimes classified as an informal optimization method. A special feature of the AHP method is the inclusion of expert opinion in the analysis process. In the paper presented here, it is an analysis in which the results of the survey and the opinions of experts intersect, resulting in a sort of synergy. As a result, proposals have been formulated for changes in curriculums and forms of instruction in higher education. These suggestions can support decisions to modify and create unconventional ways of learning. The proposal that was ranked highest in the survey gives students more freedom to shape their individual path of knowledge acquisition. This will ensure that these are choices that match their interests, so they are pursued with passion and commitment, which will contribute to a solid education. This will allow them to act on the idea found in this Pablo Picasso quote: "I am always doing that which I cannot do, in order that I may learn how to do it." Another quote, this time by Albert Einstein, "Education is what remains after one has forgotten what one has learned in school", alleviates the fears that freedom and choice will result in poorer education outcomes (Why is lifelong learning worthwhile? 11 quotes – www.edukacja.senior.pl).

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# A LITERATURE REVIEW ON THE DIFFERENCE
# BETWEEN CSR AND ESG

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**Purpose:** The purpose of this study is to review the literature on Corporate Social Responsibility (CSR) and Environmental, Social and Governance (ESG) and addresses two research questions: What is the mutual relation between CSR and ESG? and Why CSR and ESG matter to businesses?

**Design/methodology/approach:** The paper applies the method of comprehensive literature review. The analysis of keywords, abstract, and on this basis further deeper analysis of scientific texts allowed to identify the mutual relation between CSR and ESG.

**Findings:** The main conclusion from the conducted analysis is that both concepts - CSR and ESG, apart from being complementary, can be combined not only to improve the strategic management of the organization, but also, in a broader context, to serve the good of both the local community and the whole society. CSR aims to make business responsible, while ESG aims to make it measurable.

**Research limitations:** No empirical study has been conducted to support the findings presented in the study.

**Originality/value:** The paper organizes and systematizes the knowledge on two concepts, i.e., CSR and ESG, which now play an important role in the sustainable management of an organization.

**Keywords:** CSR, ESG, sustainability, reporting of sustainability matters.

**Category of the paper:** literature review.

## 1. Introduction

Between the great "good" and the enormous "harm" which is caused by activities of enterprises, there is a concern for the proper role of business in society, especially in times of globalization and technological innovations (Werthera, Chandler, 2011, p. 5). It is globalization, the rapid development of information and communication technologies and the continuous emergence of new, pressing challenges for global communities (including health challenges, lack of security, global food and environmental problems, climate change, water

deficit) that significantly influenced the development the concept of corporate social responsibility. Business organizations came under increasing pressure from their stakeholders to play a more active role in solving social and environmental problems that go beyond normal corporate philanthropy. Consumers expect more than ever from the brands they buy - and increasingly reward companies whose services and products are good both for them and the society. Governments, non-governmental organizations (NGOs) and local communities are demanding greater transparency and responsibility not only in the everyday business activities of companies, but also with regard to the impact of these activities on society.

Moreover, Hope (2022) states that today's young people (generation Z) are more than ever committed to social welfare, and that business initiatives affect their purchasing decisions and career choices. A survey by Cone Communications shows that 94% of Generation Z respondents believe that companies are responsible for solving critical social problems. A study by DoSomething Strategic shows that 76% of Generation Z respondents have purchased or would consider purchasing from organizations with good social impact (Cone Communications, 2017; DoSomethink Strategies, 2022). Therefore, according to Woods (2018), corporate social responsibility is not enough anymore, because in many cases it is usually "the path to corporate generosity". There is a need for a new approach to CSR and adapting internal business processes to the expectations of sustainable development. She also claims that "If we're going to make lasting and significant progress in the big challenges in our world, we need business, both the companies and the investors, to drive the solutions" (Woods, 2018).

In order to really "eradicate" the biggest problems of the modern world, business organizations must become innovative and manage in a sustainable manner. Equal treatment of the economic, social and environmental areas determines a new approach to the assessment and planning of economic policy. Therefore, there is a need to implement these principles in the practice of business operations. And this, in turn, creates the need to apply a new approach to reporting on the activities of companies, extended to include data concerning environmental (E) and social (S) sphere and data on corporate governance (G), ESG for short. The authors, Behl et al. (2022, p. 232) emphasize that over the last decade, the phenomenon of non-financial reporting has been gaining pace in developed economies due to increasing pressure from investors and various other stakeholders. This growing awareness, combined with the availability of huge data, has also brought an increase in academic literature in this area, mainly from developed countries (Atif et al., 2021; Beji et al., 2021; Birindelli et al., 2019).

Considering the above, the purpose of this study is to briefly present both concepts and an attempt to answer the following questions: What is the mutual relation between CSR and ESG? and Why CSR and ESG matter to businesses?

The first part of the paper describes the concept of CSR. The second part presents the essence of ESG and its impact on business development. However, the third part describes the identified relationships between the above concepts.

## 2. Research method

The paper applies the method of comprehensive literature review (foreign and domestic). The literature reviews are essential for: identifying what has been written on a subject or topic; determining the extent to which a specific research area reveals any interpretable trends or patterns; aggregating empirical findings related to a narrow research question to support evidence-based practice; generating new frameworks and theories and identifying topics or questions requiring more investigation (Paré et al., 2015). The method of critical and comparative analysis was used in relation to the views presented in the literature. The author focused on the review of available publications in three most commonly cited databases: Web of Science, Scopus and Emerald. The years 2010-2021 were adopted as the time range for the analysis. The year 2010 was adopted as the starting year due to the publication of the international ISO 26000: 2010 standard containing guidelines for social responsibility. The following search terms were adopted for the analysis:

- corporate social responsibility and environmental, social and corporate governance,
- CSR and ESG.

The publications were analyzed from the most recent and according to the number of citations, while analyzing those most often cited in the literature on the subject. Most publications came from journals whose titles clearly indicate and refer to the concept of CSR (e.g., Social Responsibility Journal, Corporate Social Responsibility and Environmental Management, or Journal of Business Ethics). A search of titles, abstracts and keywords was performed and the results filtered to remove returns not substantially focused on CSR and ESG. Each article was then reviewed to determine its relevance for the research. Author of this paper obtained 91 articles after eliminating all results in other languages than English and choosing the fields of his interest area.

## 3. CSR – essence and significance in the activities of enterprises

The widespread belief that business bears social responsibility is nothing new today. CSR has been a hallmark of sustainable business activity for many years (Włoch, 2021). Both sustainable development and CSR have become very important as management concepts and indicators of business performance (Galbreath et al., 2020; Crisan-Mitra, Stanca, Dabija, 2020; Awram, Avasilcai, 2014). The concept of corporate social responsibility focuses mainly on organization and is a response to the challenges of sustainable development. It is also one of the most dynamic, however also complex issue that businesses have to face now. Interdisciplinarity, and even transdisciplinarity of the above concept showing the need to

integrate and convert knowledge from various fields of science as well as economic practice is its important feature (Rok, 2012).

There is no single, universally accepted definition of corporate social responsibility. According to Chen, Hung-Baesecke, Bowen, Zerfass, Stacks and Boyd (2020), the term has different definitions for three main reasons. Firstly, it is a multi-dimensional concept. Secondly, there is disagreement as to what social responsibility entails. Thirdly, social responsibilities are dynamic: they are based on social needs, public expectations, and business opportunities in terms of meeting the needs. According to United Nations Industrial Development Organization (UNIDO, 2020), CSR is a management concept in which enterprises integrate social and environmental issues into their business activities. Therefore, CSR refers to the need of organizations to strive to achieve a balance between profits on the one hand and contribute to sustainable socio-economic development and improve the quality of life of the community in which it operates on the other hand (Cucari et al., 2018, Qa'dan and Suwaidan, 2019; Fernandez-Gago et al., 2018; Kiliç et al., 2015). Companies should not only maximize profit for their shareholders, but also strive to improve social well-being and environmental protection by engaging in responsible activities that go beyond the scope of law and their main business goals (Ratmono et al., 2021; Endrikat et al., 2021). A similar approach to CSR can be found in the documents prepared by the European Commission. In the Green Book of the European Commission from 2001 (Promoting a European Framework for Corporate Social Responsibility - Green Paper), "corporate social responsibility is defined as the concept of voluntary inclusion of social and environmental aspects by the organization when conducting commercial activities and in contacts with stakeholders". This definition was updated in 2011 and in its current formulation, "corporate social responsibility is simply the responsibility of enterprises for their impact on society" (KOM, 2011, 681, p. 6). The definition coming from the international standard ISO 26000 and first published in 2010 is the most commonly cited now. According to the above standard, "corporate social responsibility is the responsibility of an organization for the impact of its decisions and actions on society and the environment through transparent and ethical behavior in key areas, such as organizational governance, human rights, work practices, the environment, fair operational practices, consumer issues, social involvement and development of the local community". According to this definition, an organization perceived as socially responsible considers the stakeholders' opinions, acts in accordance with the law and international standards of behavior, and contributes to the sustainable development of societies (PN-EN ISO 26000:2021-04, p. 3). In other words, CSR is the way in which organizations achieve a balance between economic, environmental and social imperatives (Rai, Bansal, 2014).

Unfortunately, there is a very thin line regarding, how to use it properly, using it incorrectly can disturb the message, and message can be perceived more as a marketing stunt than an act of good (Gerard, 2009). Time has shown that the term CSR has often been misunderstood only through the prism of social issues or as a philanthropic activity. Moreover, a large number of enterprises have failed to adopt a long-term, strategic approach to CSR and business models that could contribute to social welfare and lead to better-quality and more productive workplaces. There were more and more suggestions that CSR requires redefining and giving it a new meaning as well as adjusting activities in the sphere of social responsibility to the top-down established goals of sustainable development. Instead of responsible companies, discussions are beginning to focus on regenerative companies and sustainable management, which is becoming an imperative for many organizations around the world. There are also other terms, such as regenerative economy or stakeholder capitalism. A dynamic change of the concept of CSR into a more precise notion of ESG (Environmental, Social and Corporate Governance) has been observed, because on the basis of the factors it comprises, ratings and non-financial assessments of enterprises are created. ESG has already become a commonly used term and trend in itself, especially among corporations and investors in the capital market (Rok, 2022). ESG data is currently the best way to quantify a company's impact on society. While companies have already found different ways to measure their environmental and social impacts, it is much more difficult for them to measure the broader impact of their initiatives on society as a whole.

## 4. ESG – planning and reporting on sustainable development

Globally, companies are adopting ESG measures to stay competitive in the dynamic environment (Yadav, Prashar, 2022). The concept of ESG comes from the financial world and its beginnings date back to the 1970s, when a small group of investors were interested in the environmental and social practices of the companies they invested in (Galbreath, 2012). "ESG" is an acronym that represents Environmental – E, Social – S, and Governance – G factors that are considered when measuring sustainability and the impact of an organization. ESG factors are a set of non-financial performance indicators intended to ensure the responsibility of the organization and may be subject to assessment by investors and other stakeholders.

**Table 1.**
*Examples of ESG metrics*

| E | S | G |
|---|---|---|
| E1. GHG Emissions | S1. CEO Pay Ratio | G1. Board Diversity |
| E2. Emissions Intensity | S2. Gender Pay Ratio | G2. Board Independence |
| E3. Energy Usage | S3. Employee Turnover | G3. Incentivized Pay |
| E4. Energy Intensity | S4. Gender Diversity | G4. Collective Bargaining |
| E5. Energy Mix | S5. Temporary Worker Ratio | G5. Supplier Code of Conduct |
| E6. Water Usage | S6. Non-Discrimination | G6. Ethics & Anti-Corruption |
| E7. Environmental Operations | S7. Injury Rate | G7. Data Privacy |
| E8. Climate Oversight/Board | S8. Global Health & Safety | G8. ESG Reporting |
| E9. Climate Oversight/ Management | S9. Child & Forced Labor | G9. Disclosure Practices |
| E10. Climate Risk Mitigation | S10. Human Rights | G10. External Assurance |

Source: (The Nasdaq ESG Reporting Guide, 2019, p. 13).

Environmental factors refer to how an organization uses renewable and non-renewable resources (including the amount and type of energy used, greenhouse gas emissions, the amount of generated waste and how it is disposed of, and the impact on the environment and biodiversity). Social factors allow to measure how the company and its business activity affects the social environment, i.e., employees, customers, suppliers and the local community. Corporate governance means the company's internal governance system. It consists of procedures, standards and control mechanisms implemented to ensure effective management, improve decision-making processes, comply with the law and consider the needs of external stakeholders, especially the investors (ESG Reporting Guidelines, 2021). This is because companies face constant pressure from shareholders and other stakeholder groups to achieve better results in the area of social responsibility (Dorfleitner, 2015). Therefore, ESG is constantly evolving, and organizations are increasingly integrating ESG factors into their operational activities. It will be important for the reporting companies to follow the global trends in ESG issues, which are becoming more and more important for investors and the business regulatory environment (Table 2).

**Table 2.**
*The most important trends shaping the ESG concept*

| Social | Environmental | Governance |
|---|---|---|
| • growing importance of non-governmental organizations<br>• influencers are the heroes of contemporary culture; trends are shaped by them, not by brands,<br>• activism of the young generation<br>• inclusiveness and diversity<br>• well-being, slow life movements, minimalism | • climatocentrism<br>• the world without plastic<br>• circular economy<br>• pure energy | • social entrepreneurship<br>• hyperlocality<br>• conscious consumerism<br>• degrowth |

Source: Own study based on: (infuture institute, 2022; Deloitte Sustainability Consulting Central Europe, 2021).

In the literature on the subject there are also more and more studies on various aspects of ESG disclosures. For example, Ellili (2020), Sharma et al. (2020) and Suttipun (2021) examined the scope of ESG information disclosures and confirmed that, while still at a low level, the scope of the information has increased over the following years. Furthermore, governance information constitutes the largest part of ESG disclosures, followed by social and environmental information. Hence, the issues related to the environment and the ongoing climate change are the sphere that requires the most urgent measures. In addition, a number of studies conducted recently (Manita et al., 2018; Arayssi et al., 2020; Shakil, 2021; De Masi et al., 2021) have examined the impact of various corporate governance mechanisms on ESG disclosure. This only confirms that ESG is gaining more and more recognition.

The lack of commonly accepted and verifiable assessment criteria is the main drawback of the ESG concept. This means that the ESG indicators may significantly differ from each other depending on who determines them. Without standardization, ESG becomes a problematic issue. The European Commission is working on the so-called taxonomy. The purpose of the taxonomy is to standardize the terminology used in ESG reporting, which in turn is aimed at preventing the phenomenon of the so-called "greenwashing" by introducing uniform criteria that allow to determine whether a given economic activity is environmentally sustainable. The EU taxonomy includes 6 main environmental objectives, representing various dimensions according to which economic activity can be assessed from the perspective of sustainable development: climate change mitigation, climate change adaptation, the sustainable use and protection of water and marine resources, the transition to a circular economy, pollution prevention and control, the protection and restoration of biodiversity and ecosystems (Deloitte Sustainability Consulting CE, 2021).

## 5. CSR and ESG – a synergetic relationship

Statements that the concept of CSR has become a precursor to ESG standards, and that the ESG triad has covered CSR, or that ESG is simply entering a higher level of CSR can be found both in the literature on the subject and among practitioners. How much truth do they contain? What is the mutual relation between CSR and ESG? CSR and ESG are terms that are used by many organizations as synonyms. These two seemingly similar terms are the key to understanding the concept of sustainable business development. Even though the two concepts are related, each has its own definitive characteristics. However, the goal remains the same; enterprises at the stage of building business strategies should consider social interests, environmental protection, as well as relations with various groups of stakeholders. Both management tools aim to adopt a set of policies and practices that have a positive impact on the world.

In short, CSR is a company's framework of sustainability plans and responsible cultural influence, whereas ESG is the assessable outcome concerning a company's overall sustainability performance. In practical terms, you could also say:

- CSR – a general sustainability framework, mainly used by companies,
- ESG – a measurable sustainability assessment, popular with investors.

Corporate social responsibility is a trend in corporate management that emerged at the beginning of the twentieth century and gradually integrated with the corporate landscape in all civilized corners of the world. It was not based on altruistic motives (after all, business is not a charity institution), but on a strong management concept, according to which the company should show its stakeholders that it gives something for the good of the environment and the local community, because it simply pays off in terms of image (Śleszyńska, 2020). Without CSR, there would be no ESG. CSR as a concept has cemented its values and importance throughout the decades into the corporate world. Due to its shortcomings, it should be treated with some level of criticism though. However, it is a valuable tool for companies to communicate transparently their sustainable actions in the global arena (Tykkä, 2022, p. 19). For some time, however, it appears that the ESG concept is replacing CSR, expanding the catalog of non-financial elements related to running a business and giving a new, deeper meaning to the concept of enterprise value. ESG uses CSR in such a way that it transfers it from the area of pure philanthropy to a specific set of numbers that can be used by both investors and consumers in understanding the company's philanthropic, social and internal practices. Moreover, ESG has now become a profitable investment strategy. According to Reuters, in 2021, the capital of $ 649 billion was injected into ESG-related funds. This is a record amount that is more than twice as high as investments in 2019 (Polley, 2022). What is certainly the common denominator of both concepts is the fact that they include sustainability in their DNA, or that they both fall under the same umbrella of sustainable development (Figure 1).
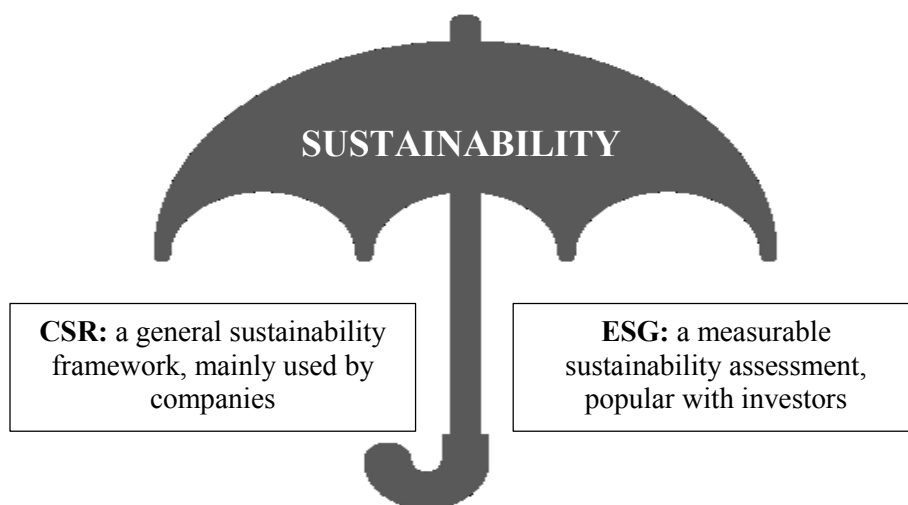


**Figure 1.** Relationship between Sustainability, CSR and ESG.
Source: own case study.

As regards looking for common elements in the descriptions of social responsibility and ESG, attention was also paid to caring for relationships with stakeholders. Identifying and engaging stakeholders is the foundation of corporate social responsibility. Whilst in CSR, firms not only have a liability towards its shareholder base but has in fact responsibilities towards other stakeholders such as: consumers, communities, and employees. Lesiewska (2022) states that the key CSR stakeholders are opinion leaders, e.g., the media, employees, politicians, local communities and consumers. She also claims that it is similar in the ESG concept, i.e., the stakeholders play an important role, although investors dominate here.

Both policies aim to make decisions based on ethically acknowledged ways. In the ESG ethical issues are more clearly presented, whereas in the CSR, they are more embedded into the decision-making process.

When it comes to CSR versus ESG, both are useful for a business's efforts toward greater social responsibility on many levels, but they have some major differences, especially regarding the benefits they can provide. Here's are the three main differences between CSR and ESG (TRC, 2022):

- *Measurability:* the ability of entities to measure the results of ESG and CSR may be the most crucial difference between the two terms. CSR is an internal framework for companies that can be hard or impossible for outside observers to measure objectively. ESG is highly measurable and quantifiable. This is crucial for investors and stakeholders needing fact-based evidence. CSR leans toward quality, while ESG leans toward quantity.

- *Usefulness:* CSR and ESG are useful, but the question of who is using them is what differentiates them. Companies use CSR to reach internal goals, including achieving greater social responsibility and developing healthy, sustainable workplace cultures. Outside entities interested in investing in a company will use ESG to gain the measurable proof they need regarding the effectiveness of these efforts.

- *Communication:* ESG and CSR offer different communication opportunities. A CSR framework can help a company better communicate its values to its employees and stakeholders, fostering a better work environment and potential for recognizable community outreach. An ESG framework will help a company prove to current and potential investors that its efforts for social, environmental and governance responsibility are paying off.

Other features characteristics of both concepts are presented in the table below.

**Table 3.**
*CSR versus ESG*

| CSR | ESG |
|---|---|
| a business model for companies that impacts their internal processes and culture | a measurable sustainably assessment, popular with investors |
| encompasses the activities a company undertakes to have a greater global impact | has become a set of criteria for sustainability assessment |
| nowadays needs to be a priority, as consumers are demanding it | financial performance is a key purpose of ESG valuation |
| about building accountability | about quantifying existing accountability |
| can be used for good but also to mislead | can be used for good but also to mislead |
| CSR policies tell a story about the organisation that it can effectively write itself | providing analytical, actionable data to tell the story |
| helping employees advance careers | % of women or people of color on the board, pay attention to equity, diversity and inclusion |
| donating products or services | ethical behavior and anti - corruption |

Source: Own study based on: (Polley, 2022, Hallgren 2021).

Certainly, ESG factors also play a huge role in motivating companies to integrate sustainable development into strategic management. In the case of the CSR concept, it was quite often observed that it entailed the risk of the so-called greenwashing. It happened when CSR was not coherent with the company's activities or was not connected with strategic initiatives. Therefore, there was a need for even greater transparency and reliability in reporting on the issues of sustainable development. In both concepts, CSR and ESG, we deal with a reporting process. Gole et al. (2021, p. 57) found that "However, while ESG reports are based on quantitative data in a concise style, CSR reports are more focused on qualitative data, photos and videos, in a bit of storytelling style". Therefore, although CSR is often unsuitable for quantitative assessment, it is nevertheless an added value and lays the foundations for an organization's ESG strategies. According to Biles (2021), CSR and ESG are the two sides of the "pro-social" company coin; you need CSR to guide components of your ESG strategy, and you need ESG to measure the efficacy and extent of your CSR goals.

Considering the above, it can therefore be concluded that there are only slight differences and clear similarities between the two management concepts. The most relevant summary of the evolution and differences between the above approaches to corporate responsibility is the definition of corporate sustainability proposed by P. Taticchi and M. Demartini (2021, p. 73), in their latest book entitled: "Corporate Sustainability in Practice: A Guide for Strategy Development and Implementation". The Authors are addressing corporate sustainability and the ESG integration. According to them "corporate sustainability is an integral approach to business aimed at enhancing competitive positioning and profitability through the sustained creation of shared value, co-creation practices with stakeholders and the integration of ESG factors in decision-making. A fully integrated corporate sustainability strategy can help organizations manage risk better, build business opportunities, and ultimately strengthen their reputation".

## 6. Conclusions

As a result of the conducted analysis of the assumptions of both CSR and ESG initiatives, it can be concluded that they are certainly complementary towards each other in the context of the implementation of the sustainable development goals. While CSR aims to make a business responsible, ESG criteria make the efforts of such a business measurable (Lexology, 2021, p. 1). As Lexology puts it: "While CSR aims to make a business accountable, ESG criteria make such business' efforts measurable.". However, implementing the ESG concept seems to be a more demanding task than implementing activities in the area of CSR. This is because it requires measurable goals, data collection and reporting. In the near future, ESG will be naturally implemented into strategic initiatives and business models, and organizations, while wishing to follow the path of sustainable development, will have to understand that the time for change and a revolution in business has come, and therefore a "reset" of the corporate governance is absolutely necessary (Gole et al., 2021, p. 57). The author of the study, however, is aware of the limitations of the above analysis, as no empirical research has been conducted to support the above findings. Furthermore, future research should broadly consider the discussions on legislation and provisions on transparency and disclosure of non-financial data, especially because ESG reporting will be obligatory in the EU. Since in the near future ESG will be naturally implemented into strategic initiatives and business models, nothing prevents organizations from using both concepts at the same time and building an ESG profile through the CSR program. Moreover, a future avenue of discussion could be to add CS (corporate sustainability) to the discussion about CSR and ESG.

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# IDENTIFICATION OF CUSTOMERS' PURCHASING BEHAVIOUR PROFILES IN THE CONTEXT OF CORPORATE SOCIAL RESPONSIBILITY

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**Purpose:** The aim of the article is to identify customers' purchasing behaviour profiles on the basis of characterizing the process of making a decision to purchase a product from food industry companies' indicators (observable variables) in the context of corporate social responsibility (CSR).

**Design/methodology/approach**: The data for the research were collected from a survey concerning a group of 801 customers from the Świętokrzyskie Voivodeship. The resources were pre-explored and pre-processed to enable further studies. In order to obtain customers profiles, the latent class analysis (LCA) method was used. It enables identification of homogeneous groups (latent classes) of customers based on selected indicators.

**Findings:** The impact on customers' purchasing behaviour of 15 CSR activities undertaken by enterprises from several different groups (in relation to: environment, society, employees, contractors, and customers) was examined. Six profiles of customer purchasing behaviour were identified. They were labelled and subjected to descriptive characteristics.

**Research limitations/implications**: The results point out the need to continue the research based on a broader countrywide data set.

**Practical implications:** The research findings can contribute to improving the effectiveness of food industry companies in the range of CSR activities. Due to this, these companies will be able to take more effective steps to retain existing customers and acquire new ones.

**Social implications:** Taking corporate social responsibility actions contributes to solve social and environmental problems. It can also affect the quality of life in a society. Nowadays, it is an important and developmental research area.

**Originality/value:** The conducted study showed that latent class analysis is proper tool for analysing the qualitative data obtained in the questionnaire surveys. The work provides a vital information on the impact of corporate social responsibility activities by food industry companies on customers' purchasing behaviour.

**Keywords:** corporate social responsibility, customer profiles, purchasing behaviour, food industry, latent class analysis.

**Category of the paper:** Research paper.

# 1. Introduction

Corporate Social Responsibility (CSR) is a complex and interdisciplinary term (Sheehy, 2015) with a multidimensional nature (Lorena, 2018). It combines economic, social, philosophical, ethical issues and refers to developments in other fields of science. CSR encompasses the economic, legal, ethical (Sheehy, 2015) and discretionary/philanthropic expectations that society places on businesses at any given time. Furthermore, it includes the active, voluntary dedication of company resources to implement activities aimed at enhancing the quality of life in society, improving the quality of the environment, and solving social problems (Kang, Liu, 2014).

At the core of the CSR concept is the stakeholder theory, which defines persons or groups of persons to whom enterprises can be socially responsible, that is, whose interests they are to take into account in their activities. Stakeholders are individuals, groups or organizations that affect or are affected by the results of actions of leaders, managers, and employees of the company (Bryson, 2004).

The essence of CSR is the conviction that no economic entity is self-sufficient, and that companies – especially large ones – are centres of power and decision-making, and that their activities influence many aspects of citizens' lives (Bowen, 1953). This means that in order to function, it needs contacts with suppliers, customers, or entities responsible for distributing the products it offers. Enterprises are elements of a broader system. In response to the growing expectations of the wider environment (Kowalczyk, Kucharska, 2020; Ahmad et al., 2021), enterprises include more and more objectives in their strategies, plans to implement activities that are part of the social responsibility concept. The entity assuming social responsibility bases its activities on decisions that favour the improvement of conditions in which it and other entities function (Sen et al., 2016).

There are no regulations and legal provisions that would enforce business entities to engage in socially responsible initiatives. The concept may be treated as going beyond the boundaries of law, carrying out tasks that aim at achieving something more than just the state in which the activities of enterprises lead to achieving their own goals (without taking into account the expectations of various interest groups). The concept of CSR is therefore about balancing the conflicting expectations put forward by different interest groups.

It is commonly believed that CSR can bring benefits to a firm, such as: increased sales (Moliner et al., 2020); increased profits (Kim, Ji, 2021); easier access to investors' funds (Cox, Wicks, 2011); improved credit rating position (Hsu, Chen, 2015); increased stakeholder confidence (Cuesta-Valiño et al., 2019); strengthening brand recognition and the brand's impact (Luo, Bhattacharya, 2006); reducing advertising expenditures (Li et al., 2015); improving reputation and image (Murè et al., 2020). CSR contributes to increasing the quality of employees' work (Lee et al., 2012), reducing the level of their turnover (Galbreath, 2010) and

promotes the implementation of innovations in enterprises, which thus strengthen their competitive position (Orlitzky et al., 2011). One of the assumptions of the CSR concept is to minimize the negative impact on the environment and rational management of resources, which results in cost reduction and savings (Halme et al., 2020).

An important benefit of engaging in socially responsible tasks by the enterprises is obtaining by these entities the so-called social consent to act (Vanhamme, Grobben, 2009), i.e. a mandate of trust (Keenan et al., 2019) and acceptance of the mode of action by stakeholders (An et al., 2019).

It is also important that the benefits are interconnected by a chain of dependencies, so it is most beneficial from the point of view of the competitive position of the enterprise to constantly engage in various social and environmental activities in strategic terms. It is necessary to integrate the various objectives of the enterprise with each other (Haigh et al., 2015) and not to treat socially responsible objectives as something additional.

The CSR concept should be identified not only with its benefits, but also with costs and risks (Kiliańska, Krechowicz, 2021). The implementation of socially responsible tasks involves the necessity to allocate a part of the profit generated by enterprises to finance activities aimed at satisfying the needs of stakeholders (Türker, 2009).

The research is focused on the activities of food companies, as the goods they offer satisfy basic needs of people, such as hunger or thirst, needs that no other products can fulfil. The food industry is the leader in implementing solutions related to safety and the impact of products on consumer health (Wei et al., 2018). The activities undertaken by the companies often go beyond the scope of the legal obligations as an expression of socially responsible initiatives. The CSR survey in relation to the food industry is also justified because this branch of economy is facing strong criticism from the public opinion due to its high dependence on natural resources (Hartmann, 2011).

The main aim of the article is to identify customers' purchasing behaviour profiles on the basis of indicators (observable variables) characterizing the process of making a decision to purchase a product from food industry companies in the context of CSR. In addition, it will be possible to investigate whether socially responsible initiatives undertaken in different CSR areas have an equal impact on these behaviours.

## 2. Customers – an important group of stakeholders

Customers are among the external stakeholders of businesses (Gürleka, Tuna, 2019). Their consumption needs are met according to their tastes, preferences, values, and habits that differentiate them (Carbonell et al., 2008). Tastes and preferences refer not only to the characteristics of food products such as taste, smell, texture, nutritional value, but also to the

packaging, the image of the manufacturer and its socially responsible activities. Customers may react differently to these characteristics (Combris et al., 2009).

Customers want companies to help solve their problems, make a real contribution to improving their quality of life, run their business with integrity, take great care to create safe products, treat employees with dignity and reduce environmental impact.

Between customers and businesses there is a two-way relationship: customers can affect the way businesses operate, shape, and determine the adoption of certain actions or inaction. At the same time, customers are influenced by the actions of the enterprise (Figure 1).
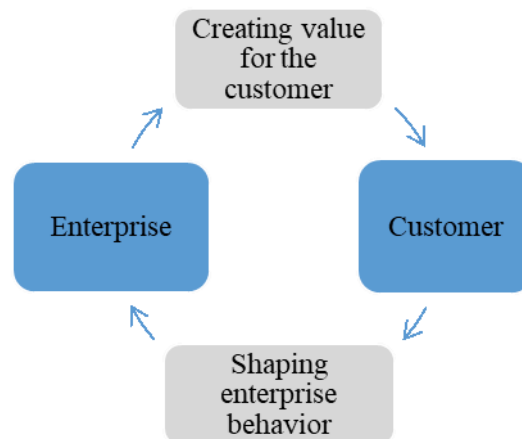


**Figure 1.** Relationships between stakeholders and an enterprise.

Source: authors' own elaboration.

Customers understand the interrelationships linking their buying behaviour to other economic processes, including the actions taken by the business sphere in CSR. Demand for particular products largely determines what businesses produce and what services they offer. Demand determines the direction that businesses should pursue in order to get customers to buy. Without customers, there is no market and no chance for the company to survive in the long term. All this means that customers should be seen as one of the key stakeholders.

Customers are at the centre of attention of socially responsible enterprises that try to adapt their activities and offered products to their needs in order to provide them with goods that are best suited to their purchase (Patnaik, Mortensen, 2009) – also in terms of socially responsible activities. Such behaviour can ensure that companies achieve their own sales targets.

The choice of products that customers buy is influenced not only by the features directly related to the product, such as price, quality, price-quality relation, or the degree of satisfaction of customer needs. Customers are not only interested in the product itself and its functionality and usability. Customers are looking for broader information about the product, including the origin of intermediate products, production methods and the possibility of indirect participation in the process of solving social problems. Factors such as the product's impact on the environment, the percentage of recycled resources used in the production of a given good or the manufacturer's commitment to donate part of the profit to solving a specific social problem are becoming important.

Enterprises take different actions – some may be socially responsible, others socially irresponsible (Janney, Gove, 2011). Customers can react to both of these by changing their purchasing behaviour. CSR is regarded to affect consumers' attitudes toward a brand and/or a company and further influence consumers' purchasing decisions (Ailawadi et al., 2014; Hartmann, 2011).

A portion of the customers become indirectly involved in socially responsible initiatives undertaken by enterprises by purchasing these goods, a part of the profit from sales of which will be transferred by business entities to finance pro-social and pro-environmental tasks. Customers buy these goods to provide themselves with emotional values – to feel that part of the profit made by the company offering them will be allocated to solving social problems. In addition to satisfying their needs that prompted them to make the purchase, customers also have a sense of participation in the process of implementation of social tasks by the company, they derive satisfaction (Islam et al., 2021) from the fact that they contributed to doing good and supported a pro-social initiative.

Behaviours that contribute to the deterioration of the widely understood quality of social life and have a negative impact on the environment naturally do not enjoy stakeholder approval (Paliwoda-Matiolińska, 2009). The entities that do not eliminate their negative influence on the environment do not receive social acceptance for their actions, which results in negative consequences for the companies (Islam et al., 2019; Wagner et al., 2020).

For example, customers express their dissatisfaction with the actions of companies by boycotting them (Lambin et al., 2020) or sharing negative opinions about specific products or companies with others (Shim, Kim, 2021). There are numerous examples in business practice of customers publicly expressing their dissatisfaction and declaring that they will stop buying products or groups of products in order to change the company's attitude in some aspect. Boycotting specific areas of business does not always result in a change in its attitude and behaviour (Yang, Rhee, 2019), but in many cases it succeeds. It is a kind of punishment for behaviour of the business entity that is unfair/inconsistent with consumer expectations (Scheidler, Edinger-Schons, 2020). Companies should take into account the opinion of customers because their disapproval in the long term may translate into poorer financial performance. Interestingly, research confirms that customers may also negate the lack of commitment to CSR or boycott irresponsible actions implemented by a business entity (Pipatprapa et al., 2017). Research shows that when faced with the risk of a consumer boycott, companies are more likely to undertake socially responsible initiatives (Karwowski, Raulinajtys-Grzybek, 2021).

## 3.  Selected aspects of data mining techniques

Nowadays, data analysis is a term used in a very broad context, including various analytical techniques – both basic ones as well as data mining and artificial intelligence. In the classic context it is data processing using mathematical and statistical methods in order to extract valuable and useful information allowing for decision making. Discovering knowledge from data requires the use of data mining methods and advanced software. Data mining is the analysis of an observed data set in order to find non-obvious relationships and interdependencies that exist in them (Foreman, 2014; Larose, 2005; Hand et al., 2001).

One of the commonly used data mining methods is clustering which allows to divide a data set into homogeneous groups in order to extract some repetitive patterns (Vermunt, Magidson, 2002). It is a well-known data mining technique, commonly used for quantitative, qualitative, and mixed data (Ruiz-Chavez et al., 2018; Xiao et al., 2019). The choice of the cluster analysis method is to some extent a subjective decision of the researcher which depends on the specifics of the data, the purpose of the research, and the practical usefulness of the results; there is no clear formula to determine which clustering tool is the most appropriate for a particular data set (Nowakowska et al., 2020; Rodriguez et al., 2019). In this study, the data collected from the surveys are qualitative in nature. Therefore, the latent class analysis (LCA) method was chosen to identify customers' purchasing behaviour profiles.

LCA is one of the clustering methods that use the concept of latent variable (that cannot be directly measured or observed). Nevertheless, this latent variable manifests its intensity and presence through other qualitative variables (called observable variables or indicators), the values of which can be measured and observed. In contrast to other techniques, LCA uses the concept of classifying units into homogeneous, directly unmeasurable groups (clusters) based on estimated conditional probabilities which means that the indicator takes a certain value provided that the observation it characterizes belongs to a specified latent class (Frątczak, 2013; Collins, Lanza, 2010; Vermunt, Magidson, 2002). LCA allows modelling the relationships between categorical variables – so it is appropriate for the data set under consideration. In addition, there are no restrictions relating to the normality of data distribution, homogeneity of variance or requirements of linearity. There is an assumption: each observation belongs to exactly one latent class and there exists a local independence condition between the indicators. Hence, the conditional membership of a latent class is unequivocal.

The research concerns objects studied in the context of a specific issue. In this case, the unit is a customer making a decision to purchase a product from a food company. The final model is built on the basis of a sample of the population. The sample consists of data collected from the survey concerning a group of 801 customers from the Świętokrzyskie Voivodeship. In particular, the indicators $X_j$, $j = 1, \ldots, J$, are defined by $J$ observable variables describing customers' purchasing decisions. Using latent class analysis, it is possible to separate $C$ latent

classes $K_c$ ($c = 1, ..., C$) – homogeneous groups enabling identification of buyer profiles. Each of the indicators $X_j$ has values in the collection of categories $R_j$; they create the contingency table which allows to define the model of LCA. In every latent class $K_c$, each observation $z$ ($z \in Z$, where $Z$ is a set of observations characterized by indicators $X_j$) and has some value for the $j$-th observable variable. Equation 1 presents the form of the LCA model that estimates the probability of occurrence in the observation $z$ belonging to the vector $r(z)$ which represents the combination of the indicator's values $X_1, ..., X_J$, having a value equal to $q$ (Nowakowska, Pajęcki, 2020, 2021; Frątczak 2013; Collins, Lanza, 2010). The publications cited earlier provide more theoretical information on the latent class analysis.

$$P(r(z) = q) = \sum_{c=1}^{C} \gamma_c \cdot \prod_{j=1}^{J} P(r_j(z) = q_j | z \in K_c) = \sum_{c=1}^{C} \gamma_c \cdot \prod_{j=1}^{J} \rho_{q_j|c} \tag{1}$$

where:

$c$ – latent class number in the LCA model; $c = 1, …, C$,

$C$ – the number of latent classes,

$K_c$ – $c$-th latent class,

$z$ – observation in the $Z$ set; $z \in Z$; $Z$ – the set of observations characterized by indicators $X_j$,

$\gamma_c$ – the probability of the $c$-th latent class (i.e. the probability of an observation belonging to the $K_c$ latent class); $\gamma_c = P(K_c) = P(z \in K_c)$; $\sum_{c=1}^{C} \gamma_c = 1$,

$\rho_{q_j|c}$ – the conditional probability that the $j$-th indicator will take the value $q_j$ in the $K_c$ latent class; $\rho_{q_j|c} = P(q_j|c) = P(r_j(z) = q_j | z \in K_c)$,

$q_j$ – the value of the $j$-th indicator; $q_j \in R_j$; $R_j$ – the set of categories of the $j$-th indicator, $j = 1, ..., J$.

In the LCA method, as in other cluster analysis methods, it is important to determine the final set of indicators and identify the most optimal number of latent classes. Generally, a universal and unambiguous way to determine the most appropriate number of clusters is not known (Weller et al., 2020; Masyn, 2013) and this issue is an important area of current research (Dziak et al., 2020, Nylund-Gibson, Choi, 2018). The quality of the estimated LCA model is assessed using measures derived from the $G^2$ statistic (Frątczak, 2013; Collins and Lanza, 2010). In order to select the most fitting model, the following aspects were considered: practical and theoretical sense of the separated latent classes; relatively small values of information criteria (*BIC – Bayesian information criterion, CAIC – consistent Akaike information criterion* and *ABIC – adjusted Bayesian information criterion*) (Lanza et al., 2015; Frątczak, 2013; Collins, Lanza, 2010); the value of entropy statistic (Collins, Lanza, 2010) – if the value is higher, the separation of latent classes is better; the values of index of the discriminating ability *AR* (Nowakowska, Pajęcki, 2021) which determines the role of individual indicators in the distinguishability of latent classes; not too large number of the classes to simplify the model (Frątczak, 2013) and insight into the estimated parameters of models located close to each other.

## 4. Data set for the research

The study was carried out using survey research. During the planning of the research process, the area of data collection was established. This article presents the results of a pilot study – the scope was limited to one of the sixteen voivodeships in Poland: Świętokrzyskie Voivodeship. This region is characterised by characterised by favourable conditions for the development of agri-food production and thus the food industry. What is important, the agri-food sector is one of the strategic sectors for the Świętokrzyskie Voivodeship (Godlewska-Majkowska et al., 2012). In addition, modern agriculture and food processing were distinguished among the four smart specializations for the region, including production of food and beverages (Noworól et al., 2019).

Based on the data provided by the Central Statistical Office, the structure of the general population in the Świętokrzyskie Voivodeship was determined. The respondents to the test sample were selected on the basis of the targeted selection of units. The survey was addressed to adult residents of the Świętokrzyskie Voivodeship who are consumers of food products. The choice was motivated by the fact that every adult can purchase foodstuffs regardless of their nature (e.g. alcoholic, non-alcoholic products or tobacco products). The control variables were age and sex, but the research also included a question about their education.

Initially, the essential study was conducted from December 2019 to February 2020, with data collection using the Paper and Pencil Interview (PAPI) technique. Due to the epidemic situation in Poland, the authors were forced to suspend data collection through direct contact with respondents. From November 2020 to March 2021, BioStat Research and Development Center continued the survey and provided data from respondents who were reached using Computer Assisted Web Interviews (CAWI) and Computer Assisted Telephone Interviewing (CATI) techniques. Data collected using three techniques for reaching respondents (PAPI, CATI, CAWI) were combined into a single database. The data collected therein ensured that the survey sample was representative in terms of gender and age of the residents of the Świętokrzyskie Voivodeship.

The data obtained from the respondents were initially assessed in terms of completeness (formal control) and accuracy of filling (substantive control). These resources were pre-explored that enable further studies. The data cleaning process has been performed. 1960 people accepted the invitation to participate in the study. Finally, 801 fully completed questionnaires were qualified for data analysis. The structure by age and sex of the general population and the research sample was presented in the Table 1. Figure 2 additionally shows the education structure of the study sample.

**Table 1.**

*Structure of Świętokrzyskie Voivodeship and research population*

| Sex | Age | Świętokrzyskie Voivodeship [%] | Research sample [%] |
|---|---|---|---|
| Female | 18-24 | 4.73 | 4.87 |
| Male | | 4.54 | 5.12 |
| Female | 25-34 | 8.92 | 8.74 |
| Male | | 8.29 | 7.99 |
| Female | 35-44 | 9.54 | 9.11 |
| Male | | 8.92 | 8.61 |
| Female | 45-54 | 7.53 | 7.74 |
| Male | | 7.40 | 7.49 |
| Female | 55-64 | 8.41 | 8.61 |
| Male | | 8.88 | 8.86 |
| Female | 65 and older | 9.12 | 9.11 |
| Male | | 13.71 | 13.73 |

Source: authors' own elaboration.
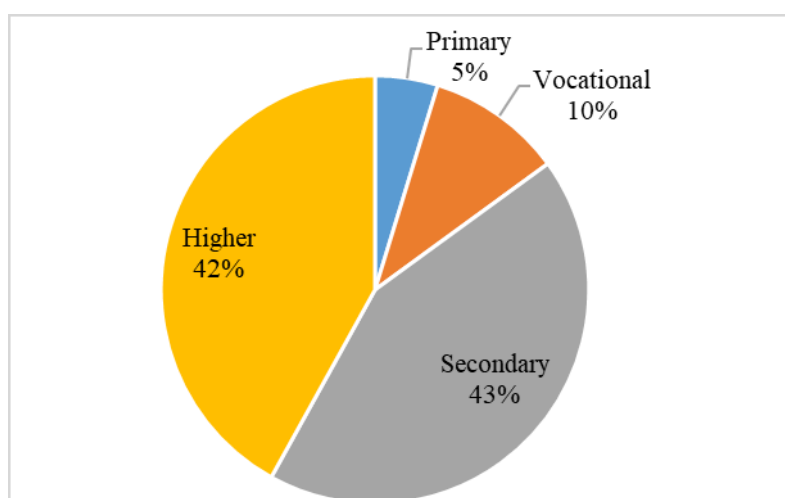


**Figure 2.** Educational structure of the research population.

Source: authors' own elaboration.

Apart from the questions about age, sex, and education, the survey asked respondents to rate how often they pay attention to the fact that food industry companies implement CSR activities before deciding to buy a product from these companies. The activities come from several different groups (in relation to: the environment, society, employees, contractors, and customers); characteristics of the relevant research data are shown in Table 2. The answer to each of the following survey questions could be rated from 1 (never) to 5 (always). Moreover, the distributions for each indicator are presented.

**Table 2.**
*Characteristics of the relevant research data*

| Group of CSR activities | Indicators, their descriptions, and values | | | |
|---|---|---|---|---|
| | Indicator name | The impact of the activities implemented by the enterprise on the purchasing behaviour of the respondents | Value | [%] |
| Contractors | CO_1 | Having and following written standards of conduct in relations with contractors | 1 | 13.86 |
| | | | 2 | 21.97 |
| | | | 3 | 38.08 |
| | | | 4 | 20.85 |
| | | | 5 | 5.24 |
| | CO_2 | Starting cooperation with contractors taking pro-environmental or pro-social activities | 1 | 13.48 |
| | | | 2 | 25.72 |
| | | | 3 | 38.08 |
| | | | 4 | 18.48 |
| | | | 5 | 4.24 |
| | CO_3 | Starting cooperation only with contractors that respect the principles of environmental protection | 1 | 8.99 |
| | | | 2 | 18.35 |
| | | | 3 | 36.95 |
| | | | 4 | 28.34 |
| | | | 5 | 7.37 |
| Customers | CU_1 | Introducing facilities for customers (e.g. mobile applications, facilities for the elderly or simplification of contracts) | 1 | 4.12 |
| | | | 2 | 12.73 |
| | | | 3 | 31.71 |
| | | | 4 | 35.96 |
| | | | 5 | 15.48 |
| | CU_2 | Taking into account the suggestions of customers regarding the way the enterprise operates | 1 | 9.49 |
| | | | 2 | 21.60 |
| | | | 3 | 39.33 |
| | | | 4 | 23.85 |
| | | | 5 | 5.74 |
| | CU_3 | Taking care of the health and life of customers | 1 | 1.87 |
| | | | 2 | 7.74 |
| | | | 3 | 26.34 |
| | | | 4 | 38.20 |
| | | | 5 | 25.84 |
| Employees | EM_1 | Recruiting employees from the local labour market | 1 | 11.11 |
| | | | 2 | 22.60 |
| | | | 3 | 36.20 |
| | | | 4 | 24.09 |
| | | | 5 | 5.99 |
| | EM_2 | Supporting the active participation of employees in the management of the enterprise | 1 | 12.98 |
| | | | 2 | 21.85 |
| | | | 3 | 38.33 |
| | | | 4 | 20.35 |
| | | | 5 | 6.49 |
| | EM_3 | Provision of additional benefits for employees (apart from those required by law) | 1 | 12.23 |
| | | | 2 | 18.73 |
| | | | 3 | 37.58 |
| | | | 4 | 21.85 |
| | | | 5 | 9.61 |

Cont. table 2.

| | | | | |
|---|---|---|---|---|
| Environment | *EN_1* | Doing more than the law requires for the environment | 1 | 5.49 |
| | | | 2 | 17.23 |
| | | | 3 | 46.19 |
| | | | 4 | 24.34 |
| | | | 5 | 6.74 |
| | *EN_2* | Taking actions to reduce the consumption of resources and energy | 1 | 4.74 |
| | | | 2 | 16.48 |
| | | | 3 | 43.07 |
| | | | 4 | 29.46 |
| | | | 5 | 6.24 |
| | *EN_3* | The use of eco-certified raw materials in the production process, even if they are more expensive than non-certified raw materials | 1 | 6.37 |
| | | | 2 | 20.60 |
| | | | 3 | 39.70 |
| | | | 4 | 26.22 |
| | | | 5 | 7.12 |
| Society | *SO_1* | Counteracting social problems | 1 | 7.12 |
| | | | 2 | 19.35 |
| | | | 3 | 40.20 |
| | | | 4 | 23.72 |
| | | | 5 | 9.61 |
| | *SO_2* | Free of charge performance of works/services for the benefit of the local community | 1 | 11.74 |
| | | | 2 | 19.60 |
| | | | 3 | 39.20 |
| | | | 4 | 21.72 |
| | | | 5 | 7.74 |
| | *SO_3* | Material support for people in need and charities | 1 | 6.37 |
| | | | 2 | 18.10 |
| | | | 3 | 40.70 |
| | | | 4 | 28.84 |
| | | | 5 | 5.99 |

Source: authors' own elaboration.

## 5. LCA model for customers' purchasing behaviour

Because the decision on the number of latent classes $C$ is one of the crucial factors, a series of experiments were carried out for the considered data set in order to obtain the most accurate model. The number of these classes ranging from 2 to 10 was taken into account. As numerical methods were used, at any time 15 model estimates were made for each $C$-class variant with different initial values for the iterative process. Each time, in the obtained fifteen-element set of $C$-class LCA models, the representative one with the best fit statistic was selected for further analysis. At the beginning, two collections of LCA models were built:

a) *LCA*-15*V*, covering only 15 variables (indicators) describing CSR activities undertaken by enterprises from several different groups (in relation to: environment, society, employees, contractors, and customers),

b) *LCA*-18*V*, comprising 18 variables, including additional questions on age, sex, and education.

For both collections of the LCA models, the values of the *AR* indexes for each indicator, linked to a certain number of latent classes *C*, were calculated as shown in Figure 3 (for *LCA*-15*V*) and Figure 4 (for *LCA*-18*V*).
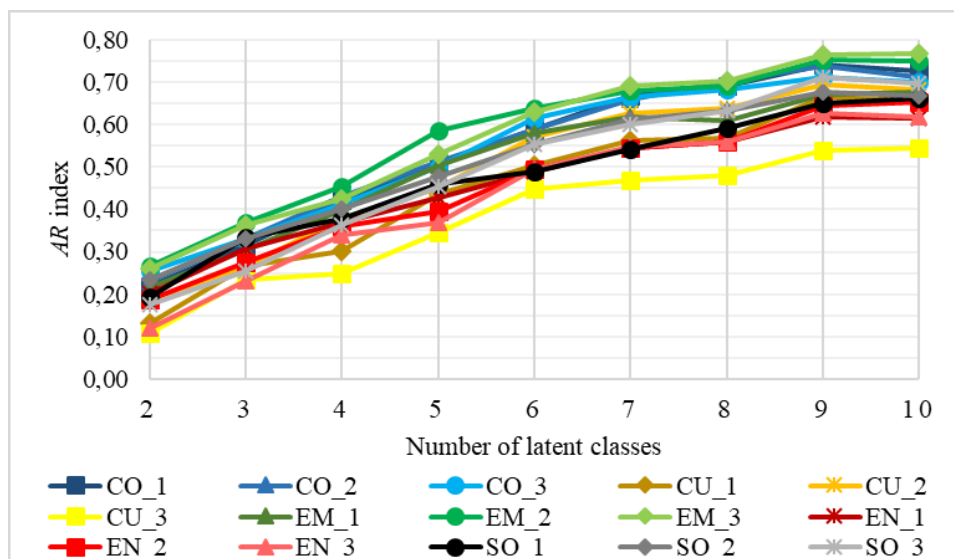


**Figure 3.** *AR* measures of indicators by the number of latent classes in the *LCA*-15*V* collection of the LCA models.

Source: authors' own elaboration.
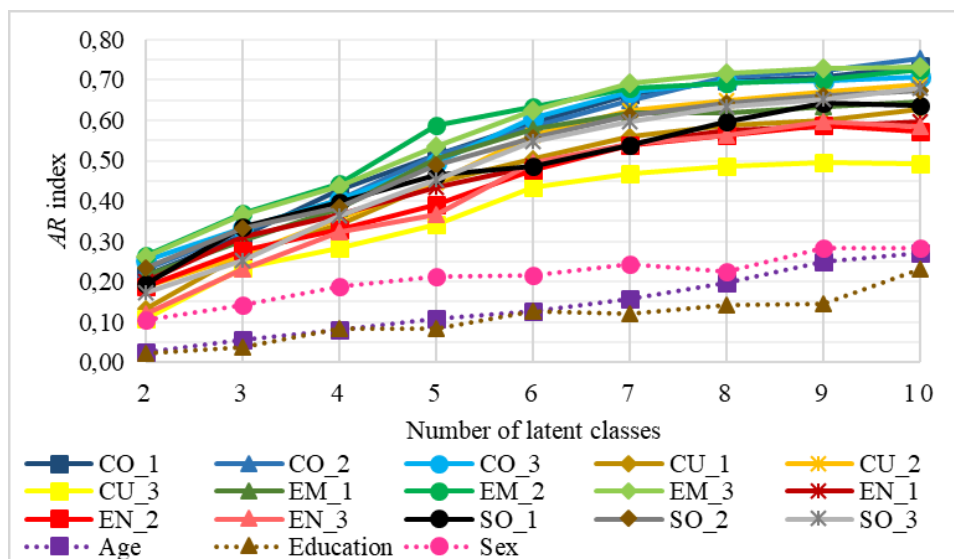


**Figure 4.** *AR* measures of indicators by the number of latent classes in the *LCA*-18*V* collection of the LCA models.

Source: authors' own elaboration.

In the case of the *LCA*-18*V* models group, the values of the *AR* measures for the variables gender, age and education were always lower than 0.3. Considering that too many indicators generate a very large number of potential response patterns (sparse contingency matrix), which may cause difficulties in model construction (Lanza et al., 2013), the *LCA*-15*V* models group was chosen for further analysis. Finally, the variables: age, sex and education were not included in the final calculations.

For the *LCA*-15*V* collection of LCA models, the values of $G^2$, *BIC*, *CAIC*, *ABIC* and *Entropy* measures were calculated for each representative *C*-class model with a particular number of latent classes varied from 2 to 10 (later referred to as the *C*-class model), as shown in Table 3. In selecting the optimum number of latent classes, the most commonly used criterion is the *BIC* measure (Killian et al., 2019; Petersen et al., 2019). In this case, it has the lowest value for the LCA model with 6 latent classes (as well as the *CAIC* measure). The good evaluation of the 6-class model is also confirmed by obtained results of the other diagnostic statistics. Moreover, the value of the *AR* index (which is assessed by discriminating ability) for each indicator is not less than 0.45. Consequently, as the best one, the 6-class model was chosen to identify customers' purchasing behaviour profiles.

**Table 3.**
*Values of selected measures for diagnosing LCA models by number of latent classes*

| Number of latent classes | $G^2$ | *BIC* | *CAIC* | *ABIC* | *Entropy* |
|---|---|---|---|---|---|
| 2 | 21089.93 | 21898.92 | 22019.92 | 21514.68 | 0.92 |
| 3 | 19445.05 | 20661.88 | 20843.88 | 20083.92 | 0.91 |
| 4 | 18706.59 | 20331.25 | 20574.25 | 19559.59 | 0.91 |
| 5 | 18005.47 | 20037.97 | 20341.97 | 19072.60 | 0.93 |
| 6 | 17476.72 | 19917.06 | 20282.06 | 18757.98 | 0.93 |
| 7 | 17153.44 | 20001.62 | 20427.62 | 18648.83 | 0.92 |
| 8 | 16916.76 | 20172.77 | 20659.77 | 18626.27 | 0.92 |
| 9 | 16684.73 | 20348.58 | 20896.58 | 18608.38 | 0.93 |
| 10 | 16513.95 | 20585.64 | 21194.64 | 18651.72 | 0.94 |

Source: authors' own elaboration.

Figure 5 presents latent class probability for the selected 6-class model – classes support is satisfactory. Figure 6 shows the obtained latent classes (in the form of the heat map) – the conditional probabilities that the indicator takes a given value provided that the observation characterised by it belongs to a certain latent class *c*. The names of these classes were labelled as *LC*-1, ..., *LC*-6.
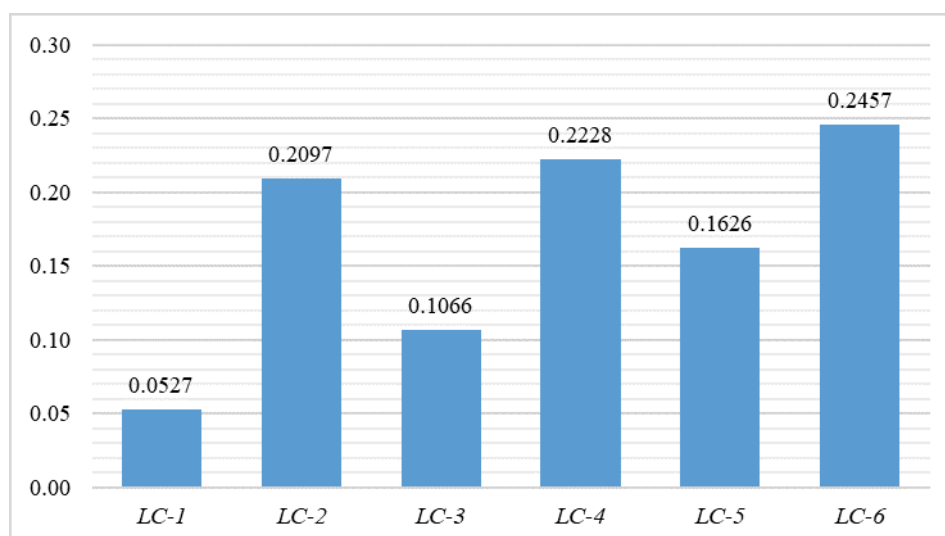


**Figure 5.** Latent class probability for the selected 6-class LCA model.

Source: authors' own elaboration.

| Indicator | Value | Latent class | | | | | | | Indicator | Value | Latent class | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LC-1 | LC-2 | LC-3 | LC-4 | LC-5 | LC-6 | | | | LC-1 | LC-2 | LC-3 | LC-4 | LC-5 | LC-6 |
| CO_1 | 1 | 0.001 | 0.000 | 0.721 | 0.078 | 0.000 | 0.180 | | EN_1 | 1 | 0.000 | 0.000 | 0.454 | 0.010 | 0.008 | 0.012 |
| | 2 | 0.001 | 0.046 | 0.145 | 0.454 | 0.068 | 0.335 | | | 2 | 0.048 | 0.027 | 0.321 | 0.368 | 0.079 | 0.143 |
| | 3 | 0.144 | 0.350 | 0.101 | 0.338 | 0.814 | 0.331 | | | 3 | 0.066 | 0.439 | 0.169 | 0.546 | 0.853 | 0.359 |
| | 4 | 0.363 | 0.599 | 0.034 | 0.119 | 0.117 | 0.060 | | | 4 | 0.463 | 0.503 | 0.056 | 0.076 | 0.061 | 0.329 |
| | 5 | 0.491 | 0.004 | 0.000 | 0.011 | 0.000 | 0.095 | | | 5 | 0.423 | 0.031 | 0.000 | 0.000 | 0.000 | 0.157 |
| CO_2 | 1 | 0.048 | 0.012 | 0.684 | 0.099 | 0.000 | 0.142 | | EN_2 | 1 | 0.000 | 0.000 | 0.362 | 0.000 | 0.008 | 0.031 |
| | 2 | 0.022 | 0.035 | 0.213 | 0.507 | 0.041 | 0.433 | | | 2 | 0.001 | 0.022 | 0.383 | 0.345 | 0.064 | 0.130 |
| | 3 | 0.126 | 0.404 | 0.079 | 0.262 | 0.904 | 0.307 | | | 3 | 0.107 | 0.334 | 0.207 | 0.499 | 0.770 | 0.394 |
| | 4 | 0.355 | 0.519 | 0.013 | 0.115 | 0.055 | 0.087 | | | 4 | 0.344 | 0.572 | 0.048 | 0.156 | 0.158 | 0.371 |
| | 5 | 0.450 | 0.029 | 0.011 | 0.016 | 0.000 | 0.031 | | | 5 | 0.548 | 0.072 | 0.000 | 0.000 | 0.000 | 0.075 |
| CO_3 | 1 | 0.000 | 0.000 | 0.493 | 0.084 | 0.000 | 0.075 | | EN_3 | 1 | 0.000 | 0.011 | 0.289 | 0.012 | 0.000 | 0.113 |
| | 2 | 0.023 | 0.041 | 0.293 | 0.552 | 0.000 | 0.079 | | | 2 | 0.095 | 0.020 | 0.331 | 0.327 | 0.041 | 0.333 |
| | 3 | 0.029 | 0.272 | 0.165 | 0.232 | 0.880 | 0.401 | | | 3 | 0.062 | 0.271 | 0.280 | 0.420 | 0.808 | 0.335 |
| | 4 | 0.361 | 0.640 | 0.048 | 0.132 | 0.119 | 0.311 | | | 4 | 0.236 | 0.604 | 0.088 | 0.241 | 0.150 | 0.145 |
| | 5 | 0.587 | 0.046 | 0.000 | 0.000 | 0.000 | 0.134 | | | 5 | 0.607 | 0.093 | 0.012 | 0.000 | 0.000 | 0.074 |
| CU_1 | 1 | 0.000 | 0.000 | 0.222 | 0.049 | 0.000 | 0.026 | | SO_1 | 1 | 0.000 | 0.009 | 0.458 | 0.038 | 0.000 | 0.048 |
| | 2 | 0.024 | 0.038 | 0.192 | 0.354 | 0.067 | 0.032 | | | 2 | 0.051 | 0.060 | 0.319 | 0.421 | 0.100 | 0.139 |
| | 3 | 0.028 | 0.257 | 0.336 | 0.271 | 0.797 | 0.146 | | | 3 | 0.188 | 0.382 | 0.223 | 0.485 | 0.827 | 0.186 |
| | 4 | 0.237 | 0.629 | 0.225 | 0.326 | 0.136 | 0.394 | | | 4 | 0.286 | 0.505 | 0.000 | 0.055 | 0.073 | 0.375 |
| | 5 | 0.711 | 0.076 | 0.024 | 0.000 | 0.000 | 0.401 | | | 5 | 0.475 | 0.043 | 0.000 | 0.000 | 0.000 | 0.252 |
| CU_2 | 1 | 0.000 | 0.006 | 0.477 | 0.064 | 0.008 | 0.111 | | SO_2 | 1 | 0.000 | 0.000 | 0.670 | 0.131 | 0.008 | 0.062 |
| | 2 | 0.001 | 0.040 | 0.265 | 0.434 | 0.080 | 0.284 | | | 2 | 0.001 | 0.076 | 0.240 | 0.481 | 0.141 | 0.099 |
| | 3 | 0.115 | 0.281 | 0.210 | 0.315 | 0.869 | 0.384 | | | 3 | 0.210 | 0.477 | 0.080 | 0.333 | 0.778 | 0.292 |
| | 4 | 0.271 | 0.627 | 0.048 | 0.187 | 0.043 | 0.158 | | | 4 | 0.256 | 0.394 | 0.009 | 0.054 | 0.073 | 0.392 |
| | 5 | 0.613 | 0.045 | 0.000 | 0.000 | 0.000 | 0.063 | | | 5 | 0.533 | 0.053 | 0.000 | 0.000 | 0.000 | 0.155 |
| CU_3 | 1 | 0.000 | 0.000 | 0.137 | 0.007 | 0.000 | 0.010 | | SO_3 | 1 | 0.000 | 0.000 | 0.473 | 0.015 | 0.000 | 0.040 |
| | 2 | 0.000 | 0.023 | 0.162 | 0.195 | 0.017 | 0.037 | | | 2 | 0.001 | 0.024 | 0.245 | 0.420 | 0.031 | 0.209 |
| | 3 | 0.051 | 0.126 | 0.235 | 0.364 | 0.670 | 0.078 | | | 3 | 0.185 | 0.242 | 0.203 | 0.407 | 0.853 | 0.389 |
| | 4 | 0.098 | 0.589 | 0.298 | 0.369 | 0.269 | 0.390 | | | 4 | 0.218 | 0.687 | 0.079 | 0.151 | 0.117 | 0.292 |
| | 5 | 0.850 | 0.262 | 0.168 | 0.065 | 0.044 | 0.484 | | | 5 | 0.595 | 0.047 | 0.000 | 0.006 | 0.000 | 0.070 |
| EM_1 | 1 | 0.024 | 0.007 | 0.649 | 0.084 | 0.000 | 0.083 | | | | | | | | | |
| | 2 | 0.025 | 0.047 | 0.231 | 0.482 | 0.041 | 0.310 | | | | | | | | | |
| | 3 | 0.137 | 0.268 | 0.096 | 0.297 | 0.840 | 0.348 | | | | | | | | | |
| | 4 | 0.339 | 0.598 | 0.024 | 0.136 | 0.119 | 0.185 | | | | | | | | | |
| | 5 | 0.476 | 0.080 | 0.000 | 0.000 | 0.000 | 0.073 | | | | | | | | | |
| EM_2 | 1 | 0.001 | 0.000 | 0.816 | 0.101 | 0.000 | 0.083 | | | | | | | | | |
| | 2 | 0.001 | 0.055 | 0.121 | 0.560 | 0.029 | 0.263 | | | | | | | | | |
| | 3 | 0.065 | 0.383 | 0.050 | 0.310 | 0.921 | 0.307 | | | | | | | | | |
| | 4 | 0.500 | 0.531 | 0.012 | 0.022 | 0.050 | 0.210 | | | | | | | | | |
| | 5 | 0.434 | 0.030 | 0.000 | 0.008 | 0.000 | 0.138 | | | | | | | | | |
| EM_3 | 1 | 0.000 | 0.000 | 0.662 | 0.089 | 0.000 | 0.130 | | | | | | | | | |
| | 2 | 0.024 | 0.056 | 0.206 | 0.505 | 0.056 | 0.125 | | | | | | | | | |
| | 3 | 0.120 | 0.360 | 0.132 | 0.321 | 0.866 | 0.275 | | | | | | | | | |
| | 4 | 0.132 | 0.541 | 0.001 | 0.074 | 0.077 | 0.281 | | | | | | | | | |
| | 5 | 0.724 | 0.043 | 0.000 | 0.010 | 0.000 | 0.190 | | | | | | | | | |

**Figure 6.** The conditional probabilities of indicators for the selected 6-class LCA model.

Source: authors' own elaboration.

## 6. Customers' purchasing behaviour profiles

The profiles (patterns) of customers' purchasing behaviour were labelled and characterized on the basis of the obtained conditional probabilities of indicators for the selected 6-class LCA model. They are discussed in the subsections below.

### 6.1. Latent Class 1 (*LC*-1) – Customers almost always taking into account CSR activities of companies in their purchasing behaviour

The first latent class includes 5.27% of all the observations of the analysed data set. These customers are very attentive to the activities taken by food companies in the area of the CSR concept. In the process of making a purchase decision, customers almost always take into account whether the enterprise from which they intend to buy a product undertakes socially responsible activities; in each question there is a predominance of response values 4 and 5. The initiatives that most strongly influence the customers' purchasing behaviour include all activities in the customers area, one activity in the employees area and one in the environment area: *Taking care of the health and life of customers*: $P(CU\_3 = 5 \mid LC\text{-}1) = 0.85$; *Provision of additional benefits for employees (apart from those required by law)*: $P(EM\_3 = 5 \mid LC\text{-}1) = 0.72$; *Introducing facilities for customers (e.g. mobile applications, facilities for the elderly or simplification of contracts)*: $P(CU\_1 = 5 \mid LC\text{-}1) = 0.71$; *Taking into account the suggestions of customers regarding the way the enterprise operates*: $P(CU\_2 = 5 \mid LC\text{-}1) = 0.61$; *The use of eco-certified raw materials in the production process, even if they are more expensive than non-certified raw materials*: $P(EN\_3 = 5 \mid LC\text{-}1) = 0.61$.

### 6.2. Latent Class 2 (*LC*-2) – Customers often taking into account CSR activities of companies in their purchasing behaviour

Out of all the observations, 20.97% belong to the second latent class. It includes customers who often include in their purchasing behaviour the fact that the companies from which they buy products implement socially responsible initiatives. Except for indicator *SO_2*, the conditional probabilities of a response value equal to 4 are greater than 0.50. Moreover, in the *LC*-2 class, the conditional probability of the variable taking the value of 3 indicating an ambivalent effect of CSR activities on customers' purchasing behaviour is also relatively high.

The study has shown that one CSR activity has the definitely strongest impact on the decision to buy a product from a company: *Taking care of the health and life of customers*: $P(CU\_3 = 4 \text{ OR } CU\_3 = 5 \mid LC\text{-}2) = 0.59 + 0.26 = 0.85$. In addition to that, the customers in the *LC*-2 class often make their purchasing decisions specifically on whether enterprises take the following actions: *Material support for people in need and charities*: $P(SO\_3 = 4 \mid LC\text{-}2) = 0.69$; *Starting cooperation only with contractors that respect the principles of environmental*

*protection*: P(*CO_3* = 4 | *LC*-2) = 0.64; *Introducing facilities for customers (e.g. mobile applications, facilities for the elderly or simplification of contracts)*: P(*CU_1* = 4 | *LC*-2) = 0.63; *The use of eco-certified raw materials in the production process, even if they are more expensive than non-certified raw materials*: P(*EN_3* = 4 | *LC*-2) = 0.60.

### 6.3. Latent Class 3 (*LC*-3) – Customers not taking into account most CSR activities of companies in their purchasing behaviour

The third latent class includes 10.66% of all the observations. The customers generally do not take into account CSR activities when making a purchasing decision. It looks like their purchasing behaviour is shaped by factors other than the CSR actions of food companies.

The following activities have the weakest impact on purchasing decisions: *Supporting the active participation of employees in the management of the enterprise*: P(*EM_2* = 1 | *LC*-3) = 0.82; *Having and following written standards of conduct in relations with contractors*: P(*CO_1* = 1 | *LC*-3) = 0.72; *Starting cooperation with contractors taking pro-environmental or pro-social activities:* P(*CO_2* = 1 | *LC*-3) = 0.68; *Free of charge performance of works/services for the benefit of the local community*: P(*SO_2* = 1 | *LC*-3) = 0.67; *Provision of additional benefits for employees (apart from those required by law)*: P(*EM_3* = 1 | *LC*-3) = 0.66; *Recruiting employees from the local labour market*: P(*EM_1* = 1 | *LC*-3) = 0.65.

Nevertheless, these customers pay little attention to the two activities in the area of customers: *Introducing facilities for customers (e.g. mobile applications, facilities for the elderly or simplification of contracts)*: P(*CU_1* = 1 | *LC*-3) = 0.22 and *Taking care of the health and life of customers*: P(*CU_3* = 1 | *LC*-3) = 0.14.

### 6.4. Latent Class 4 (*LC*-4) – Customers rarely taking into account CSR activities of companies in their purchasing behaviour

The fourth latent class contains 22.28% of the observations. These customers rarely take into account CSR activities of food companies in their purchasing behaviour (the value of some indicator equals 2) and have an ambivalent attitude (the value of some indicator equal 3). Generally, the activities in the areas of employees and contractors have the smallest impact on customers' purchasing behaviour, e.g.: *Supporting the active participation of employees in the management of the enterprise*: P(*EM_2* = 1 OR *EM_2* = 2 | *LC*-4) = 0.10 + 0.56 = 0.66; *Starting cooperation only with contractors that respect the principles of environmental protection*: P(*CO_3* = 1 OR *CO_3* = 2 | *LC*-4) = 0.08 + 0.55 = 0.63; *Starting cooperation with contractors taking pro-environmental or pro-social activities:* P(*CO_2* = 1 or *CO_2* = 2 | *LC*-4) = 0.10 + 0.51 = 0.61; *Provision of additional benefits for employees (apart from those required by law)*: P(*EM_3* = 1 OR *EM_3* = 2 | *LC*-4) = 0.09 + 0.51 = 0.60

However, it can be noted that in the *LC*-4 class, the influence (on purchasing behaviour) of the following actions in relation to customers is slightly stronger: *Introducing facilities for customers (e.g. mobile applications, facilities for the elderly or simplification of contracts)*:

P($CU\_1 = 4 \mid LC$-4) = 0.33 and *Taking care of the health and life of customers*: P($CU\_3 = 4 \mid LC$-4) = 0.37.

### 6.5. Latent Class 5 (*LC*-5) – Customers ambivalent about companies' CSR activities in their purchasing behaviour

16.26% of all the observations belong to the fifth latent class. The customers did not explicitly determine whether CSR actions by food companies influence their purchasing behaviour. For all indicators, the estimated conditional probability values are highest for an indicator's value equal to 3 and range from 0.67 to 0.92. Thus, the *LC*-5 class contains customers who have an ambivalent attitude towards CSR activities by food companies. However, it should be noted that among all the CSR activities, one of them stands out slightly: *Taking care of the health and life of customers*: P($CU\_3 = 4$ or $CU\_3 = 5 \mid LC$-5) = 0.27 + 0.04 = 0.31.

### 6.6. Latent Class 6 (*LC*-6) – Customers with varying attitudes about companies' CSR activities in their purchasing behaviour

The sixth latent class includes 24.57 % of all the observations and is difficult to characterise because of its heterogeneity. The impact of particular CSR activities on customers' purchasing behaviour is strongly variable.

The following CSR activities with reference to contractors have the weakest impact on customers' buying behaviour: *Starting cooperation with contractors taking pro-environmental/ pro-social activities*: P($CO\_2 = 1$ OR $CO\_2 = 2 \mid LC$-6) = 0.14 + 0.43 = 0.57 and P($CO\_2 = 4$ OR $CO\_2 = 5 \mid LC$-6) = 0.09 + 0.03 = 0.12; *Having and following written standards of conduct in relations with contractors*: P($CO\_1 = 1$ OR $CO\_1 = 2 \mid LC$-6) = 0.18 + 0.34 = 0.52 and P($CO\_1 = 4$ OR $CO\_1 = 5 \mid LC$-6) = 0.06 + 0.10 = 0.16. In contrast, the CSR activities shown further have the strongest impact on customers' purchasing decisions: *Taking care of the health and life of customers*: P($CU\_3 = 4$ or $CU\_3 = 5 \mid LC$-6) = 0.39 + 0.48 = 0.87; *Introducing facilities for customers (e.g. mobile applications, facilities for the elderly or simplification of contracts)*: P($CU\_1 = 4$ or $CU\_1 = 5 \mid LC$-6) = 0.39 + 0.40 = 0.79; *Counteracting social problems*: P($SO\_1 = 4$ or $SO\_1 = 5 \mid LC$-6) = 0.38 + 0.25 = 0.63 and *Free of charge performance of works/services for the benefit of the local community*: P($SO\_2 = 4$ or $SO\_2 = 5 \mid LC$-6) = 0.39 + 0.16 = 0.55.

## 7. Summary and conclusions

The study provides vital information on the impact of corporate social responsibility activities by food industry companies on customers' purchasing behaviour. The importance of this issue stems from the fact that knowledge about consumers is a very crucial field used by business entities.

The impact on customers' purchasing behaviour of 15 CSR activities undertaken by enterprises from several different groups (in relation to: the environment, society, employees, contractors, and customers) was examined. The six profiles of customer purchasing behaviour were identified. They were labelled and subjected to descriptive characteristics. Two obtained patterns refer to customers who almost always (*LC*-1) or often (*LC*-2) take CSR activities of food companies into account in their purchasing behaviour. In contrast, two profiles characterise customers who do not (*LC*-3) or rarely (*LC*-4) consider CSR actions of these enterprises in their purchasing behaviour. In one case (*LC*-5), the customers' attitude proved to be ambivalent. One pattern obtained (*LC*-6) appeared to be heterogeneous. The distinguished customers' profiles and their characteristics provide companies with knowledge of how customers differ in terms of how often they buy a product under the influence of information about the company's implementation of CSR activities in different areas. Of all the CSR activities analysed, one activity stands out: *Taking care of the health and life of customers* (*CU*_3) as having a particularly strong impact on customers' purchasing behaviour.

Świętokrzyskie Voivodeship is one of the voivodeships with a low level of development, included in the so-called "Eastern Poland" block. The results of the pilot study may contribute to development of food companies by increasing the effectiveness of influencing customers' purchasing behaviour by implementing specific CSR activities. However, the research methodology presented in the paper is universal in nature. It can be used to study the impact of various socially responsible activities on the purchasing behaviour of different populations. In the future, it is planned to expand the investigation throughout Poland.

Socially responsible activities allow companies to provide additional (beyond the product) value to customers. It is also an opportunity to generate own benefits in the form of, among other things, shaping customers' buying behaviour, which ultimately leads to an increase in the level of product sales and corporate profits. The results of the research enable companies to use resources more efficiently than before to carry out socially responsible tasks. Enterprises can perform those of their activities that most strongly influence the purchasing behaviour of the largest proportion of customers. Based on the characteristics of customer profiles, enterprises can plan their socially responsible activities more effectively, maximizing the chances of retaining current customers, attracting new ones, and thus increasing the level of sales of their goods.

The distinction of clusters and their descriptive characteristics is useful for companies that want to implement CSR activities and at the same time shape consumer purchasing behaviour. Based on the results of the research, companies can influence the purchasing behaviour of consumers, who include in their purchasing behaviour the fact that the companies from which they buy products implement socially responsible initiatives. The research results provide insight into which CSR activities are most likely to influence consumers' purchasing behaviour

The conducted study showed that latent class analysis (LCA) is the proper tool for analysing the qualitative data obtained in the questionnaire surveys.

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# DEDICATED DATA MANAGEMENT SYSTEM
# FOR UNIVERSITY DIDACTIC PROCESSES

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**Purpose:** The objective of the work is to develop and implement the original concept of Repository of Didactic Processes Data (RDPD) for universities. The task of the Repository is to handle formally organised content in a digital form, covering resources created in connection with didactic processes, and the origin of which is a university community. These data should be: as complete as possible, available on the Internet at any time and easy to find and retrieve, stored in commonly used formats, contain a clear indication of the stored resources, without any costs for the user downloading them.

**Design/methodology/approach**: The concept of the Repository was developed on the basis of the results of consultations with the academic community – its primary target audience. Comments from the representatives of the Repository future main users were taken into account. An analysis of the existing available repository systems in terms of their functionality, adaptability to the specificity of data, and popularity was carried out in order to select the solution that could be the foundation for RDPD. Then, the following tasks were undertaken in the environment of the selected system: adapting the data schema developed for RDPD, the implementation of the operations of loading, browsing, and searching of data, and user management.

**Findings:** As a result of research and analyses, DSpace was proposed as the basis for the RDPD system. The logical metadata layers as well as the technical implementation of the proposed Repository in the DSpace system were elaborated.

**Practical implications:** The implementation of the RDPD system may significantly facilitate and support the university management process.

**Originality/value:** There are many initiatives regarding institutional repositories within the higher education sector. However, there is no institutional repository dedicated strictly to the storage and management of data generated by university educational processes. The developed repository is the solution to the problem.

# 1. Introduction

A repository is a type of digital library designed for permanent storage, preservation and sharing of materials in the form of disk files containing resources such as: documents (books, scientific articles, or reports), data from various fields of activity (especially scientific), photographs, graphics (designs, diagrams), computer programs, films, and audio files. The repository content may be originally digital or from a physical medium that has been digitised. Four repository types can be distinguished (Armbruster, Romary, 2010): subject-based repository, research repository, national repository system and, institutional repository IR.

Institutional academic repositories play a special role. Most of them are intended to handle library resources (Kabir Khan, Sheikh, 2022) or to manage information on research works and projects, as well as scientific publications of academics (Hixson, Cracknell, 2007). Academics submit their work to IR for archiving, and the types of materials submitted are generally journal articles and publications in conference proceedings (Ukwoma et al., 2019; Sabharwal, Natal, 2017; Patel, D., Patel, U., 2013). The repositories, apart from storing and providing access to digital resources, are also used to create statistical summaries useful in planning the scientific development of the university and its individual units, and may serve as a platform that brings together the academic community. In a small number of cases, data generated in the didactic processes by the university, faculties, or university employees can also be found, and they basically refer to teaching or learning materials and study programs as well (frequently along with syllabi) (King et al., 2008; Sarker et al., 2010; Asadi et al., 2019). Institutional repositories of the higher education sector, either dedicated to research output or to teaching and learning materials, are usually Open Access, rarely with limited or authenticated access to selected user groups.

In Polish conditions, the solutions used in the management of electronic documents collected, processed and made available to institutional academic repositories were presented in the book of Szafrański (2019). The Polish achievements in the field are relatively rarely presented in literature. Nahodko (2007) discussed the issue relating to the creation of digital libraries and institutional repositories, focusing, however, his attention on the library aspect of the systems. Sapa (2009) considered the same aspect; he presented a study on the functionality of Polish academic libraries in creating, maintaining, and providing free access to e-prints of parent university academic staff. Koperwas et al. (2017) and Rybinski et al. (2017) described

the same university's knowledge base system, implemented at the Warsaw University of Technology. The solution combines the functionality of an institutional repository with the functionality of a current research information system. In the monograph edited by Tadeusiewicz (2021), a digital repository idea was related to the context of distance learning.

To the best of the authors knowledge, there is no publication on repositories relating to resources other than scientific or learning materials, in particular those derived from didactic processes.

The data generated in the university didactic processes are not only teaching materials and study programs. They may also include transcripts of records, theses, orders of authorities, reports for accreditation bodies, study plans, etc. The data can be accessed from various university websites and at different levels of the university website's structure. That is why it is sometimes difficult to find them. In addition, some materials from didactic processes have only a paper form. After fulfilling their role of providing current information, some materials are not kept. The archival value of all such data is significant because they can be used in the organisation of work and university management in the context of educational needs. In particular, they can provide materials and templates necessary for reports and auditing procedures (e.g. accreditation ones). On the basis of archival data on students' performance, it is possible to create summaries, diagnose the situation, or search for signals of disturbances in teaching processes. An insight into past syllabi and study programs enables analysing and tracking development trends in the educational process (e.g. disappearance and creation of study courses or subjects). The study module creators can compare past and current programs or modules in different university units; find gaps, and offer new programs or modules. Taking into account the resulting resources, all such data should be stored in a single institutional repository with a logical and intuitive structure.

The authors undertook the task of building a repository of data derived from the didactic processes for Kielce University of Technology (KUT), Poland, as part of the KMD project entitled "National Data Warehouse. Universal infrastructure for storing and sharing data as well as for efficient processing large data volumes in HPC, Big Data, and artificial intelligence models", Intelligent Development Operational Program, Agreement: POIR.04.02.00-00-D010/20-00. Work on the Repository of Didactic Processes Data system began in April 2021.

The objective of the work is to develop and implement the original concept of Repository of Didactic Processes Data (RDPD) for universities. Work on the Repository began in April 2021. The repository's resources are intended to provide information that is valuable to university stakeholders of various types: university authorities, academic teachers, and administration. Therefore, these data should be: as complete as possible, available on the Internet at any time and easy to find and retrieve, stored in commonly used formats, contain a clear indication of the stored resources, without any costs for a user downloading them. The methodology employed in the work covers conceptual and technical stages of the project. In the conceptual stage, the Repository data structure was elaborated and the analysis of the

existing repository systems in order to select the solution that could be the foundation for RDPD was carried out. In the technical stage, key elements of RDPD installation and configuration, the metadata structure, RDPD data and users management were implemented. While working on the system, the principle was that the content stored in the institutional repository is both accumulated and maintained indefinitely (Crow, 2002).

## 2. Institutional university repository systems

There are many repository systems available on the market that universities can use. They are both free and commercial software. A list of university repositories can be found on the OpenDOAR institution's website (OpenDOAR, 2021). The service is the product of a joint project between the University of Nottingham (UK) and Lund University (Sweden). It is currently managed by the University of Nottingham. The system defines the following repository categories (available through *Advanced Search*): *Repository Type* (5 values; among them: *Institutional*), *Software Name* (the software used to create the repository; 32 values), *Content Types* (11 values; among them: *Learning Objects*), *Subjects* (8 values). In July 2021, 5,079 academic repositories were registered by OpenDOAR, and most of them were classified into more than one category. Practically, all 5,068 systems have been assigned to the institutional repository type.

Figure 1 shows the frequency of each content type in a group of institutional academic repositories. Figure 2 illustrates the global popularity of the software used to create repositories. The classifications considered in OpenDOAR can hardly be matched with the tasks and content intended for RPDP. It seems that with the assumed functionality of the Repository, *Learning Objects* is the closest in terms of content type. According to OpenDOAR, there were 785 academic institutional repositories offering the Learning Objects content type (July 2021). The scale of software usage to build such repositories is shown in Figures 3 and 4, respectively, in the world (total number of classified repositories $N = 785$) and in Poland (total number of classified repositories $N = 18$).
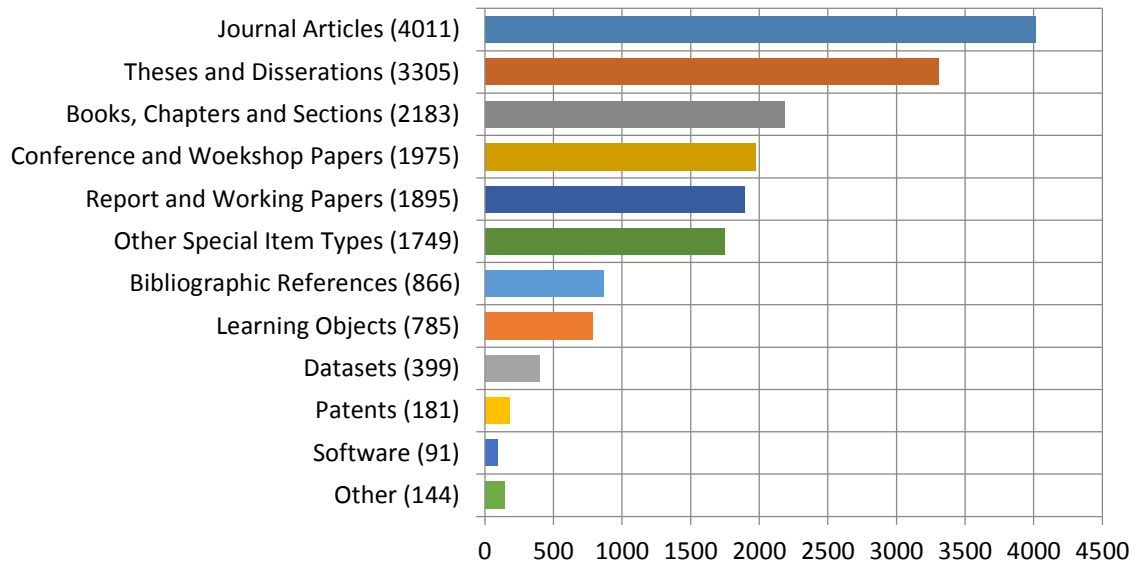
**Figure 1.** The frequencies of thematic content in academic institutional repositories.

Source: OpenDOAR.
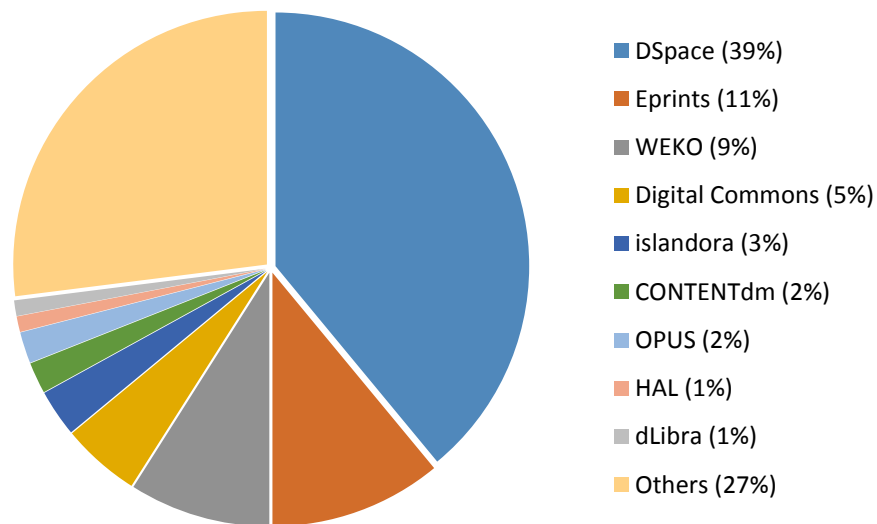


**Figure 2.** Distribution of software usage in institutional academic repositories.

Source: OpenDOAR.
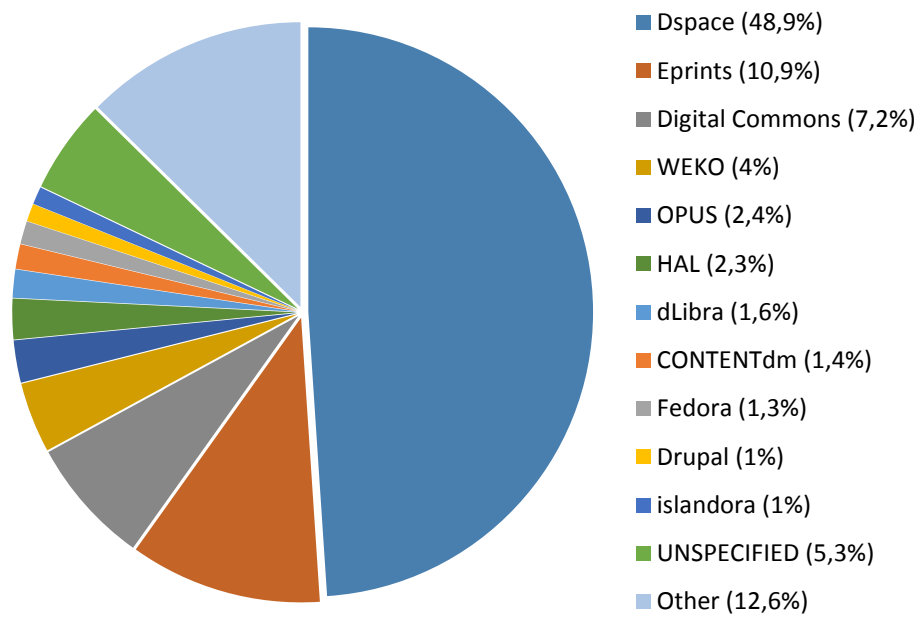
**Figure 3.** Distribution of software usage in institutional academic repositories with *Learning Objects* classification.

Source: authors' own elaboration on the OpenDOAR website basis.
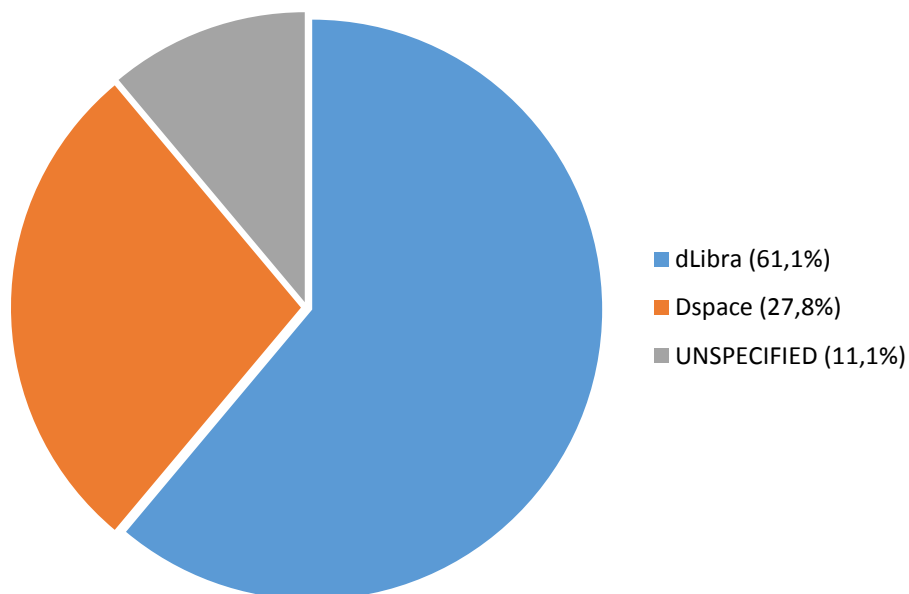


**Figure 4.** Distribution of software usage in institutional academic repositories with *Learning Objects* classification in Poland.

Source: authors' own elaboration on the OpenDOAR website basis.

DSpace (DSpace, 2022) is the most popular repository system in the considered functionality aspect, both in terms of institutional repositories in general and those relating to *Learning Objects* content. In the latter case, DSpace's worldwide usage reached 50%.

The second is EPrints, but its popularity is several times lower than that of DSpace. In Poland, DSpace takes second place, overtaken by dLibra (dLibra, 2022), which is the domestic, commercial product of PSNC (Poznan Supercomputing and Networking Center). Neither Dataverse (The Dataverse Project, 2022) nor Zenodo (Zenodo, 2022) has been specified in the OpenDOAR resource. Taking into account the above, DSpace 7.2 was chosen as the base software for the RDPD system.

DSpace is open source software. It was developed at MIT in collaboration with Hewlett Packard Laboratories, originally as a repository platform for MIT research results. It enables the indexing, storage, and sharing of digital materials and their long-term preservation. It was built according to the Open Archival Information System (OAIS) reference model (Lee, 2010). The main feature of DSpace is to organise the content presentation in a hierarchical structure (tree) by defining communities, collections, and items, and the relationships (associations) between them (DSpace 7.x Documentation, 2022). The schematic structure of the repository is presented in Figure 5. DSpace collects and stores digital documents in a wide variety of disk file formats: *.pdf, *.docx, *.jpg, *.tif and others. Users have access to pages for individual items (described by metadata) containing files to be downloaded. The software allows developers to customise its interface.
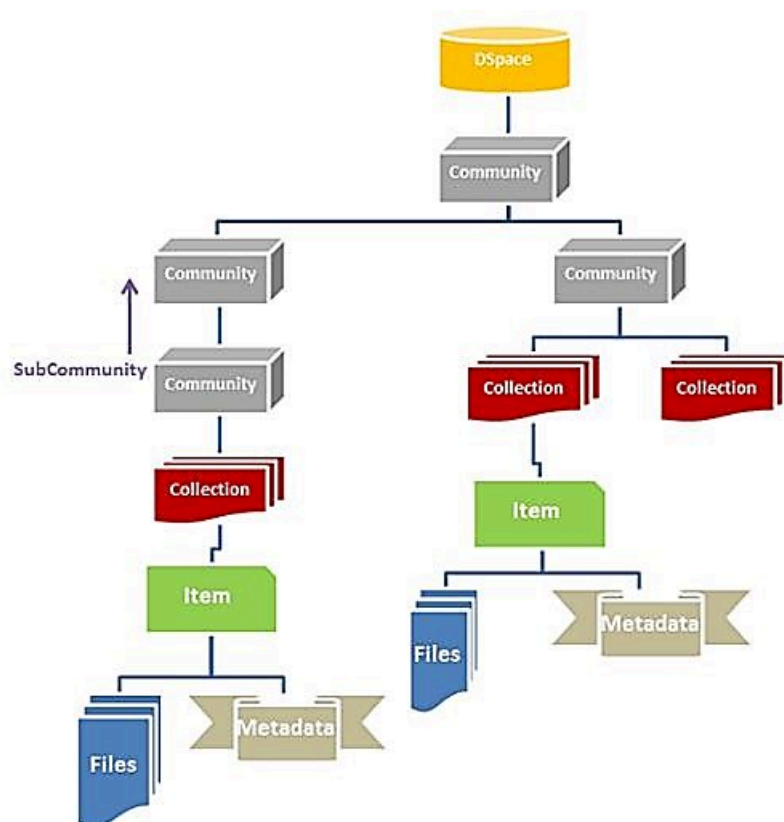


**Figure 5.** The schematic structure of the DSpace repository system.
Source: https://wiki.lyrasis.org/display/DSDOC7x/Functional+Overview.

## 3. RDPD metadata schema

Metadata is structured information that describes, explains, locates, and otherwise facilitates finding, using, or managing an information resource. Metadata is often referred to as "data about data" or "information about information." Metadata provides information enabling the data organization of (e.g. documents, graphics files, data sets), concepts (e.g. classification schemes), and reference to real world elements (e.g. people, organizations, places, images, products). A metadata schema is a labelling, tagging, or coding system used to record information about resources or to structure descriptive metadata. A metadata schema establishes the data elements and rules for using data elements to describe a resource. Each repository system is defined by a metadata schema that describes its database. Dublin Core (Dublin Core Metadata Innovation, 2022; Kurtz, 2010), denoted as *dc*, is the standard schema in DSpace. The schema is mainly used to describe scientific publications; to a slightly lesser extent for the description of learning objects (Bueno-de-la-Fuente et al., 2009; Das, 2018). In the RDPD system, *dc* can only be partially used to characterise stored documents.

It has been assumed that the documents generated by the university didactic processes are defined by means of study plans, study programs (especially syllabi), student achievements, orders of university authorities and departments related to the realisation of the educational mission. Their current versions are usually made available through various systems operating at a given university. The task of the developed RDPD system is to archive these resources. Contrary to the original DSpace concept, in which the structure of the system follows the organisational structure of an institution, RDPD is intended to reflect the classification structure of university documents.

In the initial stage of the RDPD development, consultations were carried out in Kielce University of Technology academic community, with its main target users, i.e. academic teachers and vice-deans for student affairs and teaching in all the faculties. The consultations aimed at presenting the concept of the Repository, gaining acceptance, and receiving feedback on expectations regarding the functionality of the system, especially regarding the scope of resources stored in the Repository.

The schematic RDPD structure is presented in Table 1. There are six communities at the highest level of the hierarchy. They reflect the most general university didactic document classification. Communities contain collections that are groups of thematically related content. For example, the *Thesis* collection relates to engineering, bachelor and master theses of all university students. Each collection is composed of items that are the basic archival elements of the Repository. Each item is owned by one collection, and it is described by metadata fields. The metadata schema elaborated by the authors is denoted by *rdpd*, while the DSpace default metadata schema remained unchanged as *dc*. Each field is assigned to the metadata schema to

which it belongs. In the table, the metadata for an item in the collection are marked with a tick. For example, there are the following metadata fields for items in the *Thesis* collection: *dc.date.issued* (date of diploma submission), *rdpd.osoba.student* (diploma author – student), *rdpd.osoba.opiekun* (diploma supervisor – academic teacher), *rdpd.osoba.recenzent* (diploma reviewer – academic teacher), *rdpd.poziomKsz* (education cycle), *rdpd.slowaKlu* (diploma keywords), *rdpd.studia.kierunek* (student's field of study), *dc.title* (diploma title), *rdpd.wydzial* (faculty name), *rdpd.studia.tryb* (study mode). As soon as the item is given its metadata (in the above example, the information about the diploma of a certain student), the data connected with the item are loaded to the repository. The data are a set of bitstreams. Bitstreams are streams of bits, usually ordinary disk files. For example, in the case of the student thesis these can be: the diploma information page (a *pdf* format file), the content of the diploma (a *pdf* format file), the diploma appendix (e.g. a program source code in a *txt* format file), the content of the diploma reviews (*pdf* format files; in KUT, the reviews are prepared by a reviewer and a supervisor).

**Table 1.**
*The schematic RDPD structure*

| RDPD field name* | Field description | Thesis | Course credit protocols | Applications for the creation of field of study | Programs of study | Assessment reports of field of study | Rector's orders | Deans' orders | Resolutions of university senate | Resolutions of faculty councils | Full-time study timetables | Part-time study timetables | Reports on the realisation of teaching loads | Individual student's accomplishment | Student teams' accomplishment | Student research clubs | Erasmus+ program | Promotional activities |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| dc. date.issued | Date of the respective document/event | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| rdpd. dyscyplinyNau | Scientific discipline | | | | ✓ | | | | | | | | | | | | | |

Cont. table 1.

| Field | Description | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| rdpd. formaZaj | Form of teaching | | ✓ | | | | | | | | | | | | | | | | |
| rdpd. jednostka | University department | | | | | | | | | | | | | ✓ | | | | | |
| rdpd. klasyfikacja | Accomplishment classification | | | | | | | | | | | | | | ✓ | ✓ | | | |
| rdpd. osoba.student | Student name | ✓ | | | | | | | | | | | | | ✓ | | | | |
| rdpd. osoba.nauczyciel | Teacher name | | | | | | | | | | | | | ✓ | | | | | |
| rdpd. osoba.opiekun | Supervisor name | ✓ | | | | | | | | | | | | | | | ✓ | | |
| rdpd. osoba.recenzent | Reviewer name | ✓ | | | | | | | | | | | | | | | | | |
| rdpd. nazwaKol | Research club name | | | | | | | | | | | | | | | | ✓ | | |
| rdpd. nrUch | Resolution number | | | | | | | | ✓ | ✓ | | | | | | | | | |
| rdpd. nrZar | Order number | | | | | | ✓ | ✓ | | | | | | | | | | | |
| rdpd. opis | Accomplishment description | | | | | | | | | | | | | | ✓ | ✓ | | | ✓ |
| rdpd. organizator | Activity organiser | | | | | | | | | | | | | | | | | | ✓ |
| rdpd. poziomKsz | Education cycle | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | | | | | | |
| rdpd. przedmiot.kod | Subject code | | ✓ | | | | | | | | | | | | | | | | |
| rdpd. przedmiot.nazwa | Subject name | | ✓ | | | | | | | | | | | | | | | | |
| rdpd. rodzaj | Type of action | | | | | | | | | | | | | | | | | | ✓ |
| rdpd. rokAka | Academic year | | ✓ | | ✓ | | | | | | | ✓ | ✓ | ✓ | | | | ✓ | |
| rdpd. rokNasWiz | Year of the next assesment | | | | ✓ | | | | | | | | | | | | | | |
| rdpd. semestr.nazwa | Semester name | | | | | | | | | | | ✓ | ✓ | | | | | | |
| rdpd. semestr.numer | Semester number | | ✓ | | | | | | | | | | | | | | | | |
| rdpd. slowaKlu | Keywords | ✓ | | | | | | | | | | | | | | | | | |
| rdpd. studia.kierunek | Field of study | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | ✓ | | | | | | |
| rdpd. studia.profil | Profile of study | | | ✓ | ✓ | ✓ | | | | | | | | | | | | | |
| dc. title | Title of the respective document/event | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| rdpd. wydzial | Faculty name and its acronym | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ |

Cont. table 1.

| rdpd. zespol | Team | | | | | | | | | | | | | ✓ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| rdpd. studia.tryb | Study mode | ✓ | ✓ | | | | | | | | | | | | | |

\* selected fields are taken from the DSpace *dc* metadata schema (*dc* prefix), the other fields are defined by the authors (*rdpd* prefix)

Source: authors' own elaboration.

## 4. The key elements of RDPD installation and configuration

Many institutional academic repositories are built on the basis of the DSpace system. There are non-standard implementations among them. In a few publications, the authors share their experiences in this regard (Prasad, 2006; Winter, Bowen-Chang, 2010; Ahammad, 2019; Temirbekov et al., 2019). The non-standard (custom) implementation of DSpace was carried out for the RDPD system, as required by the authors' metadata schema. The DSpace test installation for RDPD was prepared on the virtual server of Kielce University of Technology, Poland, running under the GNU/Linux operating system, equipped with a quad-core processor, 8 GB of operating memory, and 200 GB of disk space, according to the instructions provided in the DSpace documentation (DSpace 7.x Documentation, 2022). The following issues were to be addressed in the customisation process: adding new elements to the database, input forms for submission processes, indexing, displaying search results, and data uploading and downloading.

DSpace is software with a layered architecture in which logical layers are separated: data layers (database and search system), business logic (DSpace backend) and presentation (DSpace frontend). The RDPD deployment required the installation and configuration of the operating system and additional applications, as listed below:

- in the data layer: PostgreSQL database management system version 11.x with pgcrypto extension, Apache search platform Solr 8.x,
- in the business logic layer: Java JDK runtime environment (OpenJDK version 11), DSpace application building tools (Apache Maven, Apache Ant), and Apache Tomcat 9 application container,
- in the presentation layer: Node.js 14.x runtime environment, DSpace-UI user interface application building and management tools (NPM, Yarn), and PM2 process manager.

In addition, a PROXY server has been installed and configured: the Apache HTTP Server, which allows the implementation of an encrypted connection.

Adapting DSpace to the needs of the RDPD system required modifying configuration files responsible for the following activities: organization of cooperation with the database, file store customisation, backend location settings, user interface modification, and configuration.

The concept of the RDPD system is reflected in the user interface, available in Polish and English. However, the metadata values (such as the names of communities, collections, items, and item descriptions) presented on the RDPD websites are in Polish, as shown in Figure 6; the English equivalents of the communities are given in commentary frames.



**Figure 6.** The home page of the RDPD system.

Source: authors' own elaboration.

## 5.  Implementation of the metadata structure

The implementation of the RDPD metadata structure involved the development of authors' own solution concepts and their realisation by working out some components of the system. Three key steps are described below.

A.  Creating and importing the dedicated Repository structure: communities and collections within them. The custom repository structures, defined in the *file.xml*, were introduced into the system in a batch mode using the command:

*[dspace-dir]/dspace structure-builder –e <user> -f [path]/file.xml –o [path]/output_file.xml*

where *dspace-dir* stands for the home directory of DSpace installation.

DSpace assigns handles not only to each digital object in the repository, but also to each community, sub-community, and collection. The imported custom structures: communities and collections along with the handles created for them are saved in the output file *output_file.xml*.

B.  Creating the custom metadata schema. Dublin Core (*dc*) is the default DSpace metadata schema. The *dc* structure is not useful for the concept of the RDPD schema. The developed metadata schema, saved in the *rdpd-types.xml* file, is implemented in RDPD by the following import to the system:

*[dspace-dir]/dspace registry-loader –metadata [path]/rdpd-types.xml*

For each metadata in the schema, the following elements had to be specified: the name of the schema to which it belongs [*name*], the identifier [*element*], and, optionally, the qualifier [*qualifier*], which specifies the use of the metadata. An annotation of the field can also be included, which is a kind of comment for the designer [*scope_note*].

C.  Developing submission forms for collections. Because each collection requires a different set of metadata elements, a submission form was defined for each collection. The base forms for the collections are specified in the *submission-forms.xml* file. All base form items on the DSpace system websites are presented in English, which is the default language. Implementing custom RDPD forms in English requires adding their definitions in the *submission-forms.xml* file. However, a separate forms file has to be created when a language version is created. For the Polish language, the *submission-forms_pl.xml* file was prepared, in which all the labels of the base forms have their Polish equivalents. For any other language version, the code of the appropriate language should be entered instead of *pl* in the file name, according to the ISO 639-1 list (ISO 639 - Language codes, 2022). Each form defined in the file has a unique name.

D.  Developing an action path when adding new records – workflow. In this action, one defines how the process of adding a new record to a specific collection will be carried out. The definitions are stored in the *item-submission.xml* file. Each process is assigned a unique identifier and associated with a collection. The following steps constitute the process:

- the specification of the form (a unique name taken from the *submission-forms.xml* file – see point C) to be displayed on the screen (and handled by this process),
- enabling the user to enter a license (optional),
- providing the user with the ability to upload files.

  Both the number and the order of steps can be freely modified. The same form can be used by different processes.

Any changes to the configuration files require restarting the Tomcat server (refreshing the information about the new elements in the DSpace structure).

## 6.  RDPD data management

The system is prepared for the user to perform the following tasks: entering data according to the metadata schema (Table 1), data editing, browsing repository contents and searching for information, managing users.

Entering a new item involves filling in the corresponding metadata form and loading files (bitstreams) constituting the data for the item. Figure 7 presents the form for the *Full-time study timetables* item. A necessary action of registering any item in the system is to upload bitstreams to the repository (*Drop files to attach them to the item*). Following the DSpace assumptions (DSpace 7.x Documentation, 2022), the RDPD system accepts a variety of disk file formats like, for example: *.docx, *.xlsx, *.pdf, *.avi, *.zip, *.gif, *.html.

Data editing is implemented in a different form than for adding data – compare Figures 7 and 8. In the submission form, a specific data format can be enforced, e.g. in the case of the *dc.date.issued* field, only numeric data corresponding to the successive components of the date (year, month, day) can be entered. On the other hand, in the edit form, the field presenting this data has a text format; changing the value to any text overwrites the existing valid date. The same remark applies to fields with similar restrictions, such as a drop-down list. Therefore, it is the system administrator's responsibility not to allow data to be changed in the edit mode to inappropriate values.

The browsing in DSpace can take place at the main level concerning all repository resources, as well as at the community and collection levels. Indexes defined for selected fields of the metadata schema are used to support browse operations. There are two types of indexes in the DSpace system:

- *item*; it supports all items at a specific level (whole repository, community, collection), sorted by the field indicated in the index. The displayed data refer to those items for which the indexed field is not empty,
- *metadata*; if the index is of metadata type, the unique values of the indexed field are displayed, along with information on how many items there are that have the given value at a certain level of the repository structure (whole repository, community, collection).

Only two RDPD elements map with existing Dublin Core elements in the browse option: *dc.date.issued* and *dc.title*. Thus, custom metadata elements for browsing operation have to be added by the DSpace administrator. Here, the *rdpd.wydzial* field (referring to a university faculty) was introduced. Such an operation requires handling with one of the following configuration files:

- *[dspace-backend]/config/dspace.cfg* (global settings)*,*
- *[dspace-backend]/config/local.cfg* (local settings, overrides global settings, recommended for customisation); definition of indexes,

where: *[dspace-backend]* stands for the home directory of the DSpace application's business logic layer software installation.

After the modification, the indexes should be refreshed with the command:

*[dspace-backend]/bin/dspace index discovery –b*.

The browse buttons corresponding to the newly defined indexes appear automatically on the DSpace website. When an index is deleted, the corresponding button is also automatically deleted.

The search option is available from any level of the repository; if the user does not enter restrictions on a selected community or collection, it applies to the resources of the entire repository. Search indexes are configurable, which additionally enables the definition of a contextual filtering capability by selected metadata fields. Such an operation requires a modification of the configuration file:

- *[dspace-backend]/config/spring/api/directory/discovery.xml*

and refreshing the indexes with the command:

*[dspace-backend]/bin/dspace index discovery -b*.

**Figure 7.** The RDPD submission form for the metadata of the *Full-time study timetables* item; in the example, the timetable is obligatory for the whole university, therefore the box *Faculty name-acronym* is empty.

Source: authors' own elaboration.

| Field | Value | Lang | Edit |
|---|---|---|---|
| dc.date.accessioned | 2022-06-10T08:25:40Z | | |
| dc.date.available | 2022-06-10T08:25:40Z | | |
| dc.date.issued | 2020-03-01 abc | | |
| dc.description.provenance | Made available in DSpace on 2022-06-10T08:25:40Z (GMT). No. of bitstreams: 1 2020-21_lato.zip: 5288000 bytes, checksum: d96e40e64bec61526633473e85dd9a97 (MD5) Previous issue date: 2020-03-01 | en | |
| dc.identifier.uri | http://rdpd.tu.kielce.pl/handle/rdpd/70 | | |
| dc.title | Plany zajęć studiów stacjonarnych 2020-2021 lato | | |
| rdpd.rokAka | 2020/2021 | | |
| rdpd.semestr.nazwa | letni 123 | | |

This incorrect modification is accepted by DSpace; the data were previously entered using list box and drop-down list in the submission form (see Figure 7).

**Figure 8.** The RDPD edit form for the metadata of the *Full-time study timetables* item; the two fields are incorrectly modified, which is indicated by arrows.

Source: authors' own elaboration.

## 7. RDPD users management

RDPD user groups have been defined according to their roles in didactic processes:

- *Anonymous* relates to any web surfer, a student in particular.
- *Academic* relates to university teachers.
- *Dean* relates to deans and vice-deans of all university faculties (departments).
- *Rector* relates to a rector and vice-rectors.
- *Administrator* relates to persons responsible for managing the system (administrators).

The administrator has full rights (full access) to all elements of the Repository structure.

All other user groups have only the right to read communities, collections, items, and selected bitstreams. With regard to bitstreams, the read permission depends on the group to which the user is assigned. Table 2 compiles the list of permissions proposed for RDPD.

**Table 2.**
*The list of permissions available in the RDPD system*

| Collection | Bitstream | Anonymous | Academic | Dean | Rector | Administrator |
|---|---|---|---|---|---|---|
| Thesis | Thesis abstract | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Thesis content | | ✓ | ✓ | ✓ | ✓ |
| | Thesis review | | | ✓ | ✓ | ✓ |
| Course credit protocols | All bitstreams | | | ✓ | ✓ | ✓ |
| Applications for the creation of field of study | All bitstreams | | ✓ | ✓ | ✓ | ✓ |
| Programs of study | All bitstreams | ✓ | ✓ | ✓ | ✓ | ✓ |
| Assessment reports of field of study | All bitstreams | | | ✓ | ✓ | ✓ |
| Rector's orders | All bitstreams | ✓ | ✓ | ✓ | ✓ | ✓ |
| Deans' orders | All bitstreams | ✓ | ✓ | ✓ | ✓ | ✓ |
| Resolutions of university senate | All bitstreams | ✓ | ✓ | ✓ | ✓ | ✓ |
| Resolutions of faculty councils | All bitstreams | ✓ | ✓ | ✓ | ✓ | ✓ |
| Full-time study timetables | All bitstreams | ✓ | ✓ | ✓ | ✓ | ✓ |
| Part-time study timetables | All bitstreams | ✓ | ✓ | ✓ | ✓ | ✓ |
| Reports on the realisation of teaching loads | All bitstreams | | | ✓ | ✓ | ✓ |
| Individual student's accomplishment | All bitstreams | ✓ | ✓ | ✓ | ✓ | ✓ |
| Student teams' accomplishment | All bitstreams | ✓ | ✓ | ✓ | ✓ | ✓ |
| Student research clubs | All bitstreams | ✓ | ✓ | ✓ | ✓ | ✓ |
| Erasmus+ program | All bitstreams | ✓ | ✓ | ✓ | ✓ | ✓ |
| Promotional activities | All bitstreams | ✓ | ✓ | ✓ | ✓ | ✓ |

Source: authors' own elaboration.

## 8. Discussions

University institutional repositories are mainly systems created for the management of digital scientific documents (articles, PhD, MA thesis, reports) whose authors are researchers employed at universities providing the repositories. Repositories are maintained by higher education units independently or by consortia formed by such units. The access to didactic materials manifests itself in rendering university press books, textbooks and other learning materials along with making them adopted to use in e-learning.

Brief information on example repositories around the world and in Poland, the content of which is classified, among others, as *Learning Objects* is given below. The information is limited to the didactic contents of the systems.

- MIT Libraries (MIT, US); http://dspace.mit.edu/, based on the DSpace system. The repository provides access to: diploma theses, archived courses (included are: leading teachers, syllabuses, assignments and solutions to assignments). Materials for students are available as resources embedded in the repository or at other addresses through links.

- Apollo (University of Cambridge, UK); https://www.repository.cam.ac.uk/, based on DSpace system. Instructional materials and course notes are available.

- E-Prints Complutense (Complutense University of Madrid, Spain); https://eprints.ucm.es, based on the EPrints system. Teaching resources, mainly in *pdf* formats, can be downloaded by a user.

- Digital Library of Wroclaw University (Wroclaw University, Poland); https://www.bibliotekacyfrowa.pl/dlibra, based on dLibra. Educational materials contain digital copies of course lectures, textbooks, bachelor's dissertations and master's and PhD theses to be used during educational processes at the University. The materials are part of the university main library resources.

- University of Lodz Repository (University of Lodz, Poland); https://dspace.uni.lodz.pl, based on DSpace. Didactic materials are offered as *pdf* documents. The repository contains also publication of the university academic clubs.

University institutional repositories are, as a rule, dedicated to managing the scientific output of employed scholars. In terms of didactic processes, repositories provide only learning (teaching) materials and, often, to a limited extent. In most cases, the repositories are developed on the basis of ready-made systems, both in the sphere of front-end organization and metadata schema (international standard: Dublin Core). The authors have not found a concept or solution similar to the one presented in the study. Although the discussed RDPD system is also an adoption of the well-known DSpace solution, its development required a completely different concept, an approach to the metadata schema, and the maintenance.

## 9. Conclusions

It is likely that in the next few years the concept of institutional repositories will develop both in a convergent and a divergent way. The idea of open-source software, in particular, has gained increasing attention in the higher education sector over the last several years. One of the most commonly used software is DSpace, on the basis of which universities have established standard institutional repositories. However, there are few implementations in which the system is used for custom (non-standard) solutions.

In the study, the original (custom) concept of Repository of Didactic Processes Data (RDPD) for universities was presented. The Repository was developed and implemented in Kielce University of Technology (Poland) on the basis of the DSpace system. The purpose of the Repository is to handle formally organised content in a digital form, covering resources created in connection with the didactic processes, and the origin of which is a university community. The following tasks were undertaken in the environment of DSpace, the system chosen for RDPD development: adapting the data schema developed for RDPD and the implementation of the operations of loading, browsing, and searching of data as well as user management. The logical metadata layers as well as the technical implementation of the proposed Repository in the DSpace system were elaborated. In order to introduce the authors' idea, the entire work required in-depth study of the DSpace documentation, the installation of supporting software, modification of configuration files. In the study, the key elements of the development of the RDPD system were discussed.

The RDPD system was prepared for Kielce University of Technology, Poland, but, after verification of the test version, it can be made available to other universities in Poland. Users can work with the Repository developed according to the proposed schema by entering their own metadata and data into it.

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# THE IMPORTANCE AND STATE OF GENERAL RESOURCES: THE ANALYSIS OF HOUSING COOPERATIVES FROM ŚWIĘTOKRZYSKIE AND MAŁOPOLSKIE VOIVODESHIPS FROM POLAND

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**Purpose:** The main aim of the article is to determine the influence of the assessment of validity and actual state of individual resources and competences in the sphere of general resources on competitive potential. Additional aim is a comparison of these resources/competences taking into account housing cooperatives from Świętokrzyskie and Małopolskie voivodeships.

**Design/methodology/approach**: The research was conducted among cooperatives' executives who were asked to assess the validity and state of resources and competences in the sphere of general resources. All housing cooperatives from the Świętokrzyskie and Małopolskie voivodeships were asked to take part in the research, however, because of the tendency of the representatives of cooperatives to participate in the research, the research had been conducted on a sample of 27 housing cooperatives of which 7.6% from Świętokrzyskie Voivodeship and 21% from Małopolskie voivodeship, using an interview questionnaire.

**Findings:** Analysis of conducted research show that there is a positive correlation between the assessment of the importance of resources in the sphere of general resources and the competitive potential of the enterprise. The findings also show that the state of resources is not a moderator (a factor that determines whether or not there is a relationship) of the relationship between the importance of resources and the competitive potential. Moreover, voivodeship of the enterprise does not differentiate its competitive potential and the state of its resources in comparison to its competitors.

**Practical implications:** The study shows that it is very important for managers to know all general resources and competences due to the fact that the understanding of the validity of general resources and competences allows to create the competitive potential. At the same time the knowledge of the state of general resources and competences in comparison to the competition allows the company to do everything to keep up with the competition and then outrun it. It shows what resources/competences are better than competitor's and what need to be improved.

**Originality/value:** The article theoretically describes general resources/competences of the company and empirically analyses the importance of having the knowledge of possessed resources/competences and its influence on competitive potential. The value of the research is that it confirms what appears to be obvious but in fact is not taken into account by most enterprises.

## 1. Introduction

The literature on the concepts of resources and competences is countless and includes many different approaches. Generally speaking the resource based view explains how a company is able to gain a competitive edge using available resources and competences (Kabue, Kilika, 2016), which eventually lead to superior organizational performance (Ismail, Rose, Uli, Abdullah, 2012). While resources are firm-specific assets whose value is context dependent, competences are resources, which result from activities that are performed repetitively in a firm (Del Río, Carrillo-Hermosilla, Könnölä, Bleda, 2016). As writes Prahalad (1994) *to get to the future first, top management must either see opportunities not seen by other top teams or must be able to exploit opportunities, by virtue of preemptive and consistent capability-building, that other companies can't copy.* Thus every company should know which resources and competences are important for its development and competitiveness. It seems obvious, but it is not always the case. The awareness of the general resources / competences held is the basis for the assessment of other resources/competences from various spheres of the company's activity. It is important, because resources and competences contribute to the company's competitive potential. Therefore, the aim of the article is to determine the influence of the assessment of validity and actual state of individual resources and competences in the sphere of general resources on competitive potential and to compare them taking into account housing cooperatives from Świętokrzyskie and Małopolskie voivodeships from Poland.

Accordingly, the article is organized as follows. The next section briefly describes key general resources and competences of a company. Section 3 develops research methodology. In section 4 descriptive statistics of tested variables are highlighted. Finally in section 5 results of own research are presented. The last section presents conclusions.

## 2. General resources/competences

General resources/competences are the minimum resources/competences required to withstand competition. They are based on such factors as available resources and competencies to undertake activities. The company general resources/competences are basic building blocks of company and can be used to achieve its objective and target.

The general resources/competences, developed by Stankiewicz (2002), can be detailed as follows.

**The reliability of the enterprise**

One way to gain an advantage over competitors is to build customers' trust in a company and the credibility of the company. The quality of information about a company and its offer, which largely shapes trust in the company, determines whether it is perceived as credible or not. Non-economic criteria are of great importance here – intangible values of the company, such as reputation, social responsibility and sustainable development to improve the quality of life of stakeholders (Badzińska, Gołąb-Andrzejak, 2017). And from the point of view of economic reliability of an enterprise the following elements take part: reliability of management system, technical development, conservation activities, human resources management, financial and economic development, marketing activities, and in case of industrial enterprise - the production management (Timofeev, Shlychkov, Nestulaeva, 2017).

**Organizational culture of the enterprise**

Enterprise culture has been defined as encompassing the values, rules, beliefs and assumptions in the handling and behavior of an enterprise's (especially internal) stakeholders, which reflects internally as well externally the behavior of an enterprise (Belak, Milfelner, 2012). According to Schein (1985, p. 17) it is *a pattern of shared basic assumptions that was learned by a group as it solved its problems of external adaptation and internal integration that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems*.

**Cumulative knowledge**

Cumulative knowledge is the legally owned resource of the enterprise – intellectual property. These are sources of future benefits for the enterprise based on explicit knowledge (Urbanek, 2007), i.e. tangible and intangible resources in the part that can be covered by property rights, such as: brands, registered trademarks, patents, utility models, licenses, programs, databases, intellectual rights, but also purchased external services: opinions, expert opinions, audits, research results, problem solutions and the effects of consulting activities, etc. (Sopińska, 2008).

**The enterprise's ability to retain customers**

The customer retention is critical to increase the overall value of company's customer base and to withhold its customers for a long time. The loyalty and retention is built by customer relationship management (CRM), i.e. all of the activities, strategies and technologies that companies use to manage their interactions with their current and potential customers (Kulpa, 2017). It relies on *identifying, winning and educating customer loyalty, and in particular on collecting, integrating, processing and disseminating customer information in all the involved organizational units through possible information distribution channels* (Frąckiewicz, Rudawska, 2004).

**Having regular customers**

The possession of regular customers is based on loyalty, which is according to Oliver (1999) *a deeply held commitment to rebuild and re-patronize a preferred product or service in the future despite situational influences and marketing efforts having the potential to cause switching behaviors*. Generally speaking it is the intention of repurchasing products and services. It is the fidelity to the brand, which is based on a strong emotional foundation and which is followed by repeated and conscious choices – as a consequence, it makes enterprises less susceptible to incentives directed by competitors. Thanks to loyal customers, the company will not have to acquire a large number of new customers (and, as it is known, acquiring a new customer is extremely expensive), which can clearly reduce sales and marketing costs (Stachowicz-Stanusch, 2007).

**The reputation of the company's brand and the reputation of the product brand**

The importance of a brand for a buyer is determined by a large number of factors, the most important of which are probably the following two indicated by Cheverton (2002): first, the number and type of interactions with the customer – the more complex is the relationship between the customer and the brand, the greater the chance of building long-term loyalty; second, the degree of brand identification with issues that absorb consumers' attention – brand loyalty increases if it manages to reach the issues that are important to the audience. Strong customer loyalty to the brand makes it easier for the brand to find a place on store shelves. Distributors are more likely to buy recognized brands that enjoy customer loyalty than new ones (Urbanek & Kosińska, 2002).

**The ability of the enterprise to learn**

Learning enables organizations to remain or achieve competitive advantage. Organizations need to learn more than ever as they confront such factors as intensifying competition, advances in technology, and shifts in customer preferences (Gavin, Edmondson, Gino, 2008). Without learning the companies repeat the old practices and when there is no change in process or actions the success is either fortuitous or short-lived (Farrukh, Waheed, 2015). We can distinguish three building blocks of a learning organization that was proposed by Garvin, Edmondson, Gino (2008): the first, a supportive learning environment, comprises psychological safety, appreciation of differences, openness to new ideas, and time for reflection; the second, concrete learning processes and practices, includes experimentation, information collection and analysis, and education and training. These two complementary elements are fortified by the final building block: leadership that reinforces learning.

**The speed of adapting to market changes**

Adaptation, which is very essential for an organization to survive and prosper into today's business environment, is the way to respond quicker than competitors to market changes. It allows to improve performance through greater co-ordination of operating the business and drives to improve business performance. The company needs to act flexibly, to recognize and accept very early the need for change and attach high importance to change management and

its processes through their involvement in the strategic decision-making processes (Mehedintu, Munteanu, 2016). Only such action will allow the enterprise to overtake competitors and gain a competitive advantage

**Tendency to active competition (not avoiding competition)**

The ability to compete, and therefore to act and survive in a competitive environment, is called competitiveness. Companies should constantly strive to improve competitiveness, because the modern ease of communication means that no company can feel isolated, secure and free from tension market (Bramham, 2004). Therefore, companies should do everything to survive in the conditions of competition, by proving products and services that meet high quality standards at competitive prices, both nationally and internationally, in relation to the possibilities and performance of other companies (Comănescu, Ponea, Petre, Ponea, 2018). Companies should be aware that there can be three levels of competition: from firm to market and industry level, from location through the region to country level, and from firm through clusters to the level of countries (Listra, 2015). Therefore, they need to decide on which level or levels they want to compete.

**Knowledge of legal regulations**

The knowledge of legal regulations is very crucial for companies as norms can come from different sources, and many them are updated constantly. Therefore, companies have lawyers in their structures or use their services because that laws must be interpreted and adapted to the specific business processes of the organization.

**Convenience of location in terms of local legal norms and economic operating conditions**

Location plays an important role in shaping the position of enterprises on the market. Traditional location factors include: locating the company where production costs, i.e. raw materials, materials and other production factors, are lower for a given volume, proximity to sales markets, lower taxes, the issue of increasing productivity and achieving high quality, integration with other units of the organization, convenient transport, availability of properly qualified workforce and its quality, availability of social infrastructure amenities, capital costs, economic infrastructure, availability of transport routes, availability of supplies, availability of utilities, space for expansion, safety requirements, availability of climatic conditions and land characteristics, plot costs and the level of political risk, cultural and economic situation, special subsidies, local regulations and taxes, and export and import barriers (Kasiewicz, 2002; Muhlemann, 1997).

**The ability to create company-friendly informal relations with decision-making centers in the environment**

Informal relations according to Hayek (1988) are norms of behavior, conventions, and self-imposed codes of conduct, which generally underlie and supplement formal constraints. By reducing uncertainty, informal relations naturally become an instrument that increases the economic value of planned projects, and thus a generator of increased effectiveness of

undertaken initiatives. This in turn increases the availability of both equity and return capital (Kosiń, 2016).

**The ability to create a lobby supporting the activities of the enterprise**

Lobbying is the attempt to affect legislative policy for the benefit of special interests of the enterprise. According to Peterson & Pfitzer (2009) lobbying for good is an innovative way to reduce the negative value chain impacts of products and services, and the company that pushes for improved standards can create competitive advantage for itself and safer, more environment- and consumer-friendly products and services.

**Participation in strategic alliances**

Strategic alliance is a partnership between two or more enterprises that concentrate resources and coordinate efforts for better results to achieve strategic goals, but they remain independent after alliance formation and they share benefit created by the strategic activity (Yoshino and Rangan, 1995; Dussauge and Garrette, 1995). The motives of the strategic alliance are comprised of possibilities related tobetter and faster access to technologies, ability to establish in newmarkets, reduce financial and political risk, form added value and derive profit (Kinderis, Jucevičius, 2013). Creating an alliance with an external partner allows to solve many problems consisting in the lack of adequate resources and competitive characteristics. The use of this variant makes it possible to make a marriage between new products of one company and the unused potential of sales services of another company, and very seriously shorten the time that elapses from the creation of the product to its introduction to the market (Faulkner, 1996).

## 3.  Research Methodology

The research was conducted among cooperatives' executives who were asked to assess the validity and state of resources and competences in the sphere of general resources. All housing cooperatives from the Świętokrzyskie and Małopolskie Voivodeships were asked to take part in the research, however, because of the tendency of the representatives of cooperatives to participate in the research, the research had been conducted on a sample of 27 housing cooperatives from Świętokrzyskie Voivodeship, i.e. 7.6% and Małopolskie voivodeship, i.e. 21% of cooperatives functioning in the year of conducting research. There was used an interview questionnaire, which was structured.

As it was showed in the introduction, every company should know which resources/ competences are important for its development and competitiveness. The knowledge of the importance of resources and competences in the sphere of general resources should be associated with the competitive potential of the enterprise. To confirm it, there was formulated the first research hypothesis, H1 as follows:

*H1. There is a positive relationship between the assessment of the importance of resources/ competences in the sphere of general resources/competences and the competitive potential of the enterprise.*

The relationship is true, when various factors strengthen, weaken, moderate, or mediate its intensity. It is assumed that the state of general resources/competences is a mediator and it is contained in the second hypothesis H2 as follows:

*H2. The state of resources moderates the relationship between the assessment of the importance of resources/competences in the sphere of general resources/competences and the competitive potential of the enterprise.*

Due to the fact that cooperatives operate in different voivodeships there can be differences in assessing the importance of resources and competences in the sphere of general resources that constitute the competitive potential. Therefore, there is proposed the following hypothesis H3:

*H3. There are differences in terms of the competitive potential depending on the voivodeship.*

Basing on the assumption that cooperatives, which operate in different voivodeships differently assess the state of resources/competences there was stated the following hypothesis H4:

*H4. There are differences in the state of general resources/competences depending on the voivodeship.*

In order to verify the research hypotheses, analyzes were performed in the IBM SPSS Statistics 27 statistical program. First, the descriptive statistics of the tested variables were calculated along with the Shapiro-Wilk distribution normality indicators to determine the applicability of parametric methods. Then, correlation analyzes and difference tests were performed to verify the hypotheses. The threshold $\alpha = 0.05$ was adopted as the level of significance in this article.

## 4. Descriptive statistics of the test variables

Table 1 presents descriptive statistics along with Shapiro-Wilk distribution normality tests for all questions posed in the survey and the calculated general results of each part of the self-questionnaire. Analyzing the results of the test, it must be noted statistically significant deviation from the normal distribution ($p < 0.001$) in all tested indicators. In addition, observing skewness indicators (Sk.) and kurtosis indicators (Kurt.) must be noted significant deviations from the zero value, both in the case of aspects of the competitive potential, as well as in the state of resources. According to the guidelines of Georg and Mallery (2019), the absolute value of | 1 | should be taken as the limit, which in most cases was exceeded towards the left-skewed distribution. Based on the presented empirical evidence and the researchers' suggestions, it was

decided to use in statistical analyzes the non-parametric Spearman's rho correlation and the Welsh difference test, which shows greater resistance to the assumptions of normality of distributions and equality of the studied groups and is more powerful than the Mann-Whitney U test (Derrick, Toher, White, 2016).

**Table 1.**
*Descriptive statistics of indicators of variables tested with Shapiro-Wilk distribution normality tests (N = 27)*

| | M | Me | SD | Sk. | Kurt. | Min. | Maks. | W | p |
|---|---|---|---|---|---|---|---|---|---|
| Competitive potential of the company | | | | | | | | | |
| 1. The reliability of the enterprise | 4.33 | 5.00 | 0.78 | -0.69 | -0.99 | 3.00 | 5.00 | 0.75 | <0.001 |
| 2. Organizational culture of the enterprise | 4.30 | 5.00 | 0.82 | -0.62 | -1.23 | 3.00 | 5.00 | 0.75 | <0.001 |
| 3. Cumulative knowledge (patents, trade secrets, databases, etc.) | 3.56 | 4.00 | 1.50 | -1.44 | 1.54 | 0.00 | 5.00 | 0.78 | <0.001 |
| 4. The enterprise's ability to retain customers | 3.74 | 4.00 | 1.26 | -1.34 | 2.09 | 0.00 | 5.00 | 0.83 | <0.001 |
| 5. Having regular customers | 3.56 | 4.00 | 1.31 | -1.40 | 2.41 | 0.00 | 5.00 | 0.82 | <0.001 |
| 6. The reputation of the company's brand | 3.56 | 4.00 | 1.50 | -1.44 | 1.54 | 0.00 | 5.00 | 0.78 | <0.001 |
| 7. The reputation of the product brand | 3.52 | 4.00 | 1.53 | -1.26 | 1.10 | 0.00 | 5.00 | 0.81 | <0.001 |
| 8. The ability of the enterprise to learn | 3.59 | 4.00 | 1.53 | -1.42 | 1.44 | 0.00 | 5.00 | 0.78 | <0.001 |
| 9. The speed of adapting to market changes | 3.56 | 4.00 | 1.45 | -1.59 | 2.17 | 0.00 | 5.00 | 0.75 | <0.001 |
| 10. Tendency to active competition (not avoiding competition) | 3.63 | 4.00 | 1.45 | -1.77 | 2.65 | 0.00 | 5.00 | 0.71 | <0.001 |
| 11. Knowledge of legal regulations | 3.48 | 4.00 | 1.50 | -1.28 | 1.21 | 0.00 | 5.00 | 0.81 | <0.001 |
| 12. Convenience of location in terms of local legal norms and economic operating conditions | 3.22 | 4.00 | 1.60 | -1.06 | 0.23 | 0.00 | 5.00 | 0.82 | <0.001 |
| 13. The ability to create company-friendly informal relations with decision-making centers in the environment | 3.30 | 4.00 | 1.64 | -1.09 | 0.21 | 0.00 | 5.00 | 0.82 | <0.001 |
| 14. The ability to create a lobby supporting the activities of the enterprise | 3.22 | 4.00 | 1.63 | -0.97 | 0.08 | 0.00 | 5.00 | 0.84 | <0.001 |
| 15. Participation in strategic alliances | 3.30 | 4.00 | 1.71 | -1.00 | -0.15 | 0.00 | 5.00 | 0.82 | <0.001 |
| Competitive potential | 3.59 | 4.00 | 1.19 | -1.21 | 1.23 | 0.53 | 5.00 | 0.88 | 0.004 |
| The company's resources/competences in comparison to the competition | | | | | | | | | |
| 1. The reliability of the enterprise | 1.81 | 2.00 | 0.48 | -0.53 | 0.74 | 1.00 | 3.00 | 0.65 | <0.001 |
| 2. Organizational culture of the enterprise | 1.89 | 2.00 | 0.42 | -0.77 | 2.67 | 1.00 | 3.00 | 0.57 | <0.001 |
| 3. Cumulative knowledge (patents, trade secrets, databases, etc.) | 1.70 | 2.00 | 0.82 | -0.72 | 0.32 | 0.00 | 3.00 | 0.81 | <0.001 |
| 4. The enterprise's ability to retain customers | 1.81 | 2.00 | 0.62 | -0.90 | 2.11 | 0.00 | 3.00 | 0.73 | <0.001 |
| 5. Having regular customers | 1.81 | 2.00 | 0.68 | -1.33 | 2.68 | 0.00 | 3.00 | 0.68 | <0.001 |
| 6. The reputation of the company's brand | 1.67 | 2.00 | 0.73 | -1.26 | 1.19 | 0.00 | 3.00 | 0.69 | <0.001 |
| 7. The reputation of the product brand | 1.63 | 2.00 | 0.69 | -1.66 | 1.42 | 0.00 | 2.00 | 0.58 | <0.001 |

Cont. table 1.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 8.  The ability of the enterprise to learn | 1.56 | 2.00 | 0.70 | -1.31 | 0.47 | 0.00 | 2.00 | 0.66 | <0.001 |
| 9.  The speed of adapting to market changes | 1.67 | 2.00 | 0.73 | -1.26 | 1.19 | 0.00 | 3.00 | 0.69 | <0.001 |
| 10. Tendency to active competition (not avoiding competition) | 1.78 | 2.00 | 0.80 | -1.02 | 1.08 | 0.00 | 3.00 | 0.75 | <0.001 |
| 11. Knowledge of legal regulations | 1.67 | 2.00 | 0.73 | -1.26 | 1.19 | 0.00 | 3.00 | 0.69 | <0.001 |
| 12. Convenience of location in terms of local legal norms and economic operating conditions | 1.52 | 2.00 | 0.75 | -1.24 | 0.03 | 0.00 | 2.00 | 0.65 | <0.001 |
| 13. The ability to create company-friendly informal relations with decision-making centers in the environment | 1.52 | 2.00 | 0.75 | -1.24 | 0.03 | 0.00 | 2.00 | 0.65 | <0.001 |
| 14. The ability to create a lobby supporting the activities of the enterprise | 1.52 | 2.00 | 0.75 | -1.24 | 0.03 | 0.00 | 2.00 | 0.65 | <0.001 |
| 15. Participation in strategic alliances | 1.67 | 2.00 | 0.83 | -1.01 | 0.46 | 0.00 | 3.00 | 0.73 | <0.001 |
| The state of resources | 1.68 | 1.93 | 0.56 | -1.57 | 1.36 | 0.27 | 2.20 | 0.74 | <0.001 |

Source: own work.

## 5. Results of own research an disussion

Table 2 presents the correlation coefficients between the importance of individual resources and the company's competitive potential. The correlations obtained indicate that there is a sufficient relationship between the variables. The borderline result was obtained in the case of organizational culture ($p = 0.053$). This means that the H1 hypothesis: *There is a positive relationship between the assessment of the importance of resources/competences in the sphere of general resources/competences and the competitive potential of the enterprise*, has been confirmed. As the importance of resources increases, so does the competitive potential of companies. The dependencies range from a moderate correlation ($r = 0.38$) to a very strong one ($r = 0.92$). However, it should be noted that the competitive potential is the general result of all resources, which allows to specify a resource hierarchy for the competitive potential, from the strongest to the weakest correlations.

Table 2 also shows the correlation coefficients between the importance of general resources and the competitive potential that interacts with the state of resources. Due to the small sample size (N = 27), the classic moderation approach would not bring significant effects. Therefore, the quotient of importance and possession of resources was calculated, considering it as a partial effect of moderating the competitive potential by the state of owned resources. Then, the obtained correlation coefficients for the interactions of variables were compared with the use of Fisher's Z test to the competitive potential without the state of owned resources, in order to determine the significance of the change of correlation coefficients. This approach made it possible to verify the H2 hypothesis*: The condition of resources/competences*

*moderates the relationship between the assessment of the importance of resources/competences in the sphere of general resources/competences and the competitive potential of the enterprise.* When analyzing the results of the Fisher test, it was found that significant differences can only concern the company's brand reputation ($p = 0.052$) and the ability to create company-friendly relations ($p = 0.048$). In both cases, the currently available resources weaken slightly the relationship between competitive potential and the importance of the reputation of the brand and the ability to create relationships. However, taking into account the number of comparisons and using the Bonferroni significance correction for multiple comparisons ($\alpha = p/$ number of comparisons), it should be assumed that to confirm the H2 hypothesis, the significance of the differences should exceed the threshold $\alpha = 0.003$, which was not obtained in the case of this research. Therefore, it should be assumed that statistically significant differences are the result of chance, and the H2 hypothesis has not been confirmed. The state of resources is not a moderator (of the relationship between the importance of resources and the competitive potential.

**Table 2.**
*Analysis of the relationship between the importance of resources/competences and the competitive potential along with the potential moderation of the state of the owned resources/competences*

| | Competitive potential | | Competitive potential x The state of resources | | Fisher test | |
|---|---|---|---|---|---|---|
| | Spearman rho | *p* | Spearman rho | *p* | *Z* | *p* |
| 1. The reliability of the enterprise | 0.50 | 0.008 | 0.51 | 0.007 | -0.05 | 0.964 |
| 2. Organizational culture of the enterprise | 0.38 | 0.053 | 0.45 | 0.019 | -0.30 | 0,768 |
| 3. Cumulative knowledge (patents, trade secrets, databases, etc.) | 0.79 | <0.001 | 0.70 | <0.001 | 0.71 | 0.478 |
| 4. The enterprise's ability to retain customers | 0.65 | <0.001 | 0.62 | 0.001 | 0.18 | 0.856 |
| 5. Having regular customers | 0.66 | <0.001 | 0.62 | 0.001 | 0.28 | 0.776 |
| 6. The reputation of the company's brand | 0.92 | <0.001 | 0.76 | <0.001 | 1.94 | 0.052 |
| 7. The reputation of the product brand | 0.88 | <0.001 | 0.85 | <0.001 | 0.43 | 0.670 |
| 8. The ability of the enterprise to learn | 0.86 | <0.001 | 0.72 | <0.001 | 1.32 | 0.188 |
| 9. The speed of adapting to market changes | 0.81 | <0.001 | 0.71 | <0.001 | 0.80 | 0.426 |
| 10. Tendency to active competition (not avoiding competition) | 0.69 | <0.001 | 0.55 | 0.003 | 0.83 | 0.409 |
| 11. Knowledge of legal regulations | 0.88 | <0.001 | 0.75 | <0.001 | 1.34 | 0.180 |
| 12. Convenience of location in terms of local legal norms and economic operating conditions | 0.90 | <0.001 | 0.78 | <0.001 | 1.52 | 0.129 |
| 13. The ability to create company-friendly informal relations with decision-making centers in the environment | 0.92 | <0.001 | 0.78 | <0.001 | 1.98 | 0.048 |
| 14. The ability to create a lobby supporting the activities of the enterprise | 0.85 | <0.001 | 0.82 | <0.001 | 0.40 | 0.692 |
| 15. Participation in strategic alliances | 0.90 | <0.001 | 0.85 | <0.001 | 0.71 | 0.476 |

Source: own work.

In order to verify the hypotheses H3: *There are differences in the competitive potential depending on the voivodeship*, and H4: *There are differences in the state of resources/ competences depending on the voivodeship*, the Welsch test was used to compare the averages for both voivodeships (Table 3). The obtained results indicate no statistically significant differences, which indicates that the H3 and H4 hypotheses were not confirmed. The voivodeship of the enterprise does not differentiate its competitive potential and the state of its resources in comparison to the competition.

**Table 3.**
*Analysis of differences using the Welsch test in terms of competitive potential and the state of resources/competences of enterprises depending on the voivodeship*

| | Małopolskie (*n* = 20) | | Świętokrzyskie (*n* = 7) | | *t* | *p* | 95% *CI* | | Cohen's *d* |
|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | | | *LL* | *UL* | |
| Competitive potential | 3.63 | 1.30 | 3.49 | 0.84 | 0.27 | 0.792 | -0.95 | 1.23 | 0.12 |
| The state of resources/commences | 1.88 | 0.68 | 2.05 | 0.47 | -0.60 | 0.555 | -0.75 | 0.41 | 0.26 |

Source: own work.

In order to verify the hypotheses H3: *There are differences in the competitive potential depending on the voivodeship*, and H4: *There are differences in the state of resources/ competences depending on the voivodeship*, the Welsch test was used to compare the averages for both voivodeships (Table 3). The obtained results indicate no statistically significant differences, which indicates that the H3 and H4 hypotheses were not confirmed. The voivodeship of the enterprise does not differentiate its competitive potential and the state of its resources in comparison to the competition.

## 6. Conclusions

As it was proved in the empirical analysis of collected data there is a positive correlation of the assessment of validity and actual state of individual resources and competences in the sphere of general resources on competitive potential. A very strong correlation occurs in case of the convenience of location in terms of local legal norms and economic operating conditions, the reputation of the company's brand, the ability to create company-friendly informal relations with decision-making centers in the environment, the participation in strategic alliances, cumulative knowledge (patents, trade secrets, databases, etc.), the reputation of the product brand, the ability of the enterprise to learn, the speed of adapting to market changes, tendency to active competition (not avoiding competition), knowledge of legal regulations, and the ability to create a lobby supporting the activities of the enterprise. Furthermore, competitive potential of companies increases with the increasing importance of resources.

When taking into account the comparison between Świętokrzyskie and Małopolskie voivodeships it was proved that the enterprise's voivodeship does not differentiate its competitive potential and the state of its resources in comparison to its competitors. This statement comes from the fact that the obtained results indicate no statistically significant differences.

The way of analysis of the topic covered in the research is novel and has practical implications, because it is very important for managers to know all general resources and competences due to the fact that the understanding of the validity of general resources and competences allows to create the competitive potential.

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# ORGANIZATIONAL AMBIDEXTERITY – THE RESULTS OF BIBLIOMETRIC ANALYSIS

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**Purpose**: Organizational ambidexterity is a promising concept in management science. It is defined as the ability of a company to leverage existing resources by increasing the productivity of current products and services while exploring development niches. The aim of the article is to identify the leading research areas within organizational ambidexterity based on bibliometric analysis carried out on a collection of scientific articles and conference papers indexed in the Scopus database.

**Findings**: Data visualisation was prepared using VOSviewer software (version 1.6.15), which allows analysis of the frequency of keywords in the analysed dataset and, at the same time, an analysis of their co-occurrence with other keywords. The article presents visualisations in the form of both a label view and a density view. Using the VOSviewer software, a summary of 2255 keywords was generated based on the uploaded set of publications and a dictionary allowing the combination or deletion of individual terms. The final map consisted of 36 keywords grouped into six clusters. The theoretical contribution of the paper consists in the identification of six clusters revolving around the issue of organisational ambidexterity. The clusters refer to 1) the relationship between organisational ambidexterity and a company's ability to innovate, 2) organisational ambidexterity and dynamic capabilities, 3) perception of organisational ambidexterity as a useful framework of product development 4) perception of organisational ambidexterity as a framework to support human resource management, 5) the notion of exploitation and exploration and 6) contextual ambidexterity.

**Research limitations/implications**: The analysis revealed a clear trend away from analysing structural and temporal ambidexterity in companies towards attributing more importance to individual ambidexterity which may be an interesting subject of future research inquiry. A limitation of the study is that it was based on publications from a single database, therefore it is interesting to analyse comparisons between other databases such as Web of Science or IEEE.

**Originality/value:** The article fills the cognitive gap in demonstrating the latest trends in the research field. The findings could serve as a guide for researchers who aim for better understanding of the main progress and promising research trends in the field of organisational ambidexterity.

**Keywords:** bibliometric analysis, organisational ambidexterity, VOSviewer software.

**Category of the paper:** Research paper.

# 1. Introduction

Organisational ambidexterity is a paradox in organisational management. Nonetheless, the existence of organisational paradoxes, contradictions and conflicts is crucial to keep the business viable and enable it to adapt to a changing and uncertain environment (Lewis, 2000; Poole, Ven, 1989). Although a large body of work on organisational tensions can be identified in the literature, Smith maintains that "we still know little about the specifics and management of strategic paradoxes" (Vafeas, Hughes, 2020, p. 1592). On the other hand, as Mesjasz aptly notes, the increasing complexity of modern organisations contributes to the increasing role of paradoxes in management theory and practice (Mesjasz, 2016). According to Czakon, paradoxes refer to contradictions that affect the behaviour of people in organisations, accompany the decisions of managers or are embedded in the development strategies of companies (Czakon, 2012). Czakon emphasises that paradoxes in contemporary management science research focus on the most innovative and mobilising promises of corporate success, among which he lists organisational ambidexterity (Czakon, 2012).

As organizational ambidexterity is still very promising and dynamically evolving concept in the management science, the purpose of the article is to present a holistic overview by the presentation of the main research trends as well as the new promising research ideas.

Thus, the considerations presented in this article fill the cognitive gap in demonstrating the latest trends in the area of organizational ambidexterity. In order to achieve the goal set in the article, a systematic literature review was conducted with the use of bibliometric analysis carried out on a collection of scientific articles and books indexed in the Scopus database. Bibliometric analysis served as a method of bibliographic counting to evaluate and quantify the literature growth, which could navigate scholars in grasping the development characteristics of the field and guide their future research (Shi et al., 2021). An additional objective is to identify the most influential and recent work in this area.

# 2. Literature review

Organisational ambidexterity is the ability of a company to leverage existing resources by increasing the productivity of existing products and services while exploring new territories and development niches in the areas of technology, markets, products or business models. Its possession is recognised in the existing published works as a critical source of competitive advantage (Eisenhardt, Martin, 2000; Fang et al., 2010; Levinthal, March, 1993).

In the body of literature, there could be identified many recognitions of organisational ambidexterity. Examples of definitions are presented in the Table 1.

**Table 1.**

*The examples of definitions of organizational ambidexterity*

| Definition | Author(s) |
|---|---|
| The ability of an organisation to engage in exploitation to ensure its current viability, while devoting sufficient energy to exploration to ensure its future viability. | Levinthal, March (1993), p. 105 |
| Ability to simultaneously create incremental and incremental innovations. | Tushman, O'Reilly (1996), p. 24 |
| The ability of the organisation to create structures and systems designed to mitigate conflicting tensions. | Gibson, Birkinshaw (2004), pp. 210-211 |
| Manager's ability to reconcile exploration and exploitation activities within a defined unit of time. | Mom et al. (2009), p. 812 |
| Ambidexterity reflects the tension or conflict of strategic pursuits of companies in the face of limited resources, such as the ability to pursue exploitative and exploratory innovation strategies. | Du, Chen (2018), p. 44 |
| A strategic capability to reconcile the conflicting demands of exploration and exploitation. This capacity can be referred to the level not only of the organisation as a whole, but also of the group or individual. | Zakrzewska-Bielawska (2018), p. 35 |
| Ambidexterity is a concept that allows a firm to simultaneously develop exploration and exploitation in order to achieve superior performance and it requires the adoption of two important organizational cultures, willingness to cannibalize (WTCA) and willingness to combine existing knowledge (WTCO), which allow firms to attain superior performance through the implementation of both radical and incremental (i.e., ambidextrous) innovations. | Harmancioglu et al. (2020), pp. 46-47. |

Source: own study.

Although the above definitions emphasise different aspects, e.g. the need for separate structures within the company or the competence of managers to manage ambidexterity, all definitions stress the need to reconcile the contradiction between exploitation and exploration. The most original interpretation of organisational ambidexterity can be found in the work of Harmancioglu et al. (2020), who introduce into this definition the notion of cannibalisation and the willingness to combine existing knowledge by adopting two different organisational cultures in the organisation. Just like Tushman and O'Reilly (1996), they highlight the important role of organisational ambidexterity in creating incremental and radical innovation.

According to Levinthal and March, the fundamental problem facing an organisation is to engage in enough exploitation to ensure its current viability, while devoting enough energy to exploitation to ensure its future viability (Levinthal, March, 1993). Exploration is expressed in experimentation, continuous searching, while exploitation is linked to increasing productivity, achieving short-term goals, implementing innovations. Hence, exploitation and exploitation require different strategies, different organisational structures and operating contexts. Researchers of the topic agree in their view that the ambidextrous organisation faces a trade-off between the appropriate use of existing competences and the exploration of new potential opportunities for organisational development (Garcia-Morales et al., 2007; Alänge, Steiber, 2018; Baškarada, 2016; Juni et al., 2013).

Several forms of organisational ambidexterity can be identified in the existing published works: structural ambidexterity, contextual ambidexterity, sequential ambidexterity, and managerial ambidexterity (Figure 1).
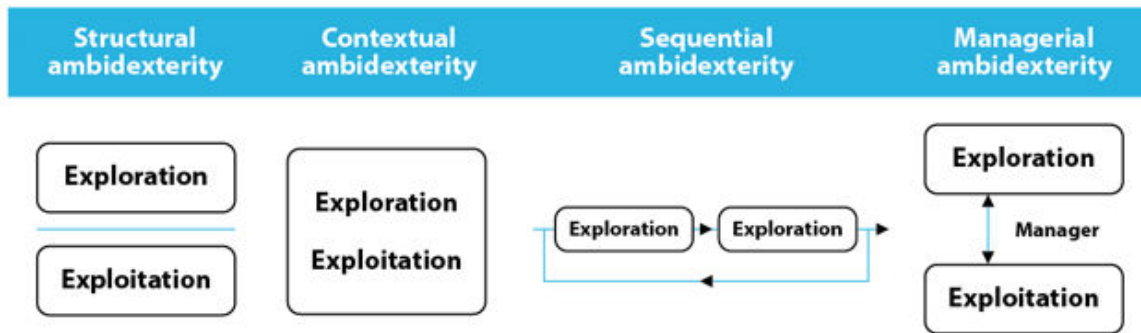


**Figure 1.** Types of organizational ambidexterity.

Source: F. Constant, R. Calvi, T. E. Johnsen, "Managing tensions between exploitative and exploratory innovation through purchasing function ambidexterity", Journal of Purchasing and Supply Chain Management 26 (2020), p. 2.

**Structural ambidexterity** is expressed in the spatial separation of organisational cells within a company that take paradoxical actions (Jansen et al., 2020). In this view, structural ambidexterity can be thought of as a system of dividing the organisation into sub-units, each of which establishes specific attributes in line with the requirements of the external environment (Mahmood, Mubarik, 2020). The author of the article shares the view of Zakrzewska-Bielawska expressed in the statement that their separation is justified by the total dissimilarity of their tasks, but on the other hand, such isolation and lack of direct links between them may cause that the ideas of exploration groups will not be implemented due to the mismatch with the basic exploitation tasks (Zakrzewska-Bielawska, 2015, p. 107).

**Contextual ambidexterity** is based on cultural values and contextual norms (Zakrzewska-Bielawska, 2015; Gibson, Birkinshaw, 2004). The organisational context is defined by the co-occurrence of hard elements, such as discipline and task scope, and soft elements, such as support and trust. This approach assumes that each employee, in his or her daily work, makes a constant trade-off between profit-maximising activities in the short term and activities aimed at better adapting the company to the dynamically changing environment (Zakrzewska-Bielawska, 2015).

**Sequential ambidexterity,** as opposed to structural ambidexterity, introduces a temporal separation perspective to exploitation and exploration activities in the organisation (Good, Michel, 2013). It comes down to the sequence of exploitative and exploratory activities in the enterprise, which do not occur in parallel, but in a sequential manner. Sequential ambidexterity is consistent with the concept of dynamic capabilities of the enterprise (Mahmood, Mubarik, 2020). Due to the constantly changing environment, companies are constantly having to adapt their structures and processes, alternating between longer exploitation periods and exploitation periods (Raisch, Birkinshaw, 2008).

Apart from the types of organisational ambidexterity most frequently described in the literature: structural, contextual, managerial and sequential ambidextrousness, the following types can also be identified in the literature: harmonic, cyclic, split and reciprocal ambidexterity. In the Polish existing published works, these types of ambidextrousness are described in detail by Zakrzewska-Bielawska (2015).

## 3. Methodology of the research

To reach the goal of the article, a systematic literature review was carried out. The author of the article followed the modified methodology posited by Glinska and Siemieniako (2018) consisting of four main stages: 1) defining the scope of the analysis, 2) narrowing down the research scope, 3) bibliometric analysis and 4) key -words co-occurrence analysis (Figure 2).
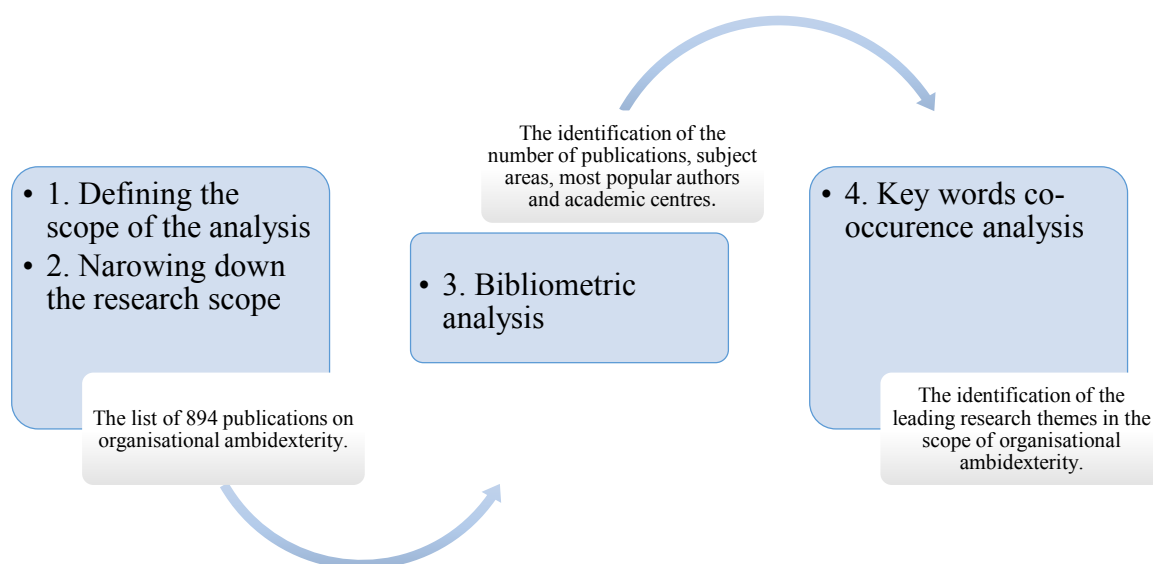


**Figure 2.** Methodology of the research.

Source: own study.

In the first stage of the research process the scope of the analysis was defined. For this purpose, sets of publications were generated in the Scopus scientific database. The criterion for selecting the database for bibliometric analysis was the number of publications in the area of organisational ambidexterity. Compared to other available databases, the Scopus database contained the largest number of publications from this thematic area. The criterion for the selection of publications was the appearance of the word 'ambidexterity' or 'organisational ambidexterity' in the title of the publication, the abstract or in the keywords indicated by the authors.

Next, the thematic scope of the publications was narrowed down to four areas: 1) business, management and accounting, 2) social sciences, 3) decision sciences, and 4) economics, econometrics and finance. The following were included in the analyses: scientific articles, chapters from books and post-conference materials. A total of 894 publications were retrieved from the Scopus database. The query entered into the database took the following form:

( TITLE-ABS-KEY ( ambidexterity ) ) AND ( organisational AND ambidexterity ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) OR LIMIT-TO ( DOCTYPE , "cp" ) OR LIMIT-TO ( DOCTYPE , "ch" ) ) AND ( LIMIT-TO ( SUBJAREA , "BUSI" ) OR LIMIT-TO ( SUBJAREA , "SOCI" ) OR LIMIT-TO ( SUBJAREA , "DECI" ) OR LIMIT-TO ( SUBJAREA , "ECON" ) ) AND ( LIMIT-TO ( EXACTKEYWORD , "Ambidexterity" ) OR LIMIT-TO ( EXACTKEYWORD , "Organizational Ambidexterity" ) ).

The third stage of the research process concerned bibliometric analysis which allowed to identify the main subject areas of the existing published works in the period 1999-2022, the most active authors and academic centres.

In the last (fourth) stage of the research process, co-occurrence analysis was performed. Co-occurrence analysis of keywords uses the assumption that keywords are an adequate description of the content of a scientific publication (Jurczuk, 2019). It involves identifying the coincidence of researcher-defined terms of interest in relation to publication titles, keyword lists and abstracts. In the existing published works, it is possible to identify publications that refer to the limitations of using this method. These include the omission of word relationships that occur in distinct forms, as well as the creation of a distinct meaning, the context of use of specific terms. As pointed out by Jurczuk (2019), this can be eliminated by defining appropriate glossaries of terms or by seeking expert consultation.

Data visualisation was prepared using VOSviewer software (version 1.6.15), which allows analysis of the frequency of keywords in the analysed dataset and, at the same time, an analysis of their co-occurrence with other keywords (Gudanowska, 2017). This application is particularly useful when working with multi-element datasets (Rollnik-Sadowska, 2019). The programme allows the generation of visualisations in the form of a label view and a density view. The label view form refers to the frequency of occurrence of given elements in the network. It provides information on the frequency of co-occurrences of keywords that are placed on a plane. The frequency of the label in the dataset is visualised by the size and colour of the element. The distance between labels also plays a role in the visualisation. The smaller the distance between labels, the more frequent their co-occurrence in the analysed set. Elements located in the centre of the map, are most frequent in the dataset and have a relationship with a large and more diverse number of other elements. In contrast, the elements located at the edge of the plane on which the visualisation is presented are characterised by a small number of connections with the remaining elements of the map. Moreover, they may even form isolated, unrelated fields (Gudanowska, 2017; Rollnik-Sadowska, 2019). The label view form also makes it possible to distinguish clusters of the most frequently occurring keywords.

These clusters are marked with different colours. A second form of visualisation is the density view, in which clusters of the most frequently occurring elements are colour-coded. In the next section, two types of visualisations are presented.

## 4. Results

Based on the visualisation of the data presented in Figure 3, it can be seen that the number of publications in the field of ambidexterity and organisational ambidexterity is steadily increasing.
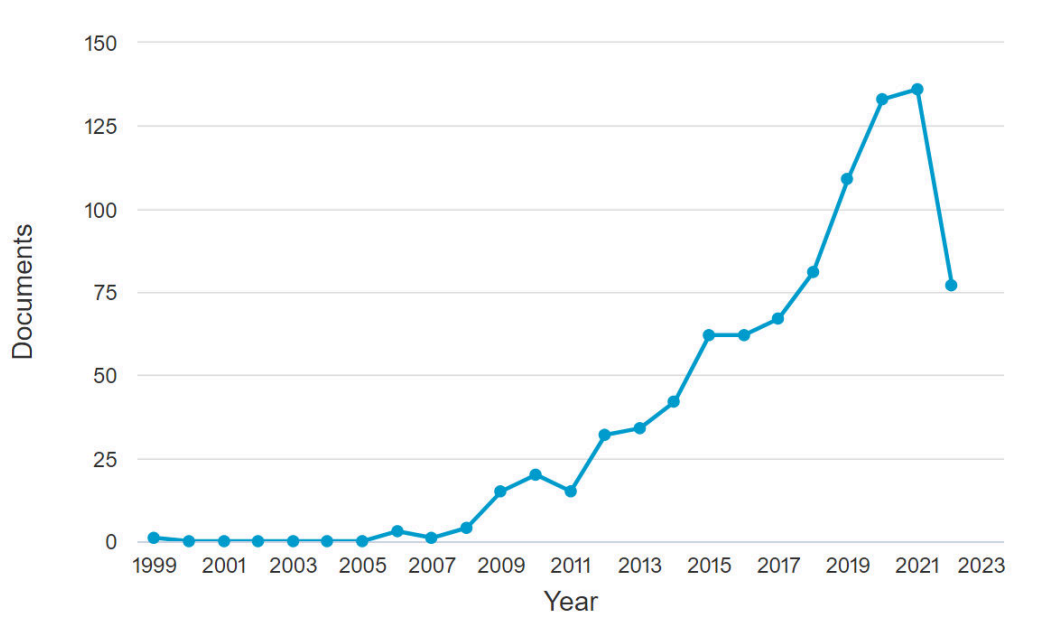


**Figure 3.** The number of ambidexterity and organizational ambidexterity publications from 1999-2022. Source: own study.

To date, the highest numbers of publications have been recorded in 2020 (133 publications) and 2021 (136 publications). The number of publications in 2022 is slightly lower (77 publications) due to the incomplete year of analysis (the bibliometric survey was conducted in June 2022).

Figure 4 shows the main subject areas of publications according to the categories provided by the Scopus database.
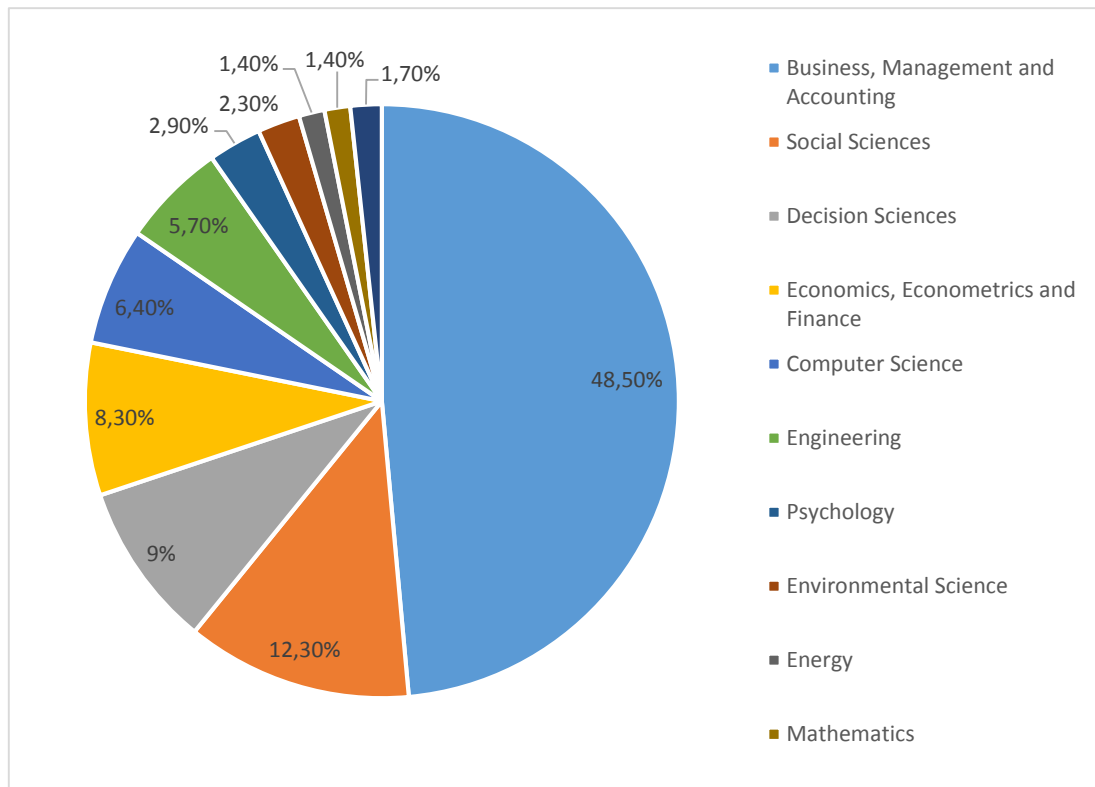
**Figure 4.** Main subject areas of publications on ambidexterity and organizational ambidexterity based on the Scopus database.

Source: own compilation based on data generated from Scopus database.

The analysis confirmed the author's assumption that most research in the field of organisational ambidexterity revolves around management science. Although it is possible to identify publications presenting adaptations to areas such as psychology, computer science or engineering, to name but a few. Almost 50% of the publications are in the subject area of business, management and accounting. 12,30% of the publications are represented by social sciences. Approximately 8-9% of the publications come from decision sciences (9%) and economics, econometrics and finance (8,3%). The remaining subject areas are represented by a low percentage of publications.

The analysis of the data on publications included in the Scopus database also made it possible to identify the leading academics working on the topic of organisational ambidexterity and the most active academic centres in this field (Figure 5).
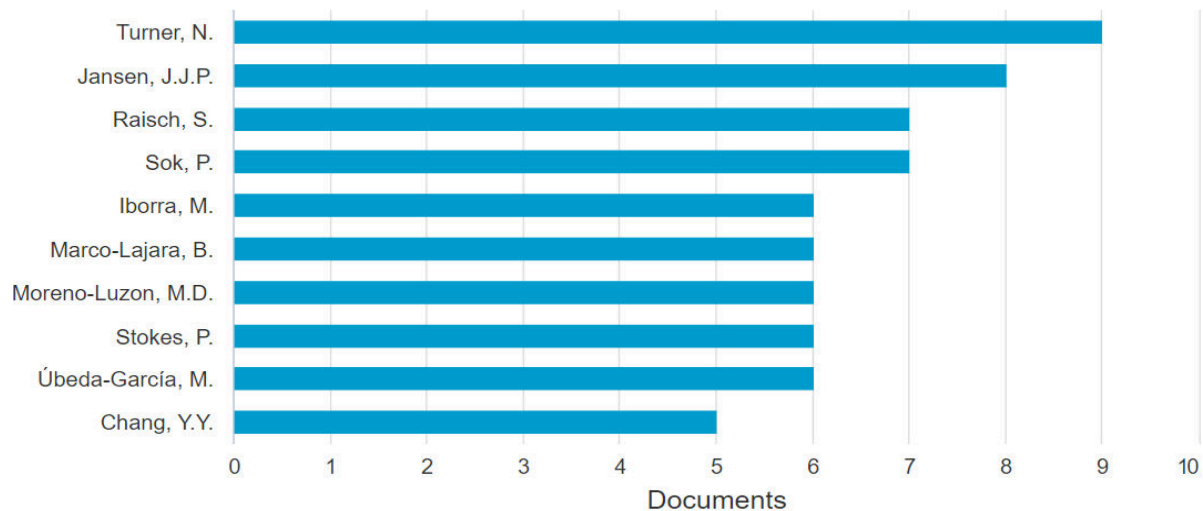
**Figure 5.** The most popular authors dealing with the issue of organizational ambidexterity.

Source: Scopus database.

From the data presented in Figure 5, it can be seen that the largest number of papers on organisational ambidexterity have been written by N. Turner, J.J.P Jansen, S. Raisch and P. Sok. Other active authors writing on organisational ambidexterity are M. Iborra, B. Marco-Lajara, Moreno-Luzon, Stokes Ubeda-Garcia and Chang.V. Savon, P. Stokes and H.W. Volberda.

In turn, the most active academic centres on the topic of ambidextrousness and organisational ambidexterity are presented in Figure 6.
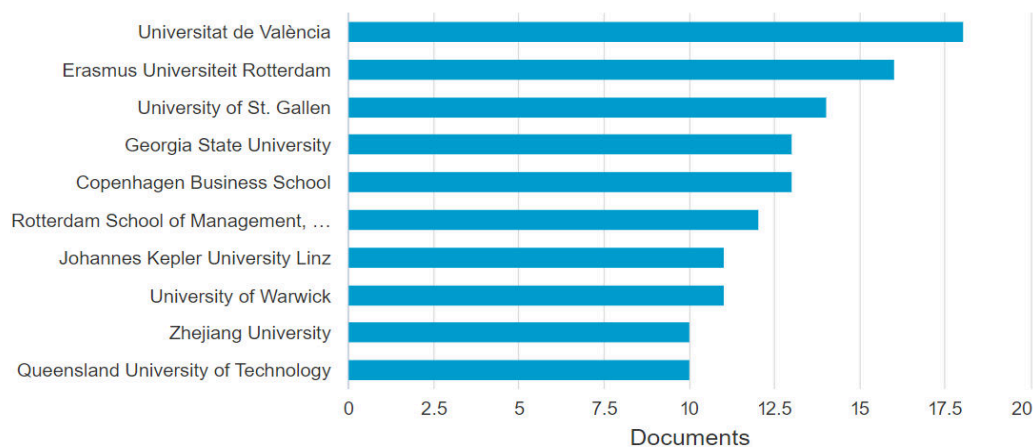


**Figure 6.** The most active academic centres dealing with the issue of organizational ambidexterity.

Source: Scopus database.

Based on the data presented in Figure 5, it can be seen that the largest number of organisational ambidexterity papers were produced at University of Valenzia, Erasmus Universitat Rotterdam and Universitat of St. Gallen.

Taking into account data on the basic description of publications by keywords in the Scopus database from 1999 to 2022, a map was prepared on the co-occurrence of keywords entered by the authors of publications (Figure 7). Using the software, a summary of 2255 keywords was generated based on the uploaded set of publications and a dictionary allowing the combination or deletion of individual terms. In order to ensure transparency of the visualisation, keywords occurring at least nine times in the analysed collection were included. The choice of this form of visualisation of the results obtained, despite the criticism of this approach noted in the literature, is justified by its significant cognitive and utilitarian values (Raan, 2003; Small, 1999; Jurczuk, 2019).

For the purpose of analysing, standardising and visualising the data, the author developed a glossary of terms, in which words or phrases with the same meaning were combined, e.g. exploration and exploitations versus exploration and exploitation, ambidextrous organisations versus ambidextrous organisation, dynamic capabilities versus dynamic capability, and words or phrases that did not seem to be related to the area of organisational ambidexterity such as natural resources exploration or those referring to the geographical area of the analyses, e.g. China, or the nature of the analyses presented in the publications, such as case studies, were removed. In order to obtain transparency and clarity of visualisation, the words constituting search criteria, such as ambidexterity and organisational ambidexterity, were removed from the set of keywords, due to the fact that the entire set of analysed publications refers to relations with the above-mentioned words. A similar approach was used in the work of Gudanowska and Kononiuk (2020). This made it possible to obtain a clear map of the co-occurrence of keywords (Figure 7).
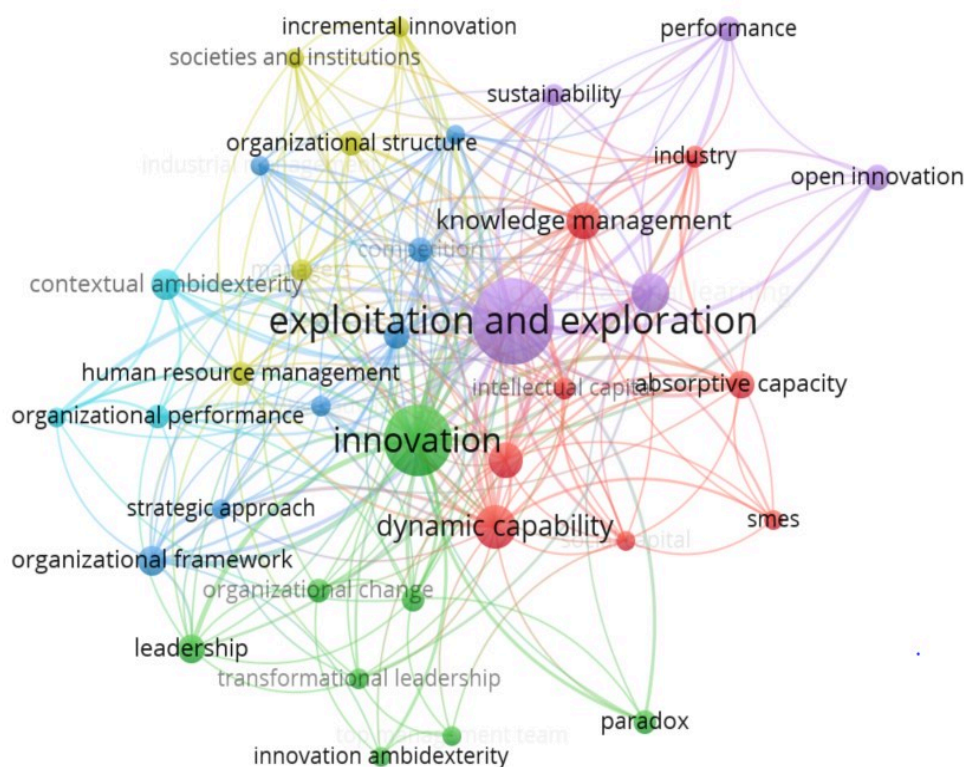
**Figure 7.** Map of co-occurrence of keywords characterising publications in the area of ambidexterity and organisational ambidexterity (by indication of the term in the title, abstract or keywords) in the Scopus database from 1999 to 2022.

Source: own development using VOSviewer software.

In the central part of the map are the most frequently occurring keywords. The frequency of occurrence of a given term is visualised by varying the size of the nodes representing each of the terms that appear, as well as the font size of the node name. Based on the analysis of Figure 7, it can be discerned that the network is quite dense and characterised by numerous connections. The central terms that appeared most frequently co-occurring with the terms: "ambidexterity" and "organisational ambidexterity" were the terms exploitation and exploration (also most frequently co-occurring with the other terms in the network), innovation, and dynamic capabilities. The following phrases also appeared frequently in connection with the context of ambidexterity: organisational learning (35 occurrences), knowledge management (30 occurrences), firm performance (27 occurrences) and contextual ambidexterity (21 occurrences).

The second form of visualisation possible in VOSviewer is the density view, in which clusters of the most frequent elements are colour-coded (Gudanowska, 2015). This is a keyword density map. Each keyword that appears on the map is surrounded by a colour from blue to green to yellow, which indicates the frequency of occurrence of the keyword in the analysed dataset (Eck, Waltman, 2020). Phrases surrounded by yellow represent those most frequently

cited. Density view of keywords characterising publications in the area of ambidexterity and organisational ambidexterity is presented in Figure 8.



**Figure 8.** Density view of keywords characterising publications in the area of ambidexterity and organisational ambidexterity (by indication of the term in the title, abstract or keywords) in the Scopus database from 1999 to 2022.

Source: own development using VOSviewer software.

For keywords relating to ambidexterity and organisational ambidexterity, the most frequently cited words in the dataset analysed are exploitation and exploration, innovation and dynamic capability.

## 5. Discussion

The co-occurrence analysis of keywords was the starting point for confronting the results obtained with the existing published works. Due to the fact that the temporal scope of the organisational ambidexterity bibliometric research carried out by the author of the article, differs from those available in the body of literature, this section identifies the key papers relevant to the cluster and the subject areas of the most recent publications addressing the topics presented in the clusters.

One of the functionalities of the VOSviewer software is to combine the analysed data set into clusters. These clusters are marked with different colours on the map, where each cluster is assigned a different colour. The combination of given phrases in a cluster indicates their most frequent co-occurrence (this does not mean that a phrase does not occur with the phrases from the other clusters, but this happens far less frequently). The map depicted in Figure 7 contains 36 keywords grouped into six clusters.

The first cluster refers to the relationship between organisational ambidexterity and a company's ability to create innovation. It includes terms such as innovation, innovation ambidexterity, leadership, management, organisational change, paradox, top management team, and transformational leaders. The most influential paper presenting the relationship between ambidexterity and innovations was published by He and Won (2004) who investigate how exploration and exploitation can jointly affect company performance in the context of an enterprise approach to innovation of a technological nature. On the basis of 206 manufacturing companies, they demonstrate that the interplay between exploration and exploitation is positively related to sales growth rate. Other important works in this cluster concern the antecedents, outcomes and moderators of organisational ambidexterity (Raish, Birkinshaw, 2008) and balancing exploitation and exploration for sustained performance (Raisch et al., 2009). The newest works in this cluster revolve around microfoundations and specific managerial actions that facilitate the implementation and operation of an ambidextrous strategy (Balarezo, Nielsen, 2022) or antecedents enabling team ambidexterity (Dean, 2022).

The second is a cluster referring to the relationship between organisational ambidexterity and dynamic capabilities, which most often co-occur with terms such as absorptive capacity, firm performance, industry, intellectual capital, knowledge management, small and medium-sized enterprises (smes) and social capital. The most highly cited work in this cluster focuses on ambidexterity as a dynamic capability where authors posit that efficiency and innovations need not to be strategic tradeoffs and emphasize the leading role of highly experienced teams in building dynamic capabilities (O'Reilly, Tushman, 2008). The authors of the newest works treat dynamic capabilities as mediator strengthening the relationship between knowledge absorption and export performance (Hoque et al., 2022) or integrate the theories of transformational leadership, ambidexterity and dynamic capabilities (Karippur, Balaramachandran, 2022).

The third cluster, which includes seven keywords, refers to the perception of organisational ambidexterity as a useful theoretical framework for product development and building competitive advantage. It is formed by concepts such as competition, competitive advantage, industrial management, organisational framework, product development, project management, strategic approach. The most popular work relevant for this cluster concerns presentation of the results of seven leading companies in product design. The authors conclude that managing paradoxes requires "paradoxical management approaches" and that paradoxes "can fuel as well as frustrate innovation" (Andriopolous, Lewis, 2010). More recent publications present the recommendations on how SME could enhance their performance to gain a competitive advantage as well as establish the mediating role of ambidexterity in entrepreneurial value creation (Garousi et al., 2022). A thought-provoking paper in this cluster deals with the issue of achieving organisational ambidexterity in the situation when niches could become constraints by the introduction of a notion of organisational inherited identities (Sirkant, Donovan, 2022).

The fourth cluster, which includes four keywords, refers to the use of organisational ambidexterity as a framework to support human resource management. The cluster includes keywords such as human resource management, managers, organisational structures societies and institutions. Relevant works in this cluster answer the questions if human resource management generates ambidextrous employess for ambidextrous learning (Prieto, Martin-Perez, 2015) , demonstrate an intellectual capital perspective (Turner et al., 2015) or present structural perspective of human resource management to achieve ambidextrous learning (Diaz-Fernandez et al., 2017).

The fifth cluster is centred around the notion of exploitation and exploration, which most often co-occur with terms such as open innovation, organisational learning, performace and sustainability. The works on exploitation and exploration are the most highly cited which is not surprising as they form the theoretical basis for the concept of ambidexterity. The most influential works concern an empirical test of the ambidexterity hypothesis (He, Wong, 2005), deal with the interplay between exploration and exploitation (Gupta et al., 2006) or discuss the antecedents, outcomes and moderators of organizaztional ambidexterity (Raisch, Birkinshaw, 2008).

The last cluster (sixth) refers to publications built around contextual ambidexterity. It is formed by terms such as contextual ambidexterity, organisational context, organisational performance. The theme of contextual ambidexterity is built upon the seminal work of Gibson and Birkinshaw (2004) who demonstrate that a context comprising stretch, discipline, support and trust have a positive impact on contextual ambidexterity.

In order to identify emerging research trends, it also seems important to learn about the latest publications in the area of organisational ambidexterity. The Vosviewer software also allows the creation of visualisations that are dynamic in nature, i.e. that take the time factor into account. This type of visualisation is referred to as overlay visualisation.

The colour of the elements present in this visualisation, is assigned based on the ratings of the element. By default, the colours range from blue (lowest score) to green and yellow (highest score). The visualisation is also accompanied by a legend, which is located in the bottom right-hand corner of the visualisation. In the visualisation presented in Figure 9, the legend refers to the period of most frequent keyword occurrence from 2014 to 2018. By changing the legend to the period 2014-2022, the yellow colour in the figure is lost, hence the most recent research themes are not clearly visible. The colours of the elements on the map are determined by the average publication date of the article (average publication year) in which the keywords occurred.
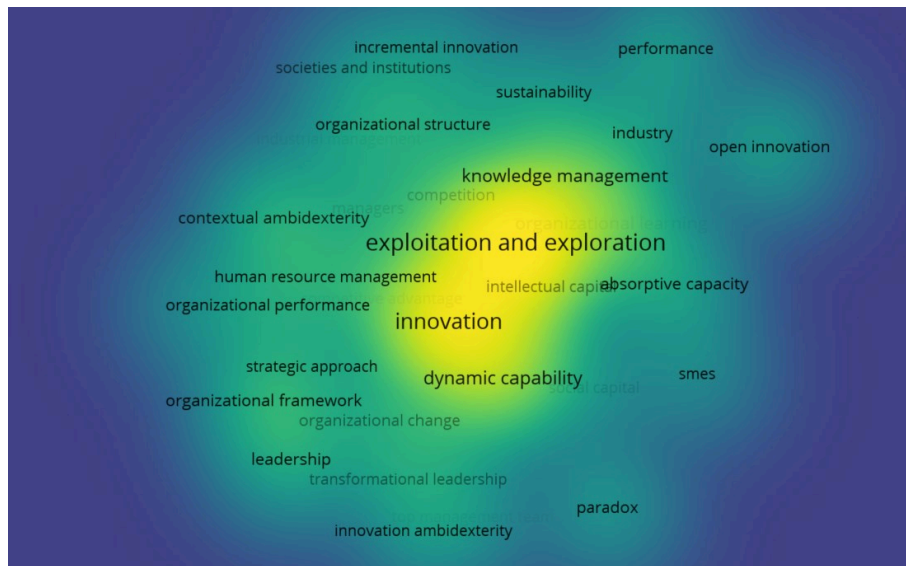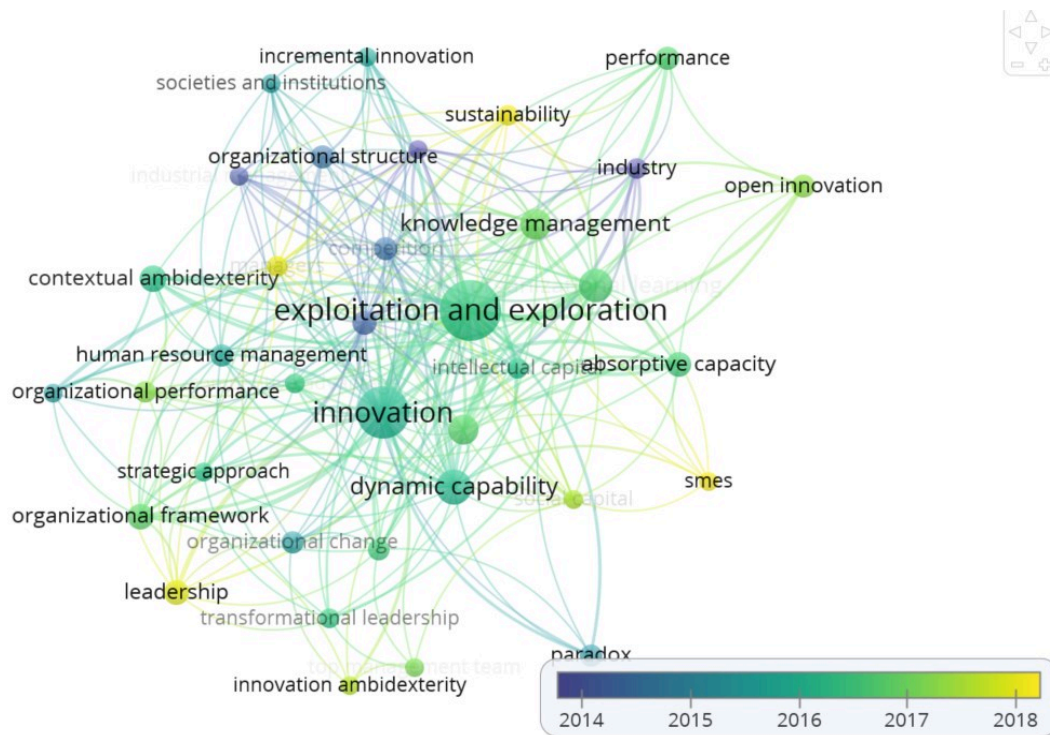
**Figure 9.** Overlay visualisation of keywords characterising publications in the area of ambidexterity and organisational ambidexterity (by indication of the term in the title, abstract or keywords) in the Scopus database from 1999 to 2022.

Source: own development using VOSviewer software.

From an analysis of the data in the chart, it can be seen that the most recent research themes concern balancing ambidexterity in small and medium-sized enterprises (Chang, Hughes, 2012; Soto-Acosta et al., 2018), the role of ambidextrous leadership (Lawrence et al., 2022), sustainability (sustainable sourcing and agility performance (Shan et al., 2022) and managing tensions in sustainable development (Chen, Eweje, 2022).

## Summary

The bibliometric analysis presented in this article provides the main research trends within the subject of organisational ambidexterity and demonstrates progress of the research field. It serves as an orientation and guide for researchers who aim for better understanding of the main progress, promising research concepts and maturity of the field. The analysis of the research themes, the most popular authors and the most active academic research centres as well as the results of co-citation analysis show that the field is still evolving. The application of the VOSviewer software made it possible to distinguish six main research themes built around such terms, concepts and relationships as 1) the relation between ambidexterity and innovation, 2) the relationship between organisational ambidexterity and dynamic capabilities,

3) the perception of organisational ambidexterity as a useful theoretical framework for product development and competitive advantage building, 4) the use of organisational ambidexterity as a framework to support human resource management 5) exploitation and exploration and 6) contextual ambidexterity. The dynamic visualisation obtained in the VOSviewer software has highlighted recent research themes such as the use of organisational ambidexterity in small and medium-sized enterprises or the links between organisational ambidexterity and sustainability. The analysis also revealed a clear trend away from analysing structural and temporal ambidexterity in companies towards attributing more importance to individual ambidexterity and the importance of leadership in balancing those two tensions which may be a future interesting subject of research inquiry and consideration.

A limitation of the study was that it was based on publications from a single database, even though this database contained the largest number of records, therefore it is interesting to analyse comparisons between other databases such as Web of Science or IEEE. In addition, the analysis carried out may be characterised by a low representation of recent influential papers, which were less frequently cited due to their recent publication date.

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# BIOECONOMY DEVELOPMENT LEVEL AT A MACRO SCALE AND FROM A REGIONAL PERSPECTIVE IN POLAND

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**Purpose:** Bioeconomy is a contemporary concept of economic development. It means focusing on increasing economic efficiency through a more extensive use of renewable environmental resources. The implementation of this concept causes structural changes in the economy and consumption at both macro, regional and local levels. The bioeconomy refers to the concept of sustainable development. The level of development of bioeconomy is important in enhancing regional cohesion in terms of economic and social development. The bioeconomy is the subject of both conceptual research and structural decision-making in economic development. The purpose of the article is to present economic diversification in Poland in 2010-2019 in relation to selected aspects of bioeconomy development.

**Design/methodology/approach**: In order to construct the indicator of the level of bioeconomy development in the regions, statistical characteristics were selected and weighted using a formula that favored the characteristics with the highest variability. Then, to illustrate the level of bioeconomy, a synthetic indicator was constructed to divide the regions into three categories: low-development regions, developing regions and developed regions.

**Findings:** The level of bioeconomy development in Polish regions shows great variation in both bioeconomy resources, economic indicators for the bioeconomy and innovation in the production process. Dispersion coefficient of regional level of bioeconomy points to the ongoing processes of regional divergence in the bioeconomy in Poland. Efficiency in the use of available resources, including the degree of renewable energy use and the level of innovation in the regions, was the most important factor in the development of the bioeconomy during the study period.

**Research limitations/implications**: The use of statistical methods should be comprehensive in order to present a picture of the subject of the research from multiple perspectives and the findings regarding other areas. Hence the need to use research methods that take into account the interdependence between different factors affecting socio-economic development both on a national and regional scale.

**Practical implications:** The development of bioeconomy is undoubtedly a factor influencing the socio-economic development of regions. However, it is not the only developmental stimulator. The activities of both national and regional authorities should be diversified, based on supporting various types of economic activity and investing in different branches and industries. A holistic approach to the issue of regional disparities that takes into account the

bioeconomy can lead to a narrowing of the development gap between different regions in the country.

**Social implications:** The development of bioeconomy is an opportunity to improve the quality of life and living conditions for the inhabitants of regions with resource potential and openness to apply new solutions and technologies in this area.

**Originality/value:** An attempt to identify the level of bioeconomy development in dynamic terms and its relationship to the positioning of regions in terms of the level of socio-economic development.

**Keywords:** bioeconomy, regional disparities, green growth, Polish and EU strategic documents.

**Category of the paper:** research paper.

# 1. Introduction

The terms "bioeconomy" and "bio-based economy" are the most commonly and interchangeably used terms in the scientific literature (Krzywonos, Marciszewska, Domiter, Borowiak, 2016: Birner, 2018). In turn, according to the OECD definition, the bioeconomy is the activity of applying biotechnology, bioprocesses and bioproducts to produce sustainable, green and competitive goods and services (Stan i kierunki, 2007). The bioeconomy is also "the activity of applying biotechnology, bioprocesses, and bioproducts to produce goods and services" (Gołębiewski, 2015). The bioeconomy concept represents an economic paradigm shift that has arisen as a result of ongoing environmental changes and the depletion of the planet's resources. The term bioeconomy itself is repeatedly used to classify resources, separate objects or build a new economic model.

Bioeconomy is reflected in the program documents of the European Union and Poland. Therefore, the paper attempts to examine the level of bioeconomy development in regions in Poland. From the point of view of its development, it is important not only to quantify the resources of the bioeconomy, but also the degree of its circularity (i.e. quantification of waste and by-products). In building a circular economy, it is necessary to use bioeconomy technologies, through which the ongoing changes in this sector can be intensified. The article is an attempt to look at the bioeconomy not only in a theoretical way but also in an analytical way. The theoretical part was based on a review of the literature, European Union program documents and Poland's strategic documents. In the practical part, an attempt was made to examine the level of bioeconomy development in 16 regions based on data collected from Statistics Poland. The article provides new knowledge on important factors affecting the development of the bioeconomy.

## 2. Bioeconomy – an overview of concepts and definitions

The issue of sustainable development has long gone beyond scientific considerations (Kot, 2016) and philosophical-ethical concepts. It is the subject of political decision-making stimulating economic and social behavior desirable from the point of view of the goals of this concept. One of the directions complementary to and supporting the implementation of sustainable development is to work towards building the bioeconomy. The concepts of bioeconomy and sustainable development are coherent and mutually reinforcing in the achievement of their objectives. The bioeconomy is a response to problems arising from a growing global population, rapid resource depletion, increasing pressures from environmental hazards, and climate change.

The world population will grow by 30% over the next forty years, i.e. from 7 million in 2020 to over 9 billion in 2050 (European Commission, 2012). Europe, like other geographical areas of the world, is part of a complex environmental, social, economic, cultural and political system. The processes taking place in the European space reflect to a large extent the challenges that the whole world is facing now and will face in the coming future. Europe is confronted with unprecedented and unsustainable exploitation of natural resources, significant and potentially irreversible climate change, a progressive process of biodiversity loss that threatens the stability of ecological and biogenic systems. The occurring adverse changes are intrinsically linked, and overcoming them requires research and innovative solutions to change lifestyles and harness the resources of all sectors of society and economic activity. The actions taken, as well as the results achieved, will support both the implementation of the concept of sustainable development and building the bioeconomy. The term bioeconomy refers to an economy in which biological land and aquaculture resources, as well as wastes, are used as raw materials for food and feed production, and for industrial and energy production. The bioeconomy also means a sustainable and balanced process of transforming renewable biological resources into food products, energy and other industrial goods. It is also defined as an economy that uses resources from the land, sea, and waste, including waste food, as inputs for energy and industrial production.

**Table 1**.
*Selected definitions of bioeconomy*

| Concept/definition | Source |
|---|---|
| "All economic activity derived from scientific and/or research activity focused on understanding mechanisms and processes at the genetic/molecular levels and its application to industrial process" | Enriquez, Martinez, 1998 |
| "The sustainable, eco-efficient transformation of renewable biological resources into food, energy and other industrial products" | DG Research, 2005 |
| "Encompasses the production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy." | En Route, 2007 |
| "Transforming life science knowledge into new, sustainable, eco-efficient and competitive products." | The Bioeconomy, 2009 |

Cont. table 1.

| | |
|---|---|
| "Production models based on biological processes and natural ecosystems using natural materials, which consume minimal amounts of energy without generating waste, as all waste resulting from one process is the material for the next and as a result it is reused in the ecosystem." | EC DG Research, 2011 |
| "Sustainable production and processing of renewable mass into a wide range of food, medicinal, industrial and energy products and services, namely into different biomaterials to be used directly and as raw materials for manufacture of other products." | Europa Bio, 2011 |
| "Based on the use of research and innovation in the biological science to create economic activity and public benefit." | The White House, 2012 |
| "Can be understood as an economy where the basic building blocks for materials, chemicals and energy are derived from renewable biological resources, such as plant and animal sources." | McCormick, 2013 |
| "Is all-encompassing and comprises those parts of the economy that make responsible use of renewable biological resources from the land and water for the mutual benefit of business, society and nature." | Nordic Council of Ministers, 2017 |

Source: the author's own study.

The definitions of bioeconomy presented in table 1 also emphasize biological and biomass resources as important inputs for the development of various economic activities, including industry and food production. In another view, bioeconomy involves the production of renewable biological resources and their subsequent processing into food, feed, bioproducts and bioenergy. The bioeconomy sector includes agriculture, forestry, fisheries, food, wood, paper, and some chemical and bioenergy industries. These activities have a high potential for innovation due to their ability to use the achievements of various fields and disciplines of science (biotechnologies, nanotechnologies, information technology, social sciences, science). The American interpretation of bioeconomy is similar to the European one, however, it places less emphasis on the sustainable development aspect. Bioeconomy is seen as the use of research and innovation in the life sciences to generate social benefits and stimulate economic activity. In the European Union, bioeconomy is understood as the integration of a wide range of natural and renewable biological resources – marine and terrestrial, biodiversity and materials of biological origin (plant, animal and microbial) in the processing and consumption of these resources. Despite the multiplicity of definitions of bioeconomy, in most cases they converge.

Bioeconomy can be seen not only as a new economic theory but also as:

- a paradigm shift in thinking about the management of scarce resources,
- a transformation of a traditional sector into a modern one through the use of modern technologies,
- a new direction in natural science research incorporating an interdisciplinary approach.

Bioeconomy is attracting increasing interest not only in terms of theoretical considerations. It is the subject of taking specific actions in the economic sphere and, what is very important, is the basis for building development strategies in individual countries and regional groupings.

Bioeconomy, like the market economy, is based not only on the efficient allocation of resources but also on their effective use. As such, it needs a new way of managing resources based on sustainability (Inoesu, 2013). It is now the basis of modern economic and social transformation.

## 3. Bioeconomy in the policy documents of the European Union

In February 2012, the European Commission adopted the strategy "Innovating for Sustainable Growth: A Bioeconomy for Europe" strategy. As emphasized, this strategy is not just an additional piece of EU legislation. Its purpose is to guide joint efforts within the EU to support a sustainable and rapidly changing sector of the economy. It is emphasized that a strongly developed bioeconomy sector will be an important factor in stabilizing the functioning as well as the development of Europe under the existing constraints. Now and in the future, when the world's population reaches 9 billion in 2050 and resources will dwindle or will be completely exhausted, Europe will need renewable biological resources, not only for healthy food and feed, but also materials and other natural products and biofuels. The development of bioeconomy, sustainable production and exploitation of natural resources will enable the production of more goods using fewer resources and producing less waste. Implementation of this strategy, as envisioned by the European Commission, will be possible using actions already taken under existing policies, such as the Common Agricultural Policy, the Common Fisheries Policy, and European initiatives such as Horizon 2020, which was launched in 2014. The main objective of the strategy is a more innovative development of low emission economy taking into account the requirements of sustainable agriculture and fisheries, food safety, the use of renewable natural resources for industrial purposes while maintaining biodiversity and respecting environmental principles (Schmid, Padel, Levidow, 2012). The operational plan for the strategy is based on three main lines of action:
- development of new technologies and processes for bioeconomy,
- development of markets and competitiveness in bioeconomy sectors
- lobbying politicians and beneficiaries to integrate actions to develop the bioeconomy.

The development of bioeconomy is expected to to lead to the achievement of the policy objectives of the European Strategy and Operational Plan for the Development of a Sustainable Bioeconomy by 2020. These include:
- strengthening Europe's position as a leader in life sciences,
- optimizing the innovation and knowledge transfer system,
- developing research on the safety and financial accessibility of healthy foods,
- activities for the development of sustainable agriculture and maritime economy,
- increasing the efficiency of agriculture, food and other industries and distribution systems,
- maintaining the competitiveness of European industry and agriculture,
- development of industries with low emissions from coal combustion,
- GHG emissions and waste reduction.

Another important document of the European Union is the Europe 2020 Strategy. The development of bioeconomy has been a key part of its implementation and realization of sustainable and inclusive growth. The development of bioeconomy in Europe will bring many benefits. The most important ones include maintaining and creating conditions for further economic growth, increasing the number of jobs in rural, coastal, and industrial areas, reducing the economy's dependence on traditional energy sources, and increasing the scale of production of basic goods in accordance with the principles of sustainable development. These benefits are mentioned in various program documents of the European Union, therefore the role of the strategy "Innovating for Sustainable Growth: A Bioeconomy for Europe" is to support activities of key importance to many areas of the European Union. The importance of the bioeconomy sector in Europe is very high. In an increasingly difficult environment for sustaining and growing national economies, but also the European Union as a whole, it is an essential element for maintaining a competitive position.

The bioeconomy sector has an annual turnover of €2 trillion and employs more than 22 million people in various sectors. This represents about 9% of the total EU workforce (European Commission, 2012). It is also a strong rationale for taking action to more closely integrate efforts across sectors to increase the potential and efficiency of manufacturing biotechnology-based products. Today, Europe is seen as a leader in many areas of biotechnology and related sciences. However, the U.S. and China are also increasingly interested in the bioeconomy as evidenced by the amounts they are spending on developing biotechnology to build the bioeconomy. Today, the bioeconomy sector is among the most important and largest sectors in the European Union, encompassing agriculture, fisheries, forestry, food and chemical industries. The bioeconomy encompasses the processes of economic growth and employment, two of the most important elements of economic, social, and political stability. The stimulators, constraints, threats and opportunities for the bioeconomy are interrelated and form a complex system. This complicates the ability to lead efforts to develop an advanced bioeconomy. Undoubtedly, the assumptions and policies of the European Union in the implementation of sustainable development principles support the development of bioeconomy. Central to this is the commitment and determination of politicians, policy makers and economic forces to fund and promote innovations that enable the implementation of sustainable development principles as an imperative for the operation and development of an advanced bioeconomy in Europe. This is especially important for the long-term development perspective, which must prevail over short-term economic benefits. Sustainable development and the bioeconomy are inextricably linked both in terms of concepts, policies, actions, and building structures that benefit economies and societies. The above discussion of bioeconomy in Europe can be summarized in the words of J. Potočnik: *The European bio-economy cannot compete on a global level by delivering only basic agricultural commodities. We must look to providing a sound institutional and financial framework, based on a rational consideration of the issues at stake. All participants in the chain – farmers, industry, regulators and consumers – will need to get together to make the bio-economy work* (EC, 2005).

## 4. Bioeconomy in Poland's strategic documents

Although Poland has not developed a separate strategic document for bioeconomy development, actions related to its development have already been included in the National Development Strategy 2007-2015 (Ministry of Regional Development, 2006). The following projects were listed in it:

- raising the technological level of the economy through increased expenditures on research and development as well as innovation,
- development of eco-innovation,
- modernization of fisheries and fish processing,
- promoting and providing financial support for efficient energy generation technologies,
- support for projects related to wastewater treatment, provision of high quality potable water,
- waste management and rehabilitation of degraded areas,
- air protection, protection against noise, vibration,
- supporting the construction of wastewater treatment plants and sewer systems,
- measures limiting the release of harmful substances, including from agriculture, into water,
- implementation of actions reducing emissions of $CO_2$, $SO_2$, NOx and dust from the municipal and household sector and industry, especially from the energy sector, as well as thermal renovation projects.

Current legislation related to bioeconomy development in Poland include:

- Renewable Energy Sources Act (Ustawa o odnawialnych źródłach energii, 2015).
- Strategy for Responsible Development until 2020 (with an outlook to 2030) (Strategia na rzecz Odpowiedzialnego Rozwoju do roku 2020 (z perspektywą do 2030 r.)) (Resolution No. 8 of the Council of Ministers, 2017).
- Sustainable Rural, Agricultural and Fisheries Development Strategy 2030 (Strategia zrównoważonego rozwoju wsi, rolnictwa i rybactwa 2030) (Resolution No. 123 of the Council of Ministers, 2019).
- National Energy and Climate Plan 2021-2030: assumptions and targets and policies and actions (Krajowy plan na rzecz energii i klimatu 2021-2030: założenia i cele oraz polityki i działania).
- National Smart Specialization (Krajowa Inteligentna Specjalizacja – KIS) (https://smart.gov.pl/).

The Act on Renewable Energy Sources sets out not only the rules and conditions for the generation of electricity from: renewable energy sources, agricultural biogas – in renewable energy source installations, bioliquids; but also defines the mechanisms and instruments

supporting them. It contains the definition of: biogas, biomass, biocarbon, geothermal energy, hydropower, renewable energy source. It may seem that the bioeconomy is seen in the context of increasing the use of renewable energy.

The Strategy for Responsible Development until 2020 (with an outlook to 2030) indicates that the bioeconomy is one of three technological revolutions taking place. The importance of using renewable energy sources including geothermal energy and biomass was emphasized.

In the third mentioned document, the following actions related to bioeconomy were indicated in objective 1: striving to maximize the use of waste as raw materials and dissemination of bioeconomy solutions in rural areas, with particular emphasis on the economic use of agricultural waste and waste from agricultural and fish processing, development of innovation and creation of new enterprises specialized in it. It has been pointed out that the bioeconomy encompasses "the production of renewable biological resources and the conversion of these resources and the resulting processing waste into value-added products such as food, feed, bioproducts and bioenergy. An important aspect of bioeconomy development is the potential for rural economic diversification and the creation of new, attractive jobs in these areas".

In the National Energy and Climate Plan 2021–2030 based on the principles of sustainable development, the priorities related to: decarbonizing the economy, increasing the share of renewable energy sources in gross energy consumption, and increasing energy efficiency play a significant role. Biogas and bioenergy from biomass of forestry, agricultural and food origin, as well as from waste management play an important role in their implementation.

In the KIS, the main objective is to *focus investment on research, development and innovation (R&D&I) in areas with the greatest innovative and competitive potential of the country, the development of which will contribute to economic growth and improve the quality of life of society and the state of the environment* (KIS). Reference can be made to the following national specializations that are related to the bioeconomy i.e.:

- KIS 2. Innovative technologies, processes and products of the agrifood as well as forestry and timber sector.
- KIS 3. Biotechnological and chemical specialty chemical processes and products and environmental engineering.

## 5. Research purpose and method

The purpose of the research was to determine the level of bioeconomy development in Poland based on selected diagnostic characteristics in 2010-2019. Development is a complex process and required consideration of many variables in the research conducted. The choice of features was made in a substantive manner, guided also by their relevance to the analyzed phenomenon, unambiguity, logic, as well as their availability and completeness of information

for all regions (Gorzelak, 1979). The study used variables that characterized as much as possible the level of bioeconomy development in the regions. They were divided into three areas (O) i.e.: endogenous resources in the regions, bioeconomy in economic indicators and ongoing innovation processes supporting production processes. Together, they define the level of the bioeconomy. The extent of information that each variable carried was tested using Pearson's correlation coefficient.

In order to construct the indicator of bioeconomy development level in the regions, statistical characteristics in which it did not exceed the value of r = 0.7 were adopted. The selected variables were given weights by means of the formula below, which favors the features with the highest variability, i.e. the ones that differentiate the studied phenomenon the most (Łuniewska, Tarczyński, 2006):

$$w_j = \frac{V_j}{\sum_{j=1}^{m} Vj} \ (j = 1,2,...,m) \tag{1}$$

where:

wj – weight of the *j*-th variable,

Vj – coefficient of variation of the *j*-th diagnostic variable before normalization.

**Table 2**.
*A set of diagnostic variables describing the level of bioeconomy development*

| Areas influencing the level of development of bioeconomy (O) | Explanatory variables | Weights (wj) |
|---|---|---|
| Bioeconomy resources (O$_1$) | Percentage of business entities operating in bioeconomy related sections (sections A, C, D, E) | 0.018 |
| | Share of employed in bioeconomy sectors (sections A, C, D, E) in employment in the economy | 0.035 |
| | Share of the area of organic farms in the agricultural land area (in ha) | 0.161 |
| | Share of gross value of fixed assets in bioeconomy in total economy | 0.025 |
| Bioeconomy in economic indicators (O$_2$) | Reforestation and afforestation (in ha) | 0.125 |
| | Share of gross added value in GDP produced in the bioeconomy sector in gross added value produced in the region (in %) | 0.024 |
| | Share of energy from renewable energy carriers in electricity production [%] | 0.166 |
| | Share of recycled industrial waste in waste generated per year [%] | 0.127 |
| Innovation in the production process (O$_3$) | Percentage of innovative enterprises in industry (in %) | 0.029 |
| | Percentage of innovative enterprises in services (in %) | 0.065 |
| | Outlays on research and development per one employee in the economy (in thousand PLN) | 0.118 |
| | Share of sold production of new and/or significantly improved products in total sales value of products (%) | 0.108 |

Source: own study, Local Data Bank.
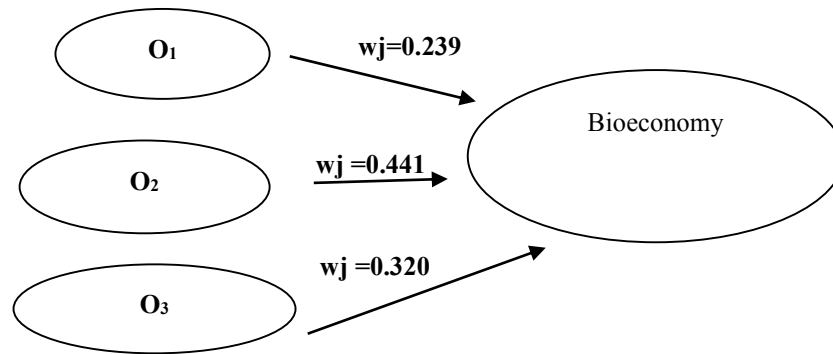
**Figure 1.** The importance of elements influencing the level of bioeconomy development.
Source: the author's own study.

The diagnostic variables were subject to unitarization which ensured the comparability of the various characteristics and eliminated non-additive values from the calculations. All variables were stimulants, therefore, from the point of view of the study conducted, they were normalized according to the following formula:

$$x_{ijt} = \frac{x_{ijt} - \min x_{ijt}}{d} \tag{2}$$

where: d – difference between maximum and minimum of a given variable in the examined time range.

The normalization of the variables carried out in this way allowed for comparability of the indicator of the level of bioeconomy development obtained in the next step. Diagnostic variables were reduced to comparability not only in terms of provinces, but also in terms of the adopted research period. The diagnostic variables presented in Table 1 were used to determine the synthetic indicator of the level of bioeconomy development. The bioeconomy development indicator has been calculated using the following formula:

$$BIO_{rt} = \frac{1}{n} \sum_{j=1}^{n} w_j \, x_{jt} (j = 1, 2, \dots, m)$$

where:
$BIO_{rt}$ – synthetic indicator of the level of bioeconomy development in the voivodeship in year t,
$t$ – designation of years,
$j$ – number of the variable (feature) used to construct the indicator,
$n$ – total number of variables used to construct the indicator,
$x_{ij}$ – value of the "j" feature for the specified "t" year,
$w_i$ – weight given to the "i" feature in the index; $\Sigma w_i = 1$.

This indicator takes values in the range from [0,1]. A value closer to one means that the region is characterized by a high level of the analyzed phenomenon.

Based on the synthetic indicator of bioeconomy development level, the total was divided into 3 groups. First, the synthetic indicator's spread was calculated according to the formula:

$$\text{rozstęp}_t = \text{BIOmax} x_{rt} - \text{BIOmin} x_{rt}$$

$$k_t = \frac{1}{3} d_t$$

The parameter $k_t$ was then determined, according to which the following grouping procedure was applied:

- with a high level of bioeconomy development $\text{BIO}_{rt} \in [\max \text{BIO}_{rt} - k_t, \max \text{BIO}_{rt]}]$,
- with an average level of bioeconomy development, $\text{BIO}_{rt} \in [\max \text{BIO}_{rt} - 2k_t, \max \text{BIO}_{rt} - k_t]$,
- with low levels of bioeconomy development $\text{BIO}_{rt} \in [\max \text{BIO}_{rt} - 3k_t, \max \text{BIO}_{rt} - 2k_t]$.

In the next part of the article, the Pearson correlation coefficient was used to look for the relationship between the indicator of the bioeconomy development level and the level of socio-economic development of the region and GDP per capita. The ready-to-use indicator presented in the article by J. Kot, E. Kraska (Kot, Kraska, 2021) was used for this purpose.

## 6. Results of the conducted research

The ranking positions held by the voivodeships in terms of the areas that make up the synthetic indicator of the level of bioeconomy development are shown in Table 2. In the area of bioeconomy resources, the ratio of its minimum value (in Mazowieckie Voivodeship) to its maximum value (in Zachodniopomorskie Voivodeship) in 2010 was as 1:4.53, while in 2019 – 1:8.67 (Mazowieckie to Warmińsko-Mazurskie). Zachodniopomorskie, Warmińsko-Mazurskie and Lubuskie Voivodeships had the most resources used in bioeconomy related production. The highest economic indicators related to bioeconomy were recorded in Podlaskie, Warmińsko-Mazurskie, Pomorskie, and Kujawsko-Pomorskie Voivodeships. In this area, the ratio of the minimum level to the maximum level in 2010 was as 1:4.16 Zachodniopomorskie: Warmińsko-Mazurskie) and in 2019 – 1:6.08 (Warmińsko-Mazurskie: Pomorskie). In terms of innovation in the production process, the ratio of the minimum level to the maximum level in 2010 was at 1:52 (Lubuskie: Pomorskie), in 2019 it decreased to 1:407 (Świętokrzyskie: Mazowieckie).

**Table 3.**
*Classification of regions in the areas that make up the synthetic indicator of the level of development of the bioeconomy in 2010 and 2019*

| Area/Voivodeships | Bioeconomy resources | | Bioeconomy in economic indicators | | Innovation in the production process | | Synthetic indicator of development level of bioeconomy | |
|---|---|---|---|---|---|---|---|---|
| | 2010 | 2019 | 2010 | 2019 | 2010 | 2019 | 2010 | 2019 |
| DOL | 8 | 10 | 11 | 16 | 8 | 4 | 12 | 12 |
| KUJ | 14 | 13 | 3 | 4 | 7 | 12 | 6 | 9 |
| LBL | 7 | 3 | 9 | 13 | 10 | 9 | 9 | 14 |
| LUB | 3 | 3 | 13 | 9 | 16 | 13 | 10 | 7 |
| ŁDZ | 11 | 11 | 15 | 15 | 12 | 6 | 16 | 16 |
| MAŁ | 9 | 14 | 7 | 5 | 4 | 1 | 5 | 3 |
| MAZ | 16 | 16 | 8 | 14 | 2 | 2 | 8 | 8 |
| OPL | 12 | 8 | 14 | 10 | 13 | 15 | 14 | 15 |
| PDK | 4 | 5 | 5 | 7 | 3 | 5 | 3 | 6 |
| PDL | 5 | 4 | 2 | 2 | 14 | 11 | 4 | 4 |
| POM | 13 | 12 | 4 | 1 | 1 | 3 | 2 | 2 |
| ŚLK | 15 | 15 | 10 | 11 | 5 | 8 | 13 | 11 |
| ŚWK | 6 | 6 | 6 | 8 | 11 | 16 | 7 | 13 |
| WRM | 2 | 1 | 1 | 3 | 9 | 10 | 1 | 1 |
| WLK | 10 | 9 | 12 | 12 | 6 | 7 | 11 | 10 |
| ZACH | 1 | 2 | 16 | 6 | 15 | | 15 | 5 |

Legend: DOL – Dolnośląskie, KUJ – Kujawsko-Pomorskie, LBL – Lubelskie, LUB – Lubuskie, ŁDZ – Łódzkie, MAŁ – Małopolskie, MAZ – Mazowieckie, OPL – Opolskie, PDK – Podkarpackie, PDL – Podlaskie, POM – Pomorskie, ŚLK – Śląskie, ŚWK – Świętokrzyskie, WRM – Warmińsko-Mazurskie, WLK – Wielkopolskie, ZACH – Zachodniopomorskie.

Source: own study, Local Data Bank.

**Table 4.**
*The value of synthetic indicator of bioeconomy development level in 2010-2019*

| Region | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| DOL | 0.279 | 0.261 | 0.293 | 0.274 | 0.218 | 0.204 | 0.177 | 0.177 | 0.218 | 0.212 |
| KUJ | 0.350 | 0.358 | 0.357 | 0.300 | 0.256 | 0.270 | 0.239 | 0.238 | 0.270 | 0.247 |
| LBL | 0.291 | 0.256 | 0.296 | 0.254 | 0.225 | 0.184 | 0.255 | 0.202 | 0.248 | 0.197 |
| LUB | 0.288 | 0.318 | 0.369 | 0.385 | 0.273 | 0.259 | 0.264 | 0.252 | 0.293 | 0.281 |
| ŁDZ | 0.186 | 0.178 | 0.209 | 0.203 | 0.180 | 0.174 | 0.165 | 0.171 | 0.177 | 0.193 |
| MAŁ | 0.351 | 0.350 | 0.356 | 0.346 | 0.323 | 0.303 | 0.339 | 0.301 | 0.344 | 0.350 |
| MAZ | 0.313 | 0.317 | 0.315 | 0.314 | 0.236 | 0.224 | 0.221 | 0.226 | 0.278 | 0.260 |
| OPL | 0.240 | 0.239 | 0.237 | 0.256 | 0.213 | 0.203 | 0.203 | 0.186 | 0.248 | 0.195 |
| PDK | 0.399 | 0.407 | 0.404 | 0.426 | 0.372 | 0.295 | 0.298 | 0.282 | 0.301 | 0.294 |
| PDL | 0.357 | 0.378 | 0.427 | 0.461 | 0.370 | 0.365 | 0.335 | 0.312 | 0.401 | 0.347 |
| POM | 0.428 | 0.447 | 0.461 | 0.399 | 0.368 | 0.314 | 0.373 | 0.334 | 0.390 | 0.389 |
| ŚLK | 0.278 | 0.254 | 0.277 | 0.275 | 0.221 | 0.209 | 0.214 | 0.191 | 0.226 | 0.213 |
| ŚWK | 0.328 | 0.329 | 0.317 | 0.285 | 0.231 | 0.269 | 0.215 | 0.199 | 0.222 | 0.207 |
| WRM | 0.494 | 0.540 | 0.539 | 0.516 | 0.375 | 0.382 | 0.383 | 0.375 | 0.402 | 0.408 |
| WLK | 0.285 | 0.315 | 0.291 | 0.268 | 0.187 | 0.212 | 0.199 | 0.184 | 0.224 | 0.225 |
| ZACH | 0.239 | 0.300 | 0.330 | 0.350 | 0.323 | 0.316 | 0.294 | 0.291 | 0.324 | 0.311 |

Source: as in Table 2.

In 2010, the following voivodeships were included in the regions with a high level of bioeconomy development: Warmińsko-Mazurskie, Pomorskie and Podkarpackie. Regions that represented an average level were: Podlaskie, Mazowieckie, Kujawsko-Pomorskie, Lubelskie, Świętokrzyskie and Małopolskie. Regions with a low level of bioeconomy development

include: Zachodniopomorskie, Lubuskie, Wielkopolskie, Dolnośląskie, Łódzkie, Opolskie, Śląskie (Figure 2). In 2019, the composition of the groups changed. Four regions were classified as having a high level of bioeconomy development: Pomorskie, Warmińsko-Mazurskie, Podlaskie and Małopolskie. The average level of bioeconomy development was observed in three voivodeships: Podkarpackie, Zachodniopomorskie and Lubuskie. The largest group was composed of voivodeships with low levels of bioeconomy development.
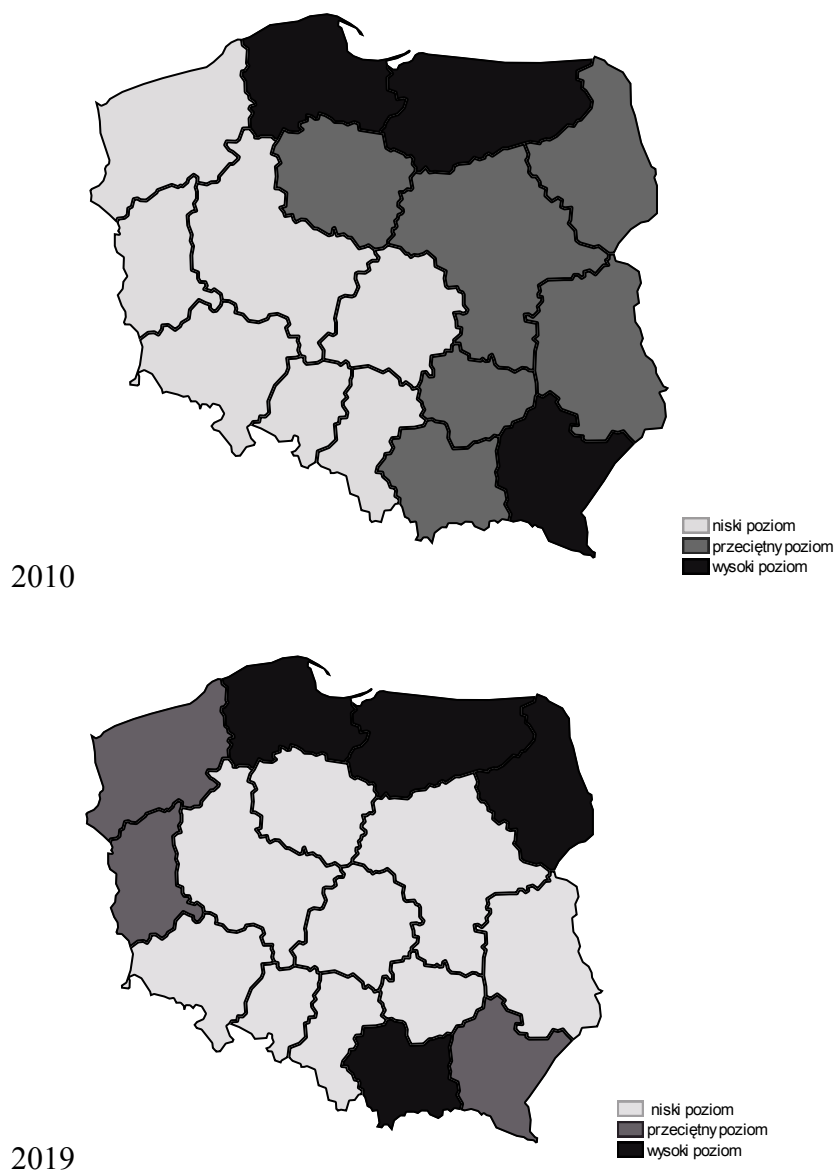


2010



2019

**Figure 2.** The level of bioeconomy development in regions in 2010 and 2019.
Source: the author's own study.

The dispersion coefficient of regional bioeconomy development level in 2010 was at 24.10%, then increased in 2011 to 26.83% (Chart 3). It took its lowest values at around 25% between 2012 and 2015, after which it gradually increased. On this basis, it can be concluded that during the studied period there were processes of regional divergence in the level of bioeconomy development in Poland.
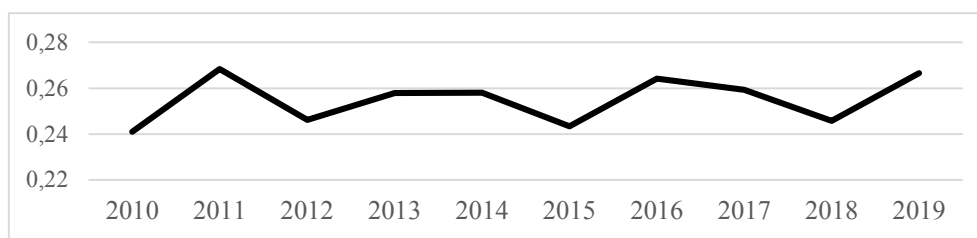
**Figure 3.** Classical analysis of the convergence of the level of bioeconomy development in Poland in 2010-2019.

Source: own development.

The study also examined the relationship between the level of bioeconomy development and: the level of socio-economic development of regions and the level of GDP per capita. The Pearson coefficient of correlation between the level of bioeconomy development and the level of socio-economic development was statistically significant in the following voivodeships: Dolnośląskie, Kujawsko-Pomorskie, Małopolskie, Mazowieckie, Opolskie, Podkarpackie, Pomorskie, Śląskie, Świętokrzyskie, Warmińsko-Mazurskie, Wielkopolskie. Negative correlation in this case means too small a share of bioeconomy in socio-economic development of these regions. The negative Pearson coefficient of correlation between the level of bioeconomy development and the size of GDP per capita should be interpreted similarly. The lack of significant correlation between the level of bioeconomy development and the level of socio-economic development and GDP per capita in the regions indicates that the use of simple statistical methods can lead to incomplete and sometimes erroneous conclusions. The search for other more advanced methods is therefore required.

**Table 5.**
*Correlation of the level of bioeconomy development with the level of socio-economic development and GDP per capita in the region*

| Voivodeship | Level of socio-economic development | PKB per capita |
|---|---|---|
| DOL | -0.796 * | -0.668* |
| KUJ | -0.848* | -0.763* |
| LBL | -0.681 | -0.641 |
| LUB | -0.376 | -0.454 |
| ŁDZ | -0.683 | -0.220 |
| MAŁ | -0.717* | -0.210 |
| MAZ | -0.869* | -0.510 |
| OPL | -0.921* | -0.518 |
| PDK | -0.949* | -0.812* |
| PDL | -0.547 | -0.337 |
| POM | -0.779* | 0.435 |
| ŚLK | -0.935* | -0.711* |
| ŚWK | -0.761* | -0.805* |
| WRM | -0.912* | -0.674* |
| WLK | -0.868* | -0.614* |
| ZACH | 0.080 | 0.219 |

* statistically significant correlation at the adopted significance level of $\alpha = 0.05$.

Source: the author's own study.

The study indicated that the level of bioeconomy development in Polish regions petrified between 2010 and 2019. At the same time, there was an increase in regional variations across the different groups of indicators studied. Regions in the group of the most developed ones in terms of socio-economic development did not have the highest level of bioeconomy development.

## 7. Summary

In view of current climate changes and depletion of the planet's natural resources, humanity is facing new challenges beyond achieving sustainable competitive advantages of particular economic groupings, countries, regions. Protecting the planet's environment and natural resources is a global value. The bioeconomy is a course of action that becomes an instrument in achieving it. The development of bioeconomy has not only an axiological, but also an economic and social dimension. This is reflected in the program documents of the European Union and Poland. Bioeconomy considerations should include not only global, but also national aspects and regional perspectives. With regard to the European Union, the development of the bioeconomy is intended to increase the cohesion of the member countries. However, an equally important issue is the impact of the bioeconomy in reducing interregional disparities within countries. The results of the study indicate that when it comes to Poland, the level of bioeconomy development in individual regions is not related to their classification according to the level of socio-economic growth. Changes in the level of bioeconomy development across regions between 2010 and 2019 were small and indicated increasing disparities. Thus, in Poland, the phenomenon of divergence of regional development in terms of the level of bioeconomy development has occurred. Regions belonging to the group of the most developed in terms of socio-economic development were not characterized by the highest level of bioeconomy development. In light of the research results obtained, it cannot be expected that the development of the bioeconomy in individual regions will lead to a reduction in regional disparities in the short to medium term.

The authors are aware that depending on the measurement methods and variables adopted, a different indicator of the level of development of the bioeconomy can be obtained. The results obtained based on the research conducted with the method used by the authors indicate the low effectiveness of the state's regional policy in reducing interregional disparities. This is evidenced by the deepening dispersion coefficient of the regional level of bioeconomy development over the 2010-2019 period. The study period is long enough for positive trends to emerge in terms of reducing regional disparities that may be the result of influence from both central and local government regional policy actors. The evaluation of interregional and regional policies in light of the research obtained is not positive. It is also significant that the

regions with the highest synthetic level of bioeconomy development in the years studied are not among the regions with the highest level of socioeconomic development. One can conclude from this that the bioeconomy is not a leading factor in the socio-economic development of regions.

Also important is the fact that a group of factors related to renewable resources has the greatest impact on the level of bioeconomy development in the region. This suggests that bioeconomy development policies should focus on measures to support the development of renewable energy and increase the level of recycling (recycled industrial waste).

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# RISK ASSESSMENT OF UNFAVORABLE INTERORGANIZATIONAL RELATIONSHIPS IN CSR PROJECTS CONSIDERING THE LOGISTIC ASPECTS

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**Purpose:** The aim of this paper is to present a new model for risk assessment of unfavorable interorganizational relationships, among other things, in ventures classified as corporate social responsibility (CSR) projects.

**Design/methodology/approach:** Scenario analysis, brainstorm sessions, literature study and own observations of interorganizational projects were used to develop a list of unwanted events and factors determining their occurrence. In the proposed risk assessment model, fault tree analysis and fuzzy logic were applied for qualitative and quantitative risk analysis. Thanks to applying the elements of fuzzy sets theory, it was possible to decrease the uncertainty and lack of precision in obtaining crisp values of the basic events' probability.

**Findings:** In this work 13 basic events and 41 risk factors determining occurrence of unfavorable interorganizational relationships in ventures were identified and described. The proposed model enabled to carry out qualitative and quantitative risk assessment of unfavorable interorganizational relationships projects. Its practical application was shown in an example of interorganizational CSR project concerning the organization of a mass event, considering its logistics aspects.

**Research limitations/implications:** It is necessary to involve experts in risk assessment. This could be overcome by applying machine learning in future research.

**Practical implications:** The application of the proposed model allows to effectively identify the critical risks, which should be of particular attention during the risk treatment stage. It aims to give a helping hand to all managers and practitioners who want to deliver attainable and successful interorganizational projects, supporting meeting the expectation of the engaged stakeholders.

**Social implications:** Socially responsible activities contribute to solving and counteracting social problems.

**Originality/value:** A novel risk assessment model of unfavorable interorganizational relationships in which 13 basic events and 41 risk determinants were considered. The model was presented at ventures classified as Corporate Social Responsibility projects.

# 1. Introduction

Corporate Social Responsibility (CSR), as a derivative of sustainable development (Zinenko et al., 2015b), is a modern way of business management by reflecting business activities for the benefit of society, care for the natural environment and relations with various stakeholder groups (Marakova et al., 2015). Running a business has social and environmental consequences that increase interest in the concepts of sustainable development and CSR (Brundtland, 1987). CSR is a complex and interdisciplinary concept (Sheehy, 2015), therefore it is virtually impossible to indicate one definition that would be acceptable to all researchers (Muñoz-Torres et al., 2018). However, it is recognized that CSR is activities that include the active, voluntary devotion of the company's resources (Kiessling et al., 2016) to the implementation of activities aimed at improving the quality of the environment, solving social problems (Kang, Liu, 2014) and responding to stakeholder expectations, going beyond the mandatory, imposed by law (Doh, Guay, 2006). CSR should include activities related to the needs of stakeholders (Mio et al., 2020), aimed at creating value for them (Goffi et al., 2018). CSR is a kind of consensus between profitability, meeting needs and social expectations (Clough, 2000). CSR activities often relate to goals that were previously within the responsibilities of the state, church institutions, or social organizations. CSR relates to corporate ethics (Carroll, 2010) and should be implemented strategically (Porter, Kramer, 2006).

Business entities increasing often implement prosocial and proenvironmental initiatives not independently, but jointly with other entities. Inter-organizational and intersectoral cooperation are increasing often established (Selsky, Parker, 2005), also in relation to socially responsible activities.Inter-organizational cooperation consists in undertaking mutually compatible and complementary activities of cooperating units that are important from the point of view of jointly defined goals (Phillips et al., 2000).Collaboration is usually undertaken by various entities if they are unable to achieve the assumed goals on their own (Schermerhorn, 1975). By working together, the entities increase their chances of overcoming the encountered difficulties and achieving the desired objectives, as well-planned cooperation provides benefits for all parties (Escher, Brzustewicz, 2020).

When different actors establish relationships, they can achieve joint goals faster and more effectively together, but on the other hand, various kinds of tensions can arise between them. They can take many forms and create challenges that the cooperating entities will have to deal with. Such a challenge may be the emerging communication problems between cooperating entities (Lewis et al., 2010), the lack of relational competences (tendency to trust, credibility,

the ability to create relationships based on cooperation) or the lack of a cooperation strategy that takes into account the risks associated with cooperation (PricewaterhouseCoopers). Therefore, it should not be forgotten that interorganizational cooperation as a part of socially responsible activities is associated with the need to accept a certain level of risk associated with it.

It is also vital to define how risk should be understood. New ISO 31000 (2018) explains risk as the "effect of uncertainty on objectives", which stresses the effect of incomplete knowledge of the adverse events or circumstances on an organization's decision making. However, this deviation can lead to positive, negative or both outcomes (opportunities, threats or both). It is vital that the organizations strive for increasing the probability of achieving objectives, improving the identification of opportunities and potential problems and fruitfully allocate and use resources for risk response. Risk assessment is a process that includes risk identification, risk analysis and risk evaluation (ISO 31000:2018). When identifying the risk, one should identify the sources of risk, predict potential impacts and consequences in various areas of the organization. The purpose of risk identification is to develop a list of possible risk factors based especially on unwanted events that may occur during the implementation of the analyzed project and pose a threat to the achievement of the objectives of a given organization. Risk analysis is the second step in risk assessment. Its purpose is to provide information necessary to carry out the third stage of risk assessment - risk evaluation and to make decisions about risk response. The classic risk analysis should take into account the probability of unwanted events occurrence and their consequences. The risk evaluation is the last step in the assessment and consists of comparing the results of the risk analysis with the benchmarks against which the significance of the risk is assessed. It is performed to determine whether the level of risk is acceptable or unacceptable. This supports decision-making regarding the selection of appropriate risk responses (active or passive risk retention, risk cause or effect reduction, risk transfer, risk elimination). It is vital to ensure the flow of information between the various stages of the risk management process and with the environment at each stage of the process.

Inter-organizational cooperation undertaken to implement socially responsible activities can be a way to spread the risk associated with taking socially responsible activities, but it can also be its source. In (Alawamleh, Popplewell, 2011) the authors identified 13 sources of risk related to cooperation between enterprises There are also studies pointing to the negative effects of interorganizational cooperation (Glinska-Newes et al., 2018) and pointing to the determinants of interorganizational relations and negative attributes of relationship quality, which can potentially be sources of risk related to inter-organizational cooperation (Jelodar, 2016).

The literature describes the role of CSR as a tool helping to reduce business risk (Bouslah et al., 2013) related to potential changes in legal regulations or environmental issues (Husted, 2005) and identifying the risk-management benefit of CSR (Kim et al., 2020). The researchers'

attention was also drawn to the issue of the impact of CSR on the reduction of risk borne by enterprises (Rehman et al., 2020), including systematic risk (McGuire et al., 1988; Albuquerque et al., 2019; Farah et al., 2021) and unsystematic risk (Kim et al., 2020). The studies also show the influence of CSR on the reduction of idiosyncratic risk (Luo, Bhattacharya, 2009). Some studies present the impact of CSR on the risk borne by enterprises through the prism of various areas of CSR (Kim, 2010; Nguyen, Nguyen, 2015). The relationship between CSR and the risk of entities operating in controversial industry sectors (e.g. alcohol, tobacco, gambling) is also examined (Jo, Na, 2012).

There are also works defining the relationship between CSR and risk considered in terms of reputation (Botero, 2015; Minor, Morgan, 2011), operational (Frederiksen, 2018) or environmental, social and governmental. CSR is examined as a kind of insurance against risk (Peloza, 2006), financial (Mishra, Modi, 2013; Viviani et al., 2019) – including the marginal cost of debt (Kordasachia, 2021). Some perceive CSR as a risk of wasting company resources (Jensen, Meckling, 1976; Barnea, Rubin, 2010).

There are few studies exploring the issue of risk related to socially responsible activities carried out as part of interorganizational cooperation. In the author's previous work (Krechowicz, 2022) some important relationship-specific risks and risk determinants which threaten to achieve the intended effect of interorganizational cooperation of engineering companies were identified. However, this research was limited to engineering companies. In another author's previous work (Krechowicz, Kiliańska, 2021) two-parametric risk and opportunity matrixes dedicated to risk/opportunity assessment in organizations carrying out of CSR ventures during the COVID-19 pandemic were presented. Risk and opportunities were assessed in four categories: significance, operational, reputational, financial, safety and legal liability. However, this research was dedicated for specific CSR ventures carried out during COVID-19 pandemic and did not take into account the specificity of inter-organizational cooperation.

Therefore, there is a research gap in the literature in relation to the issue of measuring the level of risk for CSR initiatives implemented under interorganizational cooperation. Due to the growing popularity of interorganizational cooperation established to implement socially responsible activities, a model for assessing the associated risk should be created. A model should be developed that can be used to determine the level of risk of initiatives that fit into the concept of corporate social responsibility, implemented by at least two entities. Risk assessment will allow you to protect yourself against undesirable consequences resulting from such cooperation and maximize the chances of obtaining the benefits associated with it.

This paper is an attempt to fill the identified research gap, thanks to the exploration of this issue, it provides information on the risk factors that must be taken into account by enterprises jointly implementing socially responsible activities.

The aim of this paper is to present a new model for risk assessment of unfavorable interorganizational relationships, among other things, at ventures classified as CSR projects.

In this model, Fault Tree Analysis (FTA) and fuzzy logic were applied for qualitative and quantitative risk analysis. Thanks to applying the elements of fuzzy sets theory, it was possible to decrease the uncertainty and lack of precision in obtaining crisp values of the basic events' probability.

Contribution to the body of knowledge of this paper is as follows:

- identification and description of unwanted events that are important for inter-organizational cooperation related to CSR projects,

- identification of risk factors that are important for inter-organizational cooperation related to CSR projects,

- developing a mathematical model of risk assessment using fuzzy logic and FTA, dedicated to inter-organizational cooperation related to CSR projects,

- presentation of an example of implementation of the proposed model,

- showing how various risks related to the implementation of inter-organizational projects may threaten the achievement of the overarching goal of mass event logistics, namely ensuring an appropriate level of safety and satisfaction of participants and support for organizational entities.

## 2. Methods

There are many methods that can be applied in risk assessment models, e.g. risk estimation matrixes (Rak, Tchórzewska-Cieślak, 2006), fault tree analysis (Gachlou et al., 2020), event tree analysis (Fang et al., 2020). When trying to apply the above-mentioned methods for risk assessment of CSR initiatives, it is necessary to involve expert groups in the risk assessment stage, as there is no adequate historical data to determine the probability distribution for basic events in CSR initiatives. Experts often emphasize that they are not able to give exact values of the probability of the occurrence of particular unwanted events. The solution to this problem is to use the fuzzy sets theory, which was introduced by L. Zadeh (Zadeh, 1965). A characteristic feature of fuzzy sets is the fact that they enable a gradual transition between the various membership degrees of a given element to the set. It is reflected by a membership function which takes values in the real unit interval [0, 1] (Zadeh, 1965). It means that the statement "Element a is a member of Set B" can be true to some degree, called membership degree. It enables gradual transition between the linguistic values (e.g. very low, low, medium, high). Fuzzy sets theory was successfully integrated with various risk assessment methods and applied in risk assessment – e.g. fuzzy risk estimates in (Skorupka, Kuchta, 2016), fuzzy fault tree analysis in (Abdelgawad, Fayek, 2011; Krechowicz, 2017; Shoar et al., 2019; Krechowicz, 2020), hybrid fuzzy fault and event tree analysis in (Krechowicz, 2021). In addition to risk assessment models where it is necessary to involve experts in risk assessment, there are also

some that use machine learning, eliminating the need for experts, e.g. (Hegde, Rokseth, 2020; Krechowicz, Krechowicz, 2021). However, in order to fit this type of model, one should have a large set of training data, and gathering such a set of data is often difficult or even impossible.

Fault Tree Analysis will be used in this wok. Fault Tree (FT) is a graphic representation of certain conditions and factors that cause or favor the occurrence of a specific undesirable event, the so-called peak event. With the application of FTA, both qualitative and quantitative risk analysis can be performed (NASA, 2002). Carrying out logical (qualitative) and numerical (quantitative) analysis of the system using the logical tree method lead to determination of events that may directly cause problem along with the determination of their probability of occurrence, estimation of the system's ability to work after the occurrence of a certain number of less significant problemsand obtaining information needed to locate critical elements and problem mechanisms (PN-EN 61025:2007). Due to the problems with obtaining crisp values of probability for basic events in the fault tree, it was decided to use fuzzy sets theory in this work. It resulted in decreasing the uncertainty and lack of precision in obtaining crisp values of the basic events' probability.

# 3. Proposed model

The proposed approach to risk assessment of not achieving the intended effect of interorganizational cooperation presented in a CSR venture was divided into several steps:
- familiarizing with the specificity of entities planning to cooperate and gathering data,
- risk identification,
- fault tree construction,
- qualitative risk assessment,
- quantitative risk assessment using fuzzy sets theory,
- risk evaluation.

These steps were described in detail below.

## 3.1. Risk identification

In order to identify significant risk factors that may cause failure to achieve the desired effect of interorganizational cooperation, a review of literature describing various aspects of interorganizational relations was carried out. Besides this authors' own observations of interorganizational cooperation and CSR projects and brainstorm sessions carried out among entities dealing with interorganizational CSR projects allowed to identify a number of problems in interorganizational CSR ventures. The relevant risk factors that may lead to failure to achieve the desired effect of interorganizational cooperation were described below.

When entering into cooperation with a particular economic entity, attention should paid to the relations built with it — the greater the extent to which the entity can be treated as a partner, the better it is, focus should also be placed on the communication capabilities, openness to joint problem solving, as well as the reputation of the entity — the better it is, the lower the probability of concealing problems by the entity(McWilliams, Siegel, 2001).Without the ability to properly shape and maintain relations with other entities, it is difficult to achieve high effectiveness of activities being part of the jointly undertaken initiatives. When assessing the ability to shape positive relationships, not only the relationship between a given entity and others with whom it has cooperated in the past can be considered, but also the relationship with stakeholders in general. Attention should be paid to the information that can be obtained from the partners and other cooperating parties of a given entity through various media (e.g. personal interview, Internet, press releases, media reports). To achieve the intended results as efficiently as possible, all entities involved in the process should trust each other and refrain from concealing from each other any relevant information about the problems encountered in carrying out the particular tasks. Concealing problems makes it impossible for other cooperating entities to provide assistance in solving them and, in addition, makes it impossible to create a synergistic effect (Krechowicz, Kiliańska, 2019).

If the entities are reluctant to provide information about their past activities and the projects they carried out, even though they are not asked about confidential matters, the risk related to the lack of transparency in their activities should be taken into account. Transparency of actions is of particular importance in the case of e.g. implementation of socially responsible projects or investment process, where transparency of actions taken introduces order, while at the same time building trust among cooperating entities (Ellonen, Blomqvist, 2008; Lee, H., Lee S.H., 2019). With regard to entities with which cooperation is intended to be established, the rules applied by them concerning the provision of information on their activities and the scope, accuracy and detail of the information and data made available should be assessed, as well as whether these entities allow access to documents and reports relating to previously implemented projects. Additional risks of collaboration relate to knowledge leakage and the possible misappropriation of the created value (Nyaga et al., 2010). Moreover noteworthy are opinions on the activities of entities with which it is intended to undertake cooperation obtained from entities that cooperated with them in the past or cooperate with them now. Such opinions, provided that they are verifiable, can be a valuable source of information that will facilitate the decision whether or not to cooperate with the entity concerned. Coherence of actions of all entities cooperating with each other may be ensured through efficient communication processes occurring between them (using formal and informal communication channels (Pupovac, Moeman, 2017). Problems with communication between parties translate into the quality of relations between them, as well as into lower effectiveness of activities and effectiveness of interorganizational cooperation.

Any economic entity intending to enter into interorganizational cooperation should pay attention to whether it can easily communicate with the other entity. If difficulties in communicating arise at the stage of preliminary discussions on cooperation, the risk that they may also occur during potential joint implementation of projects has to be taken into account (Krechowicz, Kiliańska, 2019).

A very important aspect of interorganizational cooperation is the shaping of the cooperation environment, which will be conducive to the development of common solutions for the implemented tasks. This requires a flexible approach to finding alternative solutions to emerging problems (Chebbi et al., 2006) and being open to consider different points of view and positions of the various entities involved in cooperation. It should be stressed that a dogmatic cooperation environment may cause the omission of valuable solutions that could effectively lead to the achievement of the intended objectives of cooperation. A conservative approach to problem-solving is not conducive to achieving the intended objectives and achieving assumed cooperation results. If the cooperating entities are unable or, for some reason, unwilling to use new, not previously applied solutions and ideas, they limit the range of possible actions that lead to the success of organizational cooperation, understood as achieving desired goals and results. The turbulent environment in which business entities operate forces flexibility of actions, therefore, not being open to new solutions results in a potential decrease in the efficiency of interorganizational cooperation. The flexibility of the entity with which it is intended to cooperate, the degree of bureaucratization of actions should be examined, as this translates into the possibility of using unconventional ideas, solutions and determines the effectiveness of action (Krechowicz, Kiliańska, 2019).

Entities considering joint initiatives should be willing to cooperate. At the initial stage of project planning, the following factors can be assessed the level of motivation of employees who are to be directly involved in the project, openness to suggestions and proposed solutions. If a given entity has participated in other projects as part of interorganizational cooperation, it is possible to assess the conscientiousness of performing the entrusted tasks — the more conscientious the entity is, the higher the likelihood of it being willing to cooperate in subsequent projects (Krechowicz, Kiliańska, 2019).

As part of interorganizational cooperation, each entity involved in the implementation of joint ventures should strive for the most effective use of resources to achieve the intended goals. Any act that puts the welfare of one of the entities above that of all the entities involved in interorganizational cooperation is undesirable. When assessing this factor in the presented model, it is necessary to take into account how the given entity engaged its resources in projects implemented in cooperation with other economic entities. If an entity has sought to use its own resources and those of other entities involved in the cooperation in such a way as to obtain the best possible individual benefits, it can be assumed that they will do the same in the next project. The more developed the culture of individualism in a given entity, the greater the risk that by undertaking cooperation with said entity, it will be difficult to achieve common goals due to

the prioritization of own, individual benefit over collective goals (Krechowicz, Kiliańska, 2019).

Despite the very precise definition of the objectives and resources needed to achieve them, each of the cooperating entities may use these resources in a slightly different way or achieve the same objectives using different methods. In order to avoid such discrepancies and to give a single direction to the actions taken, coordination mechanisms should be developed jointly. The coordinator should prevent different entities from carrying out the same activities at the same time in order to avoid wasting material resources, time and energy. It is safe to say that the coordinator, by providing a clear framework and guidelines for action, harmonizes the efforts of the autonomous entities. Before selecting a coordinator, the candidates for this function should be assessed. The assessment may cover not only the knowledge concerning project management, their competencies or skills, but also the ability to approach problems and actions in a holistic manner (Krechowicz, Kiliańska, 2019).

Modern economic entities are linked by various types of relationships, both vertical and horizontal. Sometimes these links can be a significant obstacle to interorganizational cooperation, making it difficult to clearly identify the organizational affiliation of employees. Lower level employees and managers may at the same time have employment contracts with more than one economic entity, which may give rise to problems of different specificity. In the event of a desire to establish interorganizational cooperation, it should be assessed whether the personal relationship between employees of different entities will not hinder effective cooperation or whether there is no conflict of interest between the parties. Transforming business problems into personal problems and vice versa may adversely affect the process of cooperation, therefore the risk of such problems occurring should be eliminated as far as possible (Krechowicz, Kiliańska, 2019).

Experience in interorganizational cooperation may refer to mutual knowledge of the specifics and modes of operation of particular entities cooperating with each other, as well as to the ability to work out such rules of cooperation that will enable the multi-entity implementation of tasks (Czakon, 2007). The less experience the parties have, the greater the risk. When assessing experience, the number of projects (similar to those that could potentially be the subject of cooperation) in which the economic entity concerned participated, the obligations assigned to it by the project and, where possible, the extent to which those obligations have been met should be considered.

Uneven involvement of the parties during inter-organizational cooperation means that one should take into account the risk of crisis situations resulting from unforeseen events, a surprising turn of events, or the behavior of entities with whom relationships are established during the performance of tasks. Crisis situations require the ability to react quickly to them, modify behavior and introduce changes quickly. The capacity of the entity with which cooperation on crisis response is being considered should be assessed. Consideration should also be given to whether the entity is constantly improving the competences of its employees

(who will potentially be involved in interorganizational cooperation) and whether these employees have the ability to think creatively, make rational decisions when faced with stressful situations and in difficult to predict conditions (Rydlewski, 2004). Uneven involvement of the parties may lead to increased tensions and conflict situations. However, it is possible to assess its involvement in past projects. It is therefore necessary to collect as much information as possible on the progress of similar projects carried out and to pay particular attention to the level of commitment of a particular economic entity. It can be assumed that the higher the number of projects, the lower the level of involvement of the entity in each of them. The reason for this is that tangible and intangible assets are limited and, where different undertakings are carried out simultaneously, they must be divided between all of them (Krechowicz, Kiliańska, 2019).

Through consultations, a decision-making model should be developed which will relate to the precisely defined goals that the cooperating entities want to achieve, the development of an action plan and assignment of decision-makers. Entities wanting to carry out joint tasks should assess the mutual ability to balance the interests of all the entities involved in the cooperation, so that no decision is taken against them, to collect the information needed to take the most rational decision possible, to analyze such information and to take account of the limitations of the cooperation agreement. The risk of failure to achieve the intended effect of the cooperation may arise from an agreement if its provisions are inadequate. A well-formulated agreement should be unambiguous for each of the parties to whom it is binding. All provisions contained in the agreement should be clearly specified so as to eliminate the possibility of different interpretations of individual provisions contained in the agreement by entities cooperating with each other (Lange et al., 2015). The vague framework of accountability, both with regard to the entities involved and to the individual cooperation activities undertaken, entails a risk (Xu, Beamon, 2006) of reducing the efficiency and effectiveness of the cooperation activities. When analyzing the framework of accountability, particular attention should be paid to whether entities wishing to establish cooperation have clearly and unequivocally divided responsibility for the results achieved (Aulakh et al., 1996).

Problems can largely be avoided if entities decide to develop a strategy prior to the commencement of interorganizational cooperation. The document may include not only clearly formulated objectives, which entities want to achieve through the interorganizational cooperation, but also the resources, methods and means to achieve them. Lack of a strategy may result in all activities undertaken as part of interorganizational cooperation being done in an intuitive manner and not supported by prior analysis, critical assessment of potential alternative options for action. Moreover, without said strategy, it is difficult to monitor progress and therefore to react quickly enough to problems identified. The lack of a strategy results in an increase in the risk of inefficient use of resources, the need to devote more time to solving emerging problems, which in turn leads to a decrease in the efficiency of the actions taken.

Table 1 presents the identified unwanted events and risk factors determining their risk levels. They were identified based on the literature study, authors' observations of interorganizational cooperation and CSR projects and brainstorm sessions carried out among entities dealing with interorganizational CSR projects. These events are basic events in the fault tree, which was presented in the subsection 3.2. Basic event is the indivisible event on the lowest level in a fault tree branch.

**Table 1.**
*Basic events and factors determining risk levels for particular unwanted events*

| Event symbol | Event name | Factors determining the risk level |
|---|---|---|
| F1 | Hiding problems | - unfavorable financial condition of one of the entities<br>- information in the media about the entity's dishonesty,<br>- hidden lack of competence, insufficient level of competence,<br>- hidden lack of experience in implementing projects of a given type,<br>- the attitude of the entity visible already during the initial talks, ambiguities as to the entity's intention to establish cooperation (it declares cooperation for a given reason, but its goal is something else, e.g. gaining knowledge about the cooperator in order to destroy it on the market). |
| F2 | Self-interest orientation | - contractual regulations, form of cooperation (partnership, cooperation, coordination of activities, consortium cooperation),<br>- the discrepancy between the intentions declared in the contract and the actual ones (whether in the case of disputable issues, apparently clear provisions in the contract will be interpreted in the same way),<br>- is the interest common, or can each entity focus more on achieving its own goals. |
| F3 | Communication problems, problems with listening to each other | - lack of experience in projects implemented in cooperation, in partnership, in cooperation, consortia,<br>- market / objectively unjustified belief in the rightness of one's own actions,<br>- reluctance to share information,<br>- the method of organizing the communication process between the entities (efficiency of message transmission, their completeness, information transmission channels - official/credible, informal/formal). |
| F4 | Lack of willingness to cooperate and engagement of the parties | - history of the company's/ entity's cooperation with others,<br>- no recommendations from previous partners. |
| F5 | Confrontational, dogmatic environment of cooperation | - form of ownership of the enterprise (private enterprises, sole proprietorship, etc.),<br>- lack of international experience,<br>- the nature of the entity (number of levels necessary to pass in order to make and formalize a decision),<br>- "outdated" styles of organization management (derived from centralized economic systems),<br>- the nature of the entity (number of levels necessary to pass in order to make and formalize a decision). |
| F6 | Good project coordinator missing | - lack of awareness of the need to appoint a coordinator,<br>- improper definition of the role of the coordinator,<br>- staff weakness of entities participating in the cooperation,<br>- lack of experience of the selected coordinator in multi-agency projects. |

Cont. table 1.

| | | |
|---|---|---|
| F7 | Converting work problems into personal problems and vice versa | - personal and property ties between entities willing to cooperate. |
| F8 | Inability to build beneficial relationships as part of cooperation | - opinions about the entity in the environment, <br> - previous experience in cooperation. |
| F9 | Inability to react quickly to crisis situations | -lack of internal procedures for responding to crisis situations, <br> - inability to define potential threats to the project or overly optimistic approach to project implementation. |
| F10 | Imprecise and unfavorable contract | - lack of proper right handling, <br> - work carried out carelessly and at a rapid pace, <br> - one party's use of the other party's inexperience (disproportionate contractual penalties), <br> - inability to apply contractual standards to a given cooperation (there are contractual standards, but entities begin to rewrite them, that an imprecise contract is created, e.g. a consortium contract template). |
| F11 | Unclear way to make decisions | - whether the person(s) responsible for approving the decisions have been identified, <br> - whether a decision-making model has been developed, <br> - whether the decision-making model was developed through joint consultations of the entities cooperating with each other. |
| F12 | Unclearliabilities and responsibility framework | - whether the responsibilities have been clarified and written, <br> - whether all parties confirmed that they understand the provisions, <br> - whether all parties clearly defined their expectations. |
| F13 | Lack of prepared action strategy | - no time to prepare a strategy, <br> - no possibility to use previous, already existing strategies, <br> - lack of awareness and skills of strategic thinking, ad hoc in running a business. |

## 3.2. Fault tree construction

Fault tree was developed in a vertical format, so the peak event was placed on the top of the page. The 4 intermediate events were further divided into 13 the basic events on the bottom of the page. The peak event was fully defined as not achieving the intended benefit of interorganizational cooperation in a CSR venture. Basic events were divided into 4 categories, which are intermediate events in the Fault Tree: trust issues, problems with teamwork, problems with work progress, problems with the strategy of operation. The 13 identified basic events were shown in Table 1. The proposed fault tree is presented in figure 1.
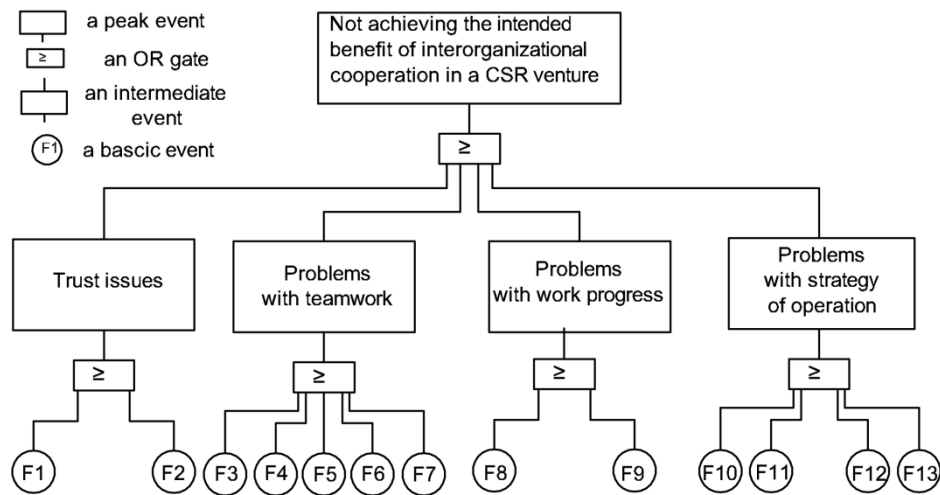
**Figure 1.** The proposed fault tree for not achieving the intended benefit of interorganizational cooperation in CSR ventures.

### 3.3. Qualitative risk assessment

Looking at Fault Tree structure it can be seen that it has only OR gates and identical events are not placed on separate FT branches. That is why, a simple methodology of general tree studies was applied to the qualitative risk analysis. Looking at the structure of the fault tree, it can be noticed that any of the 13 basic events' occurrence is sufficient to cause the peak event occurrence.

### 3.4. Quantitative risk assessment using fuzzy sets theory

A carefully selected group of experts should be asked to assign one linguistic value (very low, low, medium, high, or very high) to each of 13 basic events. When selecting the group of experts, particular attention was paid to their experience in risk assessment and the implementation of projects in the field of inter-organizational cooperation and CSR ventures. The group of experts was acquainted with the project details and specifications and familiarized with the proposed risk assessment model.

A membership function should be drawn individually for each group of experts, so that it could best capture the way they understand each linguistic value describing the probability of basic event occurrence (very low, low, medium, high, very high). A group of experts was asked to express the probability of the occurrence of individual basic events using the above-mentioned linguistic values. They then determined the significance of each linguistic value by assigning each fuzzy probability value to the degree of membership that best reflects the significance of the linguistic value represented by the fuzzy set. The trapezoidal membership function was used, which is often used to represent linguistic values.

Formula (1) can be used to calculate the risk of the peak event occurrence($\widetilde{R_{tot\alpha_{jk}}}$):

$$\widetilde{R_{tot\alpha_{jk}}} = \left[ 1 - \prod_{i=1}^{n} \left( 1 - \frac{\widetilde{P_{Fi\alpha_{jk}}} \cdot C_{Fi}}{100} \right) \right] \cdot 100\% \tag{1}$$

where:

$\widetilde{P_{Fi_{\alpha_{jk}}}}$ – fuzzy probability of the basic event Fi occurrence,

$\alpha_{jk}$ – jk-th membership degree to the set of fuzzy probabilities defining each linguistic value, $j=0,1,2,...,m-1$,

$m$ – the number of the analyzed membership grades,

$k$ – the step of changes of the membership grades to the fuzzy set, $k=1/(m-1)$,

$C_{Fi}$ – the factor determining consequences of the basic event occurrence $Fi$, -.

In the proposed approach the occurrence of each basic event can result in peak event occurrence, thus is equally important in terms of its effect. Therefore, the factor describing the consequences of a basic event $Fi$ occurrence $C_{Fi} = 1$ for all considered basic events.

Fuzzy probability of the basic event Fi occurrence ($\widetilde{P_{Fi_{\alpha_{jk}}}}$) is read for each analyzed membership grade $\alpha_{jk}$ from the trapezoidal membership function from the left $(\widetilde{P_{Fi_{a\alpha_{jk}}}})$ and right side $(\widetilde{P_{Fi_{d\alpha_{jk}}}})$.

From the membership function, the extreme values of the fuzzy probability for individual basic events for the values of α are read with the step k between each α. By substituting different values of fuzzy probability into the formula (1) for different degrees of membership α, one can calculate the fuzzy risk of a peak event for successive degrees of membership α. Based on the performed calculations, it is possible to draw a graph of the fuzzy risk distribution of a peak event for the analyzed CSR venture.

In order to select the appropriate risk of a peak event based on the fuzzy set, a defuzzification process was performed using the Center of Area (COA) method. The process of defuzzification is an operation consisting in determining the crisp (non-fuzzy) value of risk, which will represent a given set in the most "sensible" way.

The risk of a peak event is calculated from the formula (2):

$$R_t^{COA} = 0.5 \cdot \left( \frac{\sum_{j=0}^{m} \widetilde{R_{ta\alpha_{jk}}} \cdot \alpha_{jk}}{\sum_{j=0}^{m} \alpha_{jk}} + \frac{\sum_{j=0}^{m} \widetilde{R_{td\alpha_{jk}}} \cdot \alpha_{jk}}{\sum_{j=0}^{m} \alpha_{jk}} \right) \tag{2}$$

where:

$R_t^{COA}$ – the defuzzified value of the risk of the peak event occurrence (%),

$\widetilde{R_{ta\alpha_{jk}}}$ – the extreme (read from the left side) values of the peak event risk for jk-th membership grade (%),

$\widetilde{R_{td\alpha_{jk}}}$ – the extreme (read from the right side) values of the peak event risk for jk-th membership grade (%).

### 3.5. Risk evaluation

In order to determine if the risk level is acceptable or unacceptable it is important to compare the results of the risk analysis with the borderline risk level. Such analysis should be performed for both the individual basic events and the peak event. The borderline risk level should be set individually for each analyzed CSR venture, taking into consideration its specificity, the characteristics of cooperating entities, including technical, economic and legal conditioning.

## 4. Example of the application of the proposed model

The Polish city and the commercial TV station decided to organize a TV concert. Both sides acted for the public good and spent considerable financial resources, not charging money for tickets to the amphitheater for the concert. As a result, 5.5 thousand people (mainly city residents) took part in a high-quality concert for free. The concert took place in an amphitheater and was broadcast live by a TV station. The accountability framework was established from the very beginning. The city was responsible for providing the amphitheater and its technical preparation, and for promoting the event in such a way as to ensure a full amphitheater, and at the same time to avoid situations where the city residents would be frustrated that they could not attend the concert due to the lack of places. This required the development of an efficient ticketing system. The TV station was responsible for providing the artistic program, building the stage, creating the event and its transmission. The city was not prepared to build and launch a ticketing system. The risk was compounded by the fact that the decision to organize the event was made only one month in advance. The TV station had trouble organizing the artists in such a short time. Each side tried to solve its problems on its own. The TV station wanted to have a nice picture of the audience amused in the amphitheater, to get good viewership. There was a kind of buzz and communication crowd, there was a great media impact for this event and many entities became interested in it. The television did not share all the information with the city (e.g. what artists would come), which made it difficult for the city to promote the event. There was also no joint coordinator of the project. On the side of the city, there were no employees with experience in coordinating such projects. Due to the fact that the city is a public entity, it is not able to minimize problems as flexibly as it would like. It is limited by the legal and financial framework as well as the lengthy decision-making process in formal matters. The amphitheater infrastructure itself had experience in organizing such events, but the city had no experience with ticketing.

The TV station was able to react quickly in situ, and the city has experience in responding to emergencies resulting from other events (but of a different type). The city department that was supposed to deal with the event may have treated it as an "unwanted child", since it had

never been involved in such projects before. There was a week of time to work out an agreement between the city and the TV station. It generated costs on both sides, and included contractual penalties for failure to meet obligations. It was an unusual type of contract for a TV station, as it was a contract for one event, and the station was used to concluding long-term contracts with well-known partners. The city also did not have experience in concluding such type of contracts. There was no time to develop a model of how to make decisions, they were made spontaneously.

Figure 2 presents the membership function which was developed for a group of experts assessing basic events' probability of occurrence. Table 2 presents basic events with linguistic values assessing their probability of occurrence.
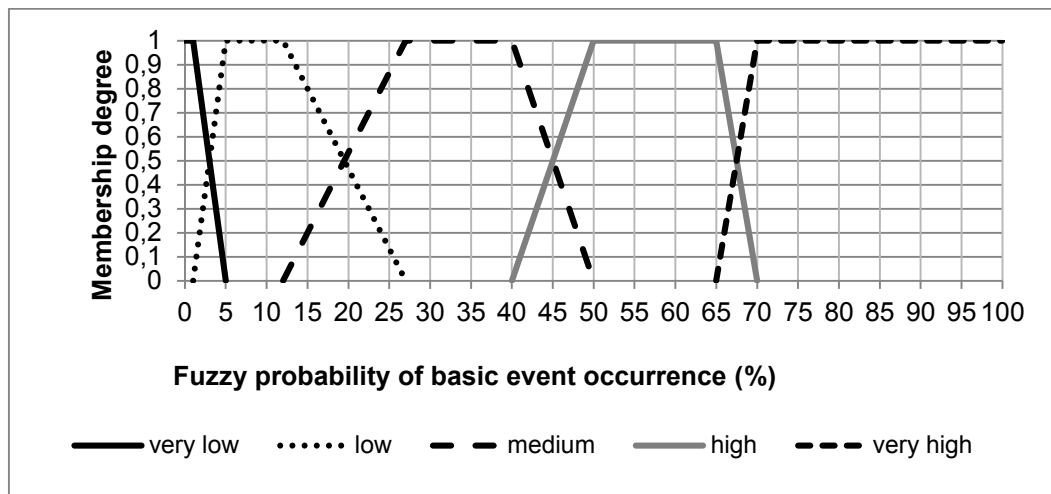


**Figure 2.** The membership function for the probability of the basic events occurrence for the group of experts.

**Table 2.**
*Basic events with linguistic values assessing their probability of occurrence for the analyzed CSR initiative*

| Symbol | Event name | Fuzzy probability |
|--------|------------|-------------------|
| F1 | Hiding problems | High |
| F2 | Self-interest orientation | Low |
| F3 | Communication problems, problems with listening to each other | Low |
| F4 | Lack of willingness to cooperate and engagement of the parties | Very low |
| F5 | Confrontational, dogmatic environment of cooperation | Low |
| F6 | Good project coordinator missing | High |
| F7 | Converting work problems into personal problems and vice versa | Very low |
| F8 | Inability to build beneficial relationships as part of cooperation | Very low |
| F9 | Inability to react quickly to crisis situations | Low |
| F10 | Imprecise and unfavorable contract | High |
| F11 | Unclear way to make decisions | High |
| F12 | Unclear liabilities and responsibility framework | Very low |
| F13 | Lack of prepared action strategy | High |

Table 3 shows fuzzy probabilities of the basic events occurrence for the analyzed CSR initiative. They were read for various membership grades α with step 0,05 from the membership function presented in figure 2. Due to the limited length of the article, only the results for the three selected grades of membership are presented.

**Table 3.**
*Fuzzy probabilities of the basic events occurrence for the analyzed CSR initiative (for α values with the step 0,05)*

| Membership degree ($\alpha_{jk}$) | Fuzzy risk of basic event occurrence (%) | | | | | |
|---|---|---|---|---|---|---|
| | F4, F7, F8, F12 | | F2, F3, F5, F9 | | F1, F6, F10, F11, F13 | |
| | $\widetilde{P_{Fi_{a\alpha_{jk}}}}$ | $\widetilde{P_{Fi_{d\alpha_{jk}}}}$ | $\widetilde{P_{Fi_{a\alpha_{jk}}}}$ | $\widetilde{P_{Fi_{d\alpha_{jk}}}}$ | $\widetilde{P_{Fi_{a\alpha_{jk}}}}$ | $\widetilde{P_{Fi_{d\alpha_{jk}}}}$ |
| 0,00 | 0,00 | 5,00 | 1,00 | 27,00 | 40,00 | 70,00 |
| 0,50 | 0,00 | 3,00 | 3,00 | 19,50 | 45,00 | 67,50 |
| 1,00 | 0,00 | 1,00 | 5,00 | 12,00 | 50,00 | 65,00 |

Knowing fuzzy probabilities of basic events occurrence, risk of the peak event occurrence was calculated from formula (1) for various membership grades. Figure 3 presents the distribution of the fuzzy risk connected with the peak event occurrence. The risk related to the occurrence of the peak event of not achieving the intended effect of inter-organizational cooperation was calculated from the formula (2) and equals $R_t^{COA} = 98{,}10\%$
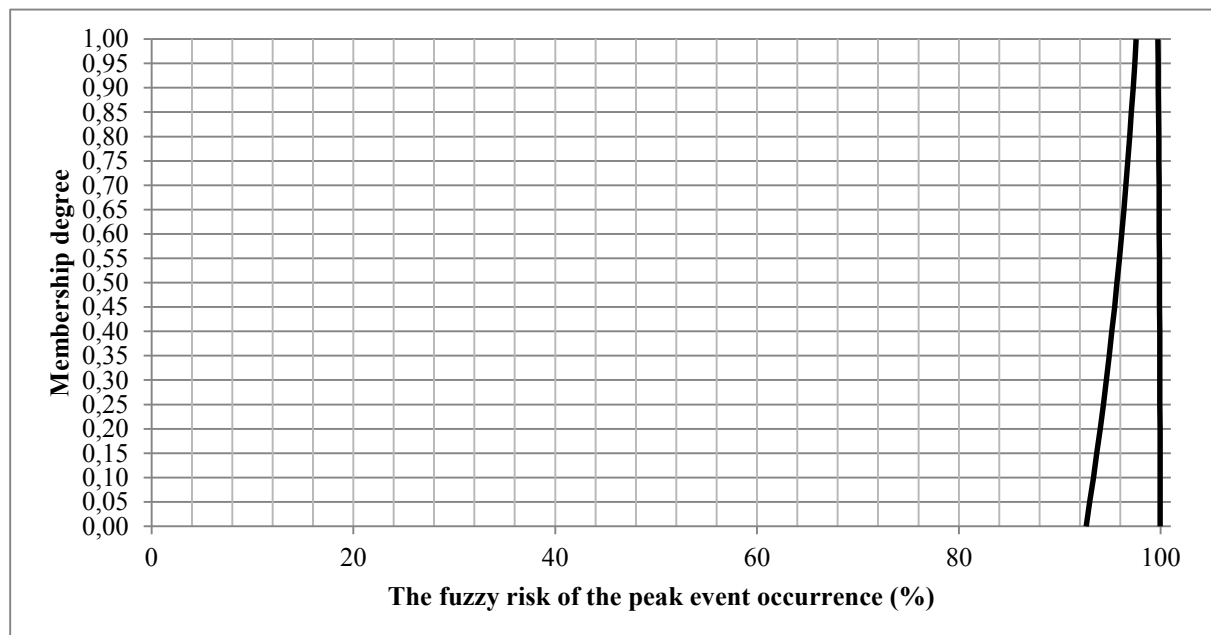


**Figure 3.** Distribution of the fuzzy risk connected with the peak event occurrence.

## 5. Discussion

The project for which the level of risk of a peak event was calculated is interesting because, despite a very high-risk level (98.10%), the project was successfully completed. However, the high level of risk for some of the basic events and the peak event corresponds to the undesirable events that occurred during the implementation of the analyzed joint venture. A number of problems were encountered during the implementation of the project. The problem for the city was the fact that it did not receive information from the TV station about the final line up (artists who will perform). In addition, the slow pace of decision-making by the television station was a problem due to the procedures that existed there, requiring successive levels of approval. The ticket distribution system was prepared by the city ad hoc. As a result, twice as many tickets were distributed as there were seats in the amphitheater. It was also not possible to fully prevent free tickets from being traded for a fee. An hour before the concert it started to rain and as a result a large part of the residents did not come. Finally, all residents that came fit into the amphitheater. Competitive TV stations followed the event. In case of visible problems (e.g. an overcrowded or not fully filled amphitheater) they could use it to publicize problems with organizing the event. In the absence of an audience, competing media could publicize that the event did not attract the attention of the public as a result of, for example, inappropriate selection of artists. In the case of an overcrowded amphitheater, the publicized problems could be related to an ineffective ticketing of the audience and the poor organization of the entire event.

It is also important to discuss how various risks related to the implementation of inter-organizational projects could threaten the achievement of the overarching goal of the analyzed event. Logistics in the organization of mass events mainly concerns planning, organizing and managing the flow of materials, people and information (Płaczek, Jaroszyński, 2012). In the analyzed case, hiding problems, lack of good project coordinator, imprecise and unfavorable contract and lack of prepared action strategy threatened the achievement of the overarching goal of mass event logistics, namely ensuring an adequate level of safety and satisfaction of participants, unabling also the proper support for organizational entities. There were problems with the flow of information causing problems with the promotion of the event, and the flow of people was severely endangered due to the ad hoc ticketing system.

All in all, the concert was successful and achieved a high level of viewership. The assembled audience was also very pleased. Both sides decided to organize such concerts every year, but already on a commercial basis and payable. The parties decided to plan them 6 months in advance.

Despite the lack of experience in cooperation in this type of projects, lack of adequate flow between the co-organizers, an agreement that was created in a hurry, the lack of a developed decision-making model, as a result of which they were made in a spontaneous, and sometimes

even chaotic manner, the concert occurred and satisfied the needs of the beneficiaries in terms of entertainment and access to cultural events. However, attention should be paid to the seemingly insignificant element that - it can be said - decided about the success of the concert. This element was the weather conditions prevailing on the day of the event, which made a large group of concert beneficiaries resign from coming to the amphitheater (experience shows that much fewer participants of cultural events come to the amphitheater if on a given day there are such weather phenomena as rainfall or low air temperature). Because it started to rain before the concert, there was no situation where people who wanted to take part in the event had nowhere to sit or could not even enter the amphitheater due to its overcrowding.

## 6. Summary

This paper is the first one to propose risk assessment model dedicated for assessing the overall risk of unfavorable interorganizational relationships occurrence in CSR ventures, as well as the occurrence of 13 unwanted events connected with interorganizational relationships in CSR ventures. Thanks to applying the elements of fuzzy sets theory, it was possible to decrease the uncertainty and lack of precision in obtaining crisp values of the basic events' probability. The practical application of the proposed risk assessment model for CSR ventures was shown on the example. The main contributions to the body of knowledge include: identifying 13basic events leading to unfavorable interorganizational relationships occurrence in CSR ventures, identifying 41 risk factors that are important for inter-organizational cooperation related to CSR projects, developing a model of risk assessment using fuzzy logic and FTA dedicated to inter-organizational cooperation related to CSR projects, and implementation of the proposed model.

To achieve increasing demanding business goals, as well as social and environmental goals, companies (regardless of their size) sometimes have to cooperate with other entities. The assessment of the risk related to the implementation of socially responsible activities becomes more important, especially in the case of interorganizational cooperation, where at least two different entities jointly pursue one goal.

The risk related to the achievement of socially responsible goals, where sacrifice of enterprise resources is required, should be a subject to the same assessment as in the case of economic goals. Socially responsible activities compete for resources with activities aimed at multiplying profit and require the commitment of limited resources of enterprises, which should be managed wisely.

Managing the risk related to the implementation of socially responsible activities as part of interorganizational cooperation is not an easy task due to its dynamics and complexity. The process of identifying risk sources is necessary to determine their level and take actions

aimed at eliminating or minimizing the negative effects of the occurrence of unfavorable quality attributes of relations between cooperating entities. Without analyzing the risk, it is difficult to take actions to correct its level, which means that identifying the sources of risk related to the implementation of the assumptions of the CSR concept as part of interorganizational cooperation is necessary to assess its level and is crucial for its management.

Failure to assess the risk may lead to failure to achieve the intended benefit of interorganizational cooperation in CSR projects. Therefore, it was important to develop a risk assessment model so that entities deciding to jointly pursue socially responsible goals could determine risk level before starting any action.

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# THE STRATEGY FOR THE INTERNAL DEVELOPMENT OF ECOLABNET'S ECO-INNOVATION PARTNERS IN THE BALTIC SEA REGION – ANALYSIS AND EVALUATION

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**Purpose:** On the basis of the obtained research results, an attempt was made to answer the following research question: what actions should be taken within the framework of the main strategic directions adopted in the developed strategy for the internal development of the research project partners, co-creating a network of service providers supporting eco-innovation of SMEs?

**Design/methodology/approach**: In the research process, the authors applied both quantitative and qualitative approaches. The primary quantitative tool was a survey questionnaire, and the qualitative tool was a panel discussion. The evaluation was based on 12 evaluation criteria which relate directly to the established procedures for preparing and implementing the Internal Development Strategy. These criteria have been divided into four groups concerning different stages of strategy implementation: 1) initiating, 2) preparing, 3) implementing, and 4) monitoring.

**Findings:** The article focuses on the evaluation of a comparative strategy for the internal development of Research and Development Institutes providing their eco-innovation services to SMEs, along with other consortium partners, intermediary organizations and companies, and the Ecolabnet eco-innovation network, also referred to as the Ecolabnet network of eco-innovation services.

**Research limitations/implications**: 1) The great diversity of project partners for whom the internal development strategy was developed. 2) The specificity of the project, as its main objective was to create a cooperation network for the provision of consulting services for the development of eco-products and eco-services for SMEs in the region of the Baltic Sea States.

**Practical implications:** Development of conception of internal development strategy of the project teams.

**Originality/value:** The summarized findings and reflections relate to the international network of eco-innovation service providers in SMEs (Ecolabnet), established under the Interreg Baltic Sea Region program for 2014-2020. The authors of the article co-founded the network as partners of a project consortium on behalf of Czestochowa University of Technology. The consortium consists of eleven partners from six countries in the Baltic Sea region.

**Keywords:** internal development strategy, eco-innovation, network of eco-innovation services, enterprises.

**Category of the paper:** Research paper.

## 1. Introduction

In the era of sustainable economic development, there is a growing phenomenon of diffusion of eco-activity, not only in enterprises but also in other organizations, in the areas of design, implementation, and utilization of various services, products, or technologies, referred to as eco-innovations (OECD, 2018). At the same time, this diffusion is reflected in the sustained and persistent improvement of competencies in creativity, entrepreneurship, communication, and cooperation with the R&D environment, business, and the competitive environment in a coopetition model. This cooperation is increasingly taking formalized forms in the shape of networks of competencies of various groups of entities, including: scientific and research units, such as universities and research institutes, business organizations, public utilities, local government entities, and intermediary organizations. The temporary structure of the network is adjusted depending on the entities' competencies in terms of designing, creating, and implementing particular eco-innovations (Triguero et al., 2013). Based on the results of secondary research, as well as observations and own research, it is noted that there is a lack of unambiguously defined in time and space interrelationships of the entities forming such networks, a lack of common strategies for the development of eco-innovation, and a lack of entities' own autonomous strategies for internal development.

In this context, this article attempts to assess and, at the same time, justify the essence of developing autonomous strategies for the internal development of eco-innovation service network partners. An attempt was also made to assess the impact of these strategies on the synergistic increase in the value of the created eco-innovation service networks. At the same time, the conducted scientific discourse is an attempt to answer the research question: what actions should be taken within the framework of the main strategic directions adopted in the developed strategy for the internal development of the research project partners, co-creating a network of service providers supporting eco-innovation of SMEs?

In order to realize the above research problem, it was important to select a research sample – entities already forming such a network of eco-innovative services and, at the same time, entities that have already defined, determined, adopted, and often already implemented strategies of internal development in the field of broadly defined eco-innovative services. Thus, the research results and the conducted scientific discourse concern the international network of eco-innovation services Ecolabnet, formed by service providers supporting eco-innovation (Ecolabnet, 2021). The Ecolabnet network was initiated within the framework of the European project Interreg Baltic Sea Region. The Ecolabnet network was formed by a founding consortium – project partners, from six Baltic Sea Region countries, such as: Finland, Lithuania, Estonia, Sweden, Denmark, and Poland. Currently, the network is formed by 41 European entities (dynamic number, as of 31.07.2022) including: Research and Development Units (RDIs), Small and Medium-Sized Enterprises (SMEs) and Intermediary Organizations (IOs) (Kuceba, Zawada, 2019; Kuceba et al., 2020).

## 2.  Project team effectiveness

The project teams is a key resource that determines the success of a project. The qualifications of the team members and their commitment to the ongoing project determine the outcome of the project. The role of the project manager is also highly significant – they assign the work to the other team members, motivate their efforts, and hold them accountable for their tasks (Birkinshaw, 2001).

Building a project team is a crucial, though often marginalized stage of project work, including research projects (Bizjak, Faganel, 2020). This is usually due to the desire to quickly begin work on the project concept itself but is to the detriment of the project's merit.

Project management is one of the typical fields describing the concept of work in teams (Michalczyk, 2013), and the functioning of teams is the dominant form of work organization (Spałek, 2016). The project implementation usually places higher demands on employees compared to those of repetitive activities. Hence, in project management, the issue of creating and managing task teams becomes crucial (Skalik, 2009). Several models of project team structures can be distinguished in the literature. However, four classic (basic) ones are indicated: – surgical structure; – expert structure; – isomorphic structure; – collective structure.

Each of the mentioned models can be applied to projects in relation to the specific characteristics of the project, such as the type, scope, size, or culture of the parent organization (Słoniec, 2015). In relation to research projects, the expert structure is predestined.

The expert structure is equivalent to the matrix structure of an organization. In such a structure, team members (experts) deal with tasks of different types but related to a specific specialization, while the project manager is the coordinator of all the work (Słoniec, 2015). Expert structures are characterized by the effective use of team members and their high degree of independence, however, they are also fraught with problems characteristic of matrix management (an unclear division of duties and responsibilities).

The processes occurring in the projects force the constant updating, upgrading, and changing of employees' qualifications and skills. Thus, a key challenge for project implementers becomes increasing the team members' competencies in the subject area of the project. This requires the acquisition of new competencies and continuous learning from the project team members (Gładys-Jakóbik, 2000).

The development of the project team must be planned. It should be conducted in accordance with the adopted development strategy. Developing the desired competencies among team members requires recognizing their current skills and work capabilities. Based on the current state of competencies in the context of project tasks, it is possible to determine the target state of competencies of the project team, which further allows determining the directions and ways of development of project team members.

## 3. Strategy for internal development of project teams co-creating the Ecolabnet network of eco-innovation services and products – primary assumptions

The strategy for the internal development of project teams in the ECOLABNET project is oriented toward improving cooperation with the SME sector and developing eco-innovation initiatives in relation to their needs, both current and prospective. The strategy defines a set of guidelines for any decisions or actions taken in a coordinated manner in specific areas with regard to both resources and time frames. The strategic management methods and techniques adopted in the strategy express the basic assumption that the entity interacts with its environment, which is a source of both threats and opportunities for its development. It was assumed that each project team (Project Partner) has certain strengths and weaknesses (Aaltonen et al., 2008).

In the adopted strategy for the internal development of project teams, the following eight main directions of strategic activities were identified:

1.  research and scientific development of the teams in the design and manufacture of eco-innovative products and services in various areas of science,
2.  strengthening the potential of research infrastructure,
3.  expanding cooperation with intermediary organizations and SMEs in the region,
4.  development of a portfolio of eco-innovation services for SMEs, taking into account current and planned research and development capabilities with current and planned laboratory infrastructure,
5.  sustainable and continuous development of the team based on the growth of knowledge, skills, and experience in developing eco-innovation initiatives,
6.  applying in heterogeneous competitions for research and development projects, among others, in the diffusion of eco-innovative solutions in SMEs – projects funded by European and national institutions,
7.  preparing and conducting training courses on increasing the competitiveness of enterprises by raising awareness and introducing eco-innovative measures,
8.  development of a system for collecting and presenting eco-innovative products and services, providing a source of professional knowledge about eco-innovative solutions.

In addition, the procedure for creating and implementing strategies for the internal development of project teams was unified. Unification concerned the definition of procedures governing the creation and implementation of internal strategies of individual Project Partners. First of all, based on the presentation of own experience, knowledge, competence in design, implementation and/or utilization of eco-innovation services, as well as the discourse during the brainstorming conducted in the group of entities co-founding the consortium of ECOLABNET eco-innovation services network, 12 corporate procedures/criteria governing the

creation and implementation of strategies for the internal development of this network's partners were identified. The development of these corporate procedures ensured the unification of the methodological approach to the formulation of these strategies by individual partners and, from the point of view of the adopted research problem, guaranteed the evaluation of the strategy of internal development of this network's entities in accordance with the unambiguously adopted corporate procedures. The procedures, which are also the evaluation criteria, were divided into four groups: initiating, creating, implementing, and controlling, depending on the stage of implementation of the internal development strategy. Each group was assigned three consecutive chronological procedures. In the initiating procedures group, the consortium of ECOLABNET eco-innovative services network partners distinguished: 1) Identifying or creating a team in charge of internal development; 2) Determining by the identified/created team the priorities and strategic actions in the context of collaboration and support for SMEs; 3) Identifying by the internal development team the needs of SMEs in the scope of eco-innovative actions. Subsequently, in the creating procedures group, further procedures were identified, such as: 4) Identifying competence gaps in particular areas of knowledge within the partnership; 5) Determining lines of action so as to eliminate competence gaps; 6) Drawing up the internal development strategy with regard to determined primary lines of action. The next group of three consecutive procedures, identified as implementing procedures, includes: 7) Decomposing strategic objectives into specific goals; 8) Indicating key development actions/activities – minimum three activities; 9) Establishing an action plan and task implementation within the developed strategy. The last group – the controlling procedures group – relates directly to control and therefore includes: 10) Periodical monitoring of the progress of undertaken actions; 11) Developing and accepting indicators of internal development evaluation; 12) Evaluating implementation of internal strategy.

## 4. Dimensions of evaluation of internal development strategies of partners of eco-innovation services network Ecolabnet

An evaluation of the internal development strategies of the Ecolabnet partners, the eco-innovation services network, was carried out in six countries of the Baltic Sea region. Specifically, the research was conducted in 11 units forming the consortium of this organizational network. Collectively, project partners possess relevant experience in technology, business, and design for eco-innovation. In addition, they perform different roles in the eco-innovation system – the consortium consists of seven research, development, and innovation organizations, two intermediary organizations, and two small and medium-sized enterprises. The multidisciplinarity and diversity of organizations within ECOLABNET ensure high quality and the ability to meet the needs of SMEs and other stakeholders. The MUOVA

Design Center (project leader) at VAMK University of Applied Sciences Ltd. is a highly experienced design unit specializing in product and service concept design and prototyping them in close cooperation with companies. The Centria University of Technology brings biomaterials for 3D printing, plastic processing technologies, and recycling expertise to the project. Centria also performs LCA analyses for sustainable prototypes and compares them to conventional solutions when possible. A partner from the Kaunas University of Technology specializes in synthesizing, modification, and researching biobased polymers, biodegradable polymers, and biocomposites from renewable resources. A partner from the Vilnius University Laser Research Center provides expertise in incremental manufacturing and infrastructure for the verification of biobased resin compositions for optical 3D micro- and nano-printing (lithography). The University of Tartu's Intelligent Materials and Systems Laboratory possesses expertise in computational materials science, material science, robotics, chemistry, computer science, and electronics. VIA University College conducts research that combines creativity, technology, and business skills. It focuses on sustainable business models, cross-cultural competence, in- and outsourcing, and export opportunities for SMEs. A partner from the Częstochowa University of Technology brings expertise in business development, environmental impact assessment, and marketing. The CUT project is working on a digital collaboration tool and ECOLABNET service packages. Labsamera MB develops and manufactures special materials for 3D printing using SLA (resin 3D printing) technology. The company provides 3D printing services to other SMEs, including prototyping, small batch production, and production of custom design products. Estrotech Ltd is an SME providing RDI & rapid prototyping services for designing and integrating electronics in industrial and consumer products. The Business Confederation of Lithuania is developing an internal cooperation model for ECOLABNET as part of the project. Sustainable Innovation has an unrivaled position in the Nordic countries in implementing sustainable solutions in cooperation with leading companies, entrepreneurs, and researchers. Sustainable Innovation introduces market-ready eco-innovations to the general public through demonstration and scale-up activities.

The research was carried out in two stages:

1. Questionnaire survey, which aimed to identify the activities conducted under the previously indicated 12 procedures/criteria by individual partners and aggregate all these activities at the level of the formed consortium.

2. Panel discussion, a remotely conducted explanatory and inference discourse, to evaluate the key strategic actions. For the generated activities in the questionnaire survey assigned in procedures/criteria 2, 4, 5, 6, 7, 8, a joint evaluation was established during the panel discussion on the basis of consensus (brainstorming). The evaluation was conducted on a five-point Likert scale (from 1 – no importance to 5 – very high importance) for aggregated activities in the database system assigned to

12 procedures/criteria, whose number of indications by individual surveyed consortium members was greater than half the number of surveyed entities, N > 5.

Both stages were conducted among all survey participants – 11 partners of the ECOLABNET eco-innovation services network consortium.

With regard to the first initiating procedure/criterion – *identifying or creating a team in charge of internal development*, all 11 consortium partners confirmed the formation of a team in charge of internal development. The assigned common role of these teams is to create and implement their own strategies for internal development, frequently separated in the network of partners. It refers to strategies oriented towards improving cooperation with, among others, the SME sector and developing eco-innovation initiatives with reference to their needs. Here, in the context of the conducted comparative assessment, a common determinant was the initiation and, for the first time, the establishment of such teams in the surveyed entities with the number of people in each team varying from 2 to 8.

In the questionnaire survey on the identification of the most relevant activities assigned in the strategy initiation group, for the second procedure/criterion – *determining by the identified/created team the priorities and strategic actions in the context of collaboration and support for SMEs*, a total of 35 strategic actions were identified by 11 entities of the ECOLABNET consortium – actions, which were aggregated in a common database. During the discussion panel, the priorities of strategic actions whose number of indications was greater than half of the number of surveyed entities (N > 5) were evaluated on a five-point Likert scale. Figure 1 summarizes in the form of a radar visualization the joint assessments of the highlighted priority strategic actions established through discussion and consensus.
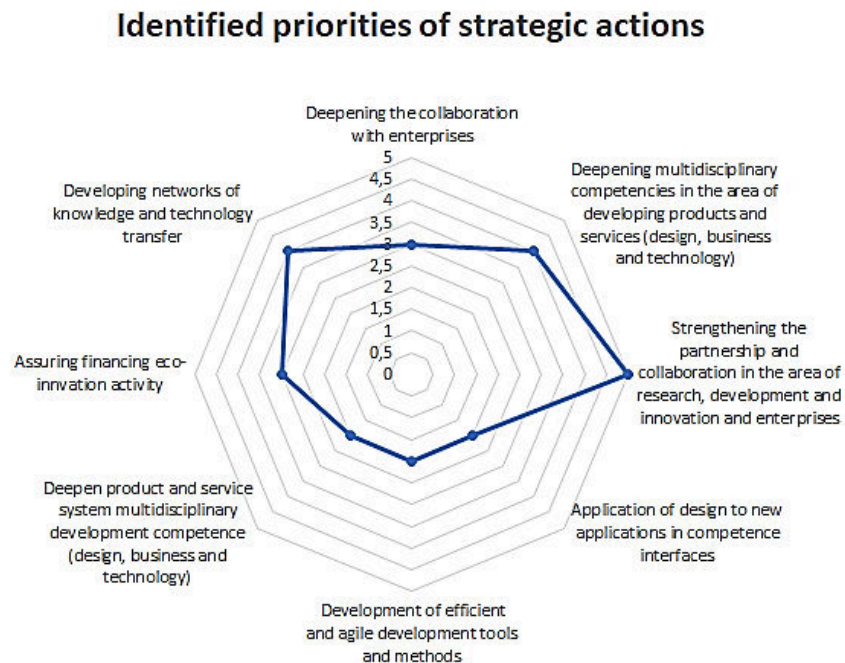


**Figure 1.** Assessment of the key expected priorities for strategic actions in the field of eco-innovation services – identified by the ECOLABNET network consortium.

Source: own elaboration.

Referring to the Likert scale ratings established through discourse and consensus by the 11 partners of the studied eco-innovation services network consortium, the highest rating of 5 (very high importance) was assigned to strategic actions that stimulate the strengthening of partnerships and cooperation in research, development, and innovation. This is also confirmed by the high consensus rating (4 – high importance) assigned to developing networks of knowledge and technology transfer. The cooperation in the diffusion of eco-innovation solutions was also granted a high rating (4), assigned to cooperation activities stimulating the growth of multidisciplinary competence in the development of products and services (design, business, and technology). The other priorities summarized in Figure 1 received lower ratings, respectively: Assuring financing eco-innovation activity – 3, Application of design to new applications in competence interfaces – 2, Development of efficient and agile development tools and methods – 2. However, it should be noted here that they were already selected in the quantitative measurement (questionnaire surveys), meeting the condition – the number of indications was greater than half of the number of surveyed entities (N > 5). The quantitative assessment, as the second selection stage of identified priorities for strategic actions, justifies the essence of including cooperation, especially within the framework of eco-innovation networks, in the strategies of the entity's internal development in the sphere of eco-innovation. Since the measurement has already been conducted in entities that have established and now cooperate within the framework of eco-innovation services networks, the essence of including cooperation in the strategies and establishing networks of eco-innovation services is determined as *best practices*.

In the case of the third procedure – *identifying by the internal development team the needs of SMEs in the scope of eco-innovative actions*, the consortium used the results of the pilot study that was the justification for the implementation of the ECOLABNET project. In justifying the creation of the ECOLABNET eco-innovative services network consortium, the partners, using identical research techniques and methods, identified the needs and barriers of SMEs in their own countries (Marin, Marzucchi, Zoboli, 2015, pp. 671-705). Research on the identification, measurement, and assessment of the significance of the heterogeneous eco-innovation needs of SMEs in the Baltic partner countries, as part of the ECOLABNET project, was carried out in the second half of 2019. In total, N = 296 SMEs in the countries of the project consortium partners participated in the research, including: Estonia – 23,31% (69), Poland – 19,26% (57), Finland –18,24% (54), Lithuania – 15,88% (47), Sweden – 12,84% (38), Denmark – 10,47% (31). Analyzing the subject structure of all surveyed SMEs, micro enterprises accounted for 42.23% (125) of the research population, and small enterprises – 27.36% (81). The remaining group – 30.41% (90) are medium-sized enterprises. In the scope of developmental needs of the research enterprises, the following are distinguished: development of eco-innovative products and services (highlighted needs 32,08% and possible needs 32,55%) and packaging development (highlighted needs 23.58% and possible needs 37,26%). In the project of the IT system, also life-cycle assessments (highlighted needs 19,81% and possible needs 38,21%)

have been considered as a need of external support – perceived by enterprises in which eco-innovations are in line with the company's strategy, and even in their mission. While referring to the need defined as Technology/Production high activeness and at the same time needs of European enterprises in the scope of energy saving are fully confirmed. In the context of the obtained research results, 81,60% of the investigated entities expect support in the scope of energy optimization. In the case of: biocomposites, bioresins, or 3D printing, current needs of Baltic SMEs are low. Due to the fact that these indications came from enterprises where eco-innovations are in line with the mission or/and strategy of the company, they have also been considered in the project of the IT system. Details regarding the measurements of eco-innovative needs have been published among others in the scientific paper of joint authorship with the author of the present paper (Kuceba, 2019).

Analyzing the implementation of the fourth procedure – *identifying competence gaps in particular areas of knowledge within the partnership*, a total of 21 competence gaps in terms of eco-innovation activities were identified in the first stage of the questionnaire survey conducted in a group of 11 members of the ECOLABNET eco-innovation services network consortium. In the second part of the research, during a panel discussion, the evaluation on a five-point Likert scale carried out during the discussion based on consensus was subjected to those distinguished competence gaps whose number of indications by individual subjects was greater than 50% of all survey participants (N > 5). The evaluations of the distinguished competence gaps obtained during the panel discussion of the 11 consortium members are summarized in a radar diagram (Figure 2).
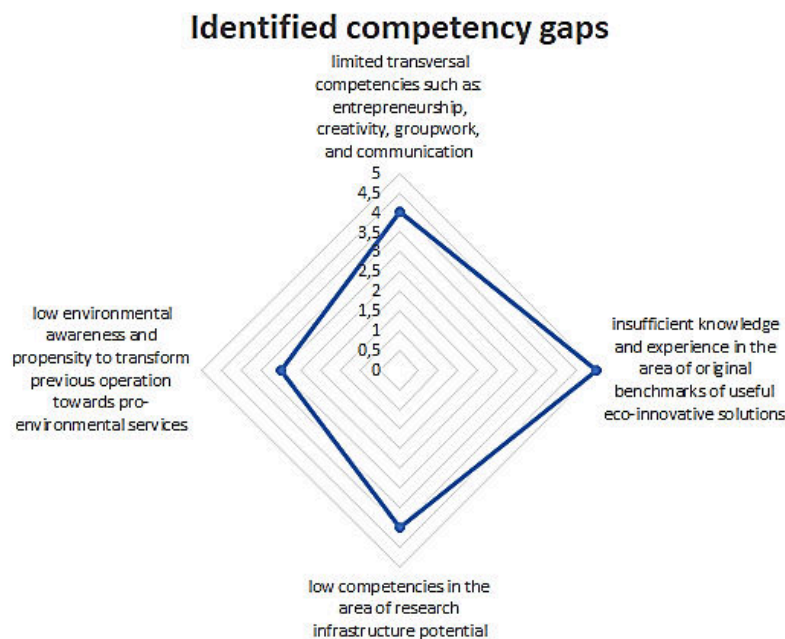


**Figure 2.** Assessment of the key competence gaps in eco-innovation services – identified in the ECOLABNET consortium.

Source: own elaboration.

A key competence gap of very high importance (rating of 5 obtained through a consensus), identified by panel members in the field of eco-innovation services, is insufficient knowledge and experience in access to benchmarks – useful eco-innovation solutions implemented primarily in the SME sector. The panelists thus confirmed the priority of strategic actions referring to cooperation with external entities, which will synergistically increase the value of the individual entities forming the cooperation network, both intellectually through the growth of knowledge, skills, and experience, as well as expanding their portfolio of eco-innovation services. Individual entities participating in the panel survey (members of the ECOLABNET eco-innovation services network consortium) highly rated cross-cutting competencies: entrepreneurship, creativity, teamwork, communication skills, and also, as emphasized, limited access to modern research infrastructure (limited in-house capabilities) in the context of perceived competence gaps (rating of 4 obtained through a consensus). All entities participating in the study indicated environmental awareness (Kuceba, Zawada, 2019, pp. 67-72) and the propensity to transform their existing activities towards ecological services (Gładys-Jakóbik, 2000) as competence gaps at the level of medium importance (rating of 3 obtained through consensus), still too insufficient in their organizations, despite declaring at least one area of activity offering eco-innovative services before entering the consortium. The above competence gaps identified as key gaps, highlighted from a portfolio of 21 indications and assessed in the panel discussion, constituted an argument in justifying the creation of internal development strategies for eco-innovative services by individual ECOLABNET partners.

Referring to the next procedure/criterion from the group of creating strategies for internal development in the field of eco-innovation – procedure five – *determining lines of actions so as to eliminate competence gaps*, it should be emphasized that only five out of eleven partners of the ECOLABNET eco-innovation services network consortium explicitly determined the directions of actions reducing their competence gaps. The directions assessed by these five partners as directions of very high importance were: the growth of existing competences in terms of quantitative and qualitative expansion of the eco-innovation services portfolio dedicated, among others, to SME manufacturing enterprises. Multidimensional activities aimed to reduce the lack of knowledge or insufficient knowledge through, among others, internal training and the use of good practices and benchmarks in the field of eco-innovation services were also indicated as key directions for reducing competence gaps.

All 11 entities forming the ECOLABNET eco-innovation services network consortium, in accordance with the adopted sixth procedure/criterion – *drawing up internal development strategy with regard to determined primary lines of actions*, set strategic goals for their internal development. In the first phase of the adopted research – questionnaire surveys, 11 partners formulated a total of 23 strategic objectives. In the second part of the research (regarding the sixth procedure/criterion), the evaluation on a five-point Likert scale conducted during the panel discussion based on consensus was subjected to those distinguished key strategic objectives of internal development whose number of indications by individual subjects was greater than 50%

of all participants in the research (N > 5). The evaluations of the distinguished key strategic objectives of internal development, obtained during the panel discussion of the 11 consortium members, are summarized in the following radar diagram (Figure 3).
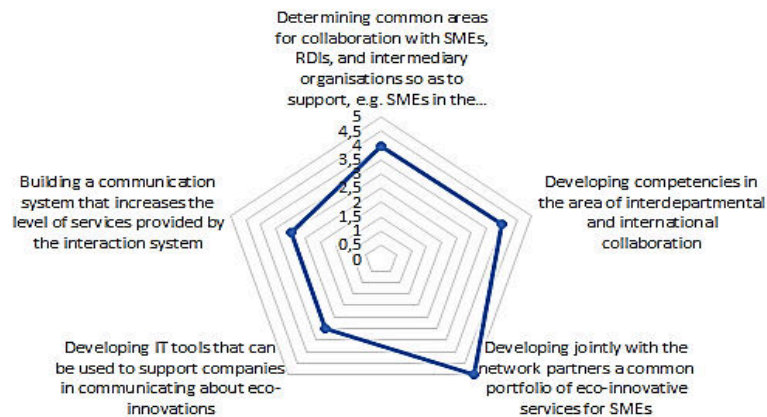


**Figure 3.** Assessment of the key strategic objectives for eco-innovation services – identified in the ECOLABNET consortium.

Source: own elaboration.

The N > 5 criterion, out of a portfolio of 23 strategic objectives, was met by five key strategic objectives for internal development. The highest rating (rating of 5 obtained through consensus) was given to the strategic objective, which, although it relates to the internal strategies of each partner, opens the given entity to the environment and to cooperation in the network, intending to develop a common extended portfolio of eco-innovation services, and thus expanding the market of recipients of these services. This goal is aligned with the identified competence gap of useful eco-innovation solutions – insufficient knowledge and experience in access to benchmarks. Highly rated objectives of internal development in the field of eco-innovation services (rating of 4 obtained through consensus) are formulating the unambiguous definition of cooperation areas with SMEs, R&D entities, and intermediary organizations supporting SMEs in the field of eco-innovation services, as well as developing and accelerating competencies in the field of interdepartmental and intergovernmental cooperation. The Panelists positively assessed (rating of 3 obtained through consensus) the virtualization of cooperation and the virtualization of eco-innovation services models through the creation of repositories, information portals, and digital integrators of the partner network, which supports communication, dissemination of information about eco-innovation services, and often their diffusion. In this context, a common strategic objective has been established, which should be identified also as a strategic objective for the internal development of individual network entities – the development, design, and implementation of a communication system that increases the quality of services provided through, for example, n-ary interaction.

Referring to the next implementing procedure/criterion – *decomposing strategic objectives into specific objectives*, specific objectives were specified, similarly to the fifth procedure/criterion, by five partners of the ECOLABNET eco-innovation services network consortium. In the process of comparative analysis conducted during the panel section, from the group of specific objectives highlighted by five consortium members, all of the 11 partners, searching for a common framework, distinguished as objectives of very high importance (rating of 5 obtained through consensus): 1) research and scientific development of the personnel of individual partners, 2) strengthening the capacity of the research infrastructure, 3) seeking new sources of funding for research and development for new eco-innovative services as well as for increasing productivity or promoting new products, 4) expanding communication channels for increasing the availability of services provided by related business structures, 5) lobbying for networking between business sectors, business organizations, and intermediary organizations. Specific strategic objectives, according to the panelists (rating of 4 obtained through consensus), should also significantly target branding and promoting the development and availability of the business ecosystem and RDI infrastructure of the partner network. In the context of the highlighted core strategic objective (sixth procedure/criterion) – virtualization of cooperation and virtualization of business models, the ECOLABNET consortium partners attribute quite significant importance (rating of 3 obtained through consensus) to specific objectives aimed at using the digital integrator of the partner network to: 1) gather and present knowledge about eco-innovative services and 2) increase the network's spread by registering and introducing new network partners' services and mobilizing these partners to create an eco-innovative image of the network.

In the subsequent research phase concerning Procedure 8 – *indication of key development actions/activities*, eco-innovation services network partners indicated at least three key actions they identify in their internal strategies for eco-innovation services. In the first phase of the adopted questionnaire research, 11 partners of the ECOLANBET eco-innovation services network consortium identified, in total, 54 key development actions. In the second part of the research (concerning the eight procedure/criterion), the evaluation on a five-point Likert scale conducted during the discussion panel based on consensus was subjected to those distinguished key development activities whose number of indications by individual entities was greater than 50% of all survey participants (N > 5). The evaluations of the distinguished key development activities are summarized in Figure 4 in the form of a radar diagram.
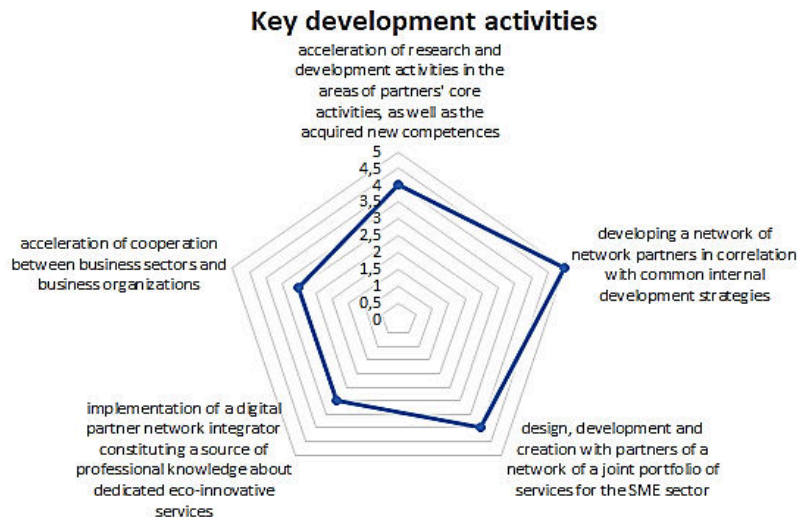
**Figure 4.** Assessment of the key development activities resulting from adopted strategies for eco-innovation services – identified in the ECOLABNET network consortium.

Source: own elaboration.

Analyzing the summary of key strategic activities of internal development, partners attributed the highest rating (very high importance – rating of 5 obtained through consensus) to the creation and networking of network partners in correlation with joint strategies of internal development. In addition, high importance (rating of 4 obtained through consensus) was attributed to all activities stimulating the diffusion of research and development activities in the areas of the partners' core business, as well as the acquisition of new competencies in new eco-innovation services. Key development activities, according to the partners forming the ECOLABNET eco-innovation services network consortium, should be fully convergent with the adopted key strategic objectives. Therefore, an activity of high importance (rating of 4 obtained through consensus) is, according to the strategic objective highlighted in the sixth procedure/criterion (Figure 3) – the development and creation of a common service portfolio for the SME sector with the network partners, which constitutes the added value of network integration in the dissemination and implementation of new heterogeneous eco-innovation services. In the context of the already highlighted strategic objectives, the partners also recommend intensifying development activities in terms of accelerating interdepartmental and, at the same time, interdisciplinary cooperation.

In the case of the ninth implementing procedure/criteria – *establishing an action plan and tasks implementation within the developed strategy*, in the first part of the questionnaire survey, individual partners of the ECOLABNET eco-innovation services network developed 11 autonomous plans for the implementation of the tasks concerning eco-innovation services within the framework of the internal development strategies created in each unit. In the second part of the research – panel discussion, it was found that the plans varied in the context of: place, time of implementation, and, to some extent, planned substantive tasks arising from the

developed strategic goals. Thus, the autonomy of the internal development strategies created by individual project teams was confirmed, despite their cooperation in a single network of eco-innovation services. In the course of the explanatory and inference discourse and the conducted brainstorming based on consensus, a conjunctive plan for the strategy implementation for the entire consortium was proposed. The unified plan includes the following phases: 1) definition of goals and priorities of activity; 2) diagnosis of the current competence level in the field of eco-innovation; 3) competence development, strengthening the image of eco-innovation (products, processes, and services) through the use of differentiated communication tools; 4) expansion of the financial and material resources portfolio; 5) strengthening the potential of research infrastructure; 6) expansion of the portfolio of eco-innovation services for the SME sector; 7) expansion of the network of contacts; 8) monitoring and controlling the progress of the implementation of the internal development strategy; 9) identification of risks and taking corrective action; 10) ongoing and periodic evaluation.

The consecutive three implemented procedures (10 – *periodical monitoring of the progress of undertaken actions*; 11 – *developing and accepting indicators of internal development evaluation*; 12 – *evaluating implementation of internal strategy*) are strictly of controlling nature. These procedures were developed by four partners, and therefore, following the recommendation of one of the partners of the ECOLABNET eco-innovation services network consortium represented by the authors of this article, the uniform control criteria and restrictions were adopted during the panel section in all 11 analyzed entities. Adoption of the homogeneous control criteria and restrictions was justified by the identified significant importance of transparency, openness of the obtained control results, regularity, periodicity, and the possibility of comparing the implementation of key common strategic objectives in the network. In the case of monitoring the progress of undertaken actions, the ECOLABNET partners jointly adopted the essence of control and evaluation of the ongoing implementation of internal strategies at intervals of no more than one month and periodic evaluation at intervals of no less than six months. Based on the indications of the four partners of the analyzed network, during the panel section, the 10 most relevant quantitative indicators of internal development evaluation were aggregated and recommended to all 11 entities. The employment of the uniform indicators ensures transparency and comparability of the individual partners' development in the eco-innovation services network. The unified indicators are: 1) the number of held trainings/specialized workshops; 2) the number of publications in the field of sustainable development and promotion of pilot eco-innovation services; 3) the level of employment of the laboratory base (%); 4) the number of acquired partners from the business environment; 5) the number of developed new eco-innovation products and services for SMEs; 6) the number of designed new eco-innovation products and services for SMEs; 7) the number of prepared and submitted project applications for R&D grants; 8) the number of R&D projects accepted for implementation; 9) the number of developed patents and industrial models of eco-innovative services; 10) the number of conducted events/trainings/workshops supporting processes of

transferring eco-innovative services to business. It was assumed that partners of the eco-innovation services network have the voluntariness to expand the portfolio of measures for assessing internal development with further indicators tailored strictly to their own needs. In the context of evaluating the implementation of the strategy, an annual cycle of periodic evaluations was recommended for all partners.

## 5. Conclusions

The results of the conducted literature and empirical studies enable the authors to conclude that the effective work of project teams is a key factor in project success. It requires continuous improvement of team members, both in terms of their expertise and skills necessary to achieve the main project objectives in a highly effective manner. The development of the project team must be planned. It should be conducted in accordance with the adopted development strategy.

This article presents the internal development strategy of project teams co-creating the ECOLABNET network of eco-innovation services and products and evaluates it.

In the autonomous, independently determined strategies and resulting objectives and activities of the internal development of the partners of the ECOLABNET network of eco-innovation services, the fundamental common direction is unambiguously identified, which is the competence development in the partner network – a platform for transferring knowledge and competencies as well as exchanging experience and skills. The added value of network integration in the dissemination and implementation of new and diverse eco-innovation services constitutes a joint portfolio of eco-innovation services that expands the competence of each ECOLABNET partner.

In this context, a common strategic objective has been established, which should also be identified as a strategic objective for the internal development of the network's individual entities – the development, design, and implementation of a digital communication system that increases the level of provided services through n-ary interaction.

The conducted scientific discourse, the carried out analyses, and the aggregated information on internal strategies and their implementation by the partners of the eco-innovation services network is a cumulative knowledge of the strategic goals and tasks dedicated to business entities that have a propensity to develop new eco-innovation initiatives, as well as a propensity for self-improvement and strengthening of their value in the networks of partners – in this case, eco-innovation services networks.

The considerations presented in the article are not exhaustive and require further research. The principal limitations of the study are: 1) The great diversity of project partners for whom the internal development strategy was developed. Each of the distinguished stakeholder groups has its own objectives, which translated into different degrees of implementation of the

developed strategy. In order to determine the utilitarianism of the developed strategy, it would be necessary to test it on a larger number of project teams; 2) The specificity of the project, as its primary objective was to create a cooperation network for the provision of consulting services for the development of eco-products and eco-services for small and medium-sized enterprises in the region of the Baltic Sea States. The subject of the research determines the need for members of the project team to have specific competencies, the development of which requires the use of other methods and tools. Therefore, it would be necessary to study a larger number of project teams diversified in different fields.

## Acknowledgements

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# DEVELOPMENT OF THE FUNCTIONALITY OF MOBILE APPLICATIONS IN CRISIS SITUATIONS: THE CASE OF POLISH COMMERCIAL BANKS

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**Purpose:** This paper aims to contribute to the field by exploring the development of the functionality of mobile applications in crises using commercial banks as an example.

**Design/methodology/approach**: This research was conducted between 2020 and 2022 in 13 commercial banks, performing a total of 390 complete tests of mobile applications by 30 clients (respondents).

**Findings:** It was found that mobile applications are becoming a significant customer service channel in some banks. In addition, the mobile application is helpful for the client since it can replace personal contact with the bank in terms of service without needing additional support from an advisor in other contact channels. It was also found that crises significantly accelerate the development of mobile applications to meet customers' needs and expectations.

**Research limitations/implications**: The research was conducted as part of the Institution of the Year project in 2020, 2021, and 2022. The study was carried out in 13 commercial banks, performing 390 complete tests of mobile applications by 30 clients (respondents).

**Practical implications:** Crises, which have occurred frequently in recent years, force managers to take measures to respond quickly to the needs and expectations of customers. The outbreak of the Covid-19 pandemic made it impossible for many customers to contact direct sales field personnel directly. The banking sector has also been affected by this problem. Although banks had used mobile applications for some time, customers could only use a limited set of functions. They had to go to a bank branch to open an account or take a loan.

**Social implications:** To meet customer requirements, bank managers make strategic decisions to improve mobile applications to meet the needs and expectations of customers and achieve a high level of satisfaction. There are many studies on responding to crises in various sectors. The research results will positively influence the improvement of the quality of services as well as the progress of the quality of life of society.

**Originality/value:** No research has been conducted on customers' role in creating new mobile application improvements. Therefore, the article presents the research results in this field, and the appropriate conclusions were drawn.

# 1. Introduction

Crises frequently occur due to natural disasters, technical failures, terrorist activities, disturbances to public order, and threats to the state's and citizens' security, e.g., a pandemic. Organizations should prepare appropriate contingency plans in the event of a crisis. This also applies to the banking sector; in situations where uncertainty is high, managers of banks should be prepared to change their approach to communication via the web interface to reach their clients.

Many organizations try to meet their client's needs and expectations in such situations. Bank managers should be prepared for crises like pandemics or war and adapt smoothly. Bank management must view the banking system approach from a strategic point of view. The development of electronic banking is a way to meet customer expectations, which allows customers to make transactions without leaving home. The introduction of several restrictions in the public domain and some industries due to the pandemic and the economic lockdown lasting several months did not diametrically affect how customers use electronic banking. Banks, on the other hand, make every effort to ensure that the transition to remote service takes place smoothly and without significant inconvenience for customers and employees while maintaining transaction safety. Therefore, we should expect an increased emphasis on developing and refining electronic banking systems.

The development of banking services and keeping up with subsequent changes in the banking industry, as well as caring for the quality of services and meeting customer wishes, is one of the main approaches to increasing and developing the competitiveness of banks. The quality of banking services is one of the most important factors influencing the customer's perception of a bank and, consequently, its financial results (Matuszak-Flejszman, Łukaszewski, 2022).

Electronic banking has become essential to achieving customer satisfaction and loyalty, establishing closer customer relationships, and meeting user expectations.

In addition, bank customers using mobile banking applications experience many advantages, including convenience and time saving, availability, information transparency, curiosity, choice and comparison, customization, bank promotional campaigns, fashion for mobile banking, and financial benefits (Filotto et al., 2020; Śmiatacz, Samek, 2016).

Technological innovation and digitalization offer customers easy access to banking services, and customers appreciate a need-based sales approach. A bank's attitude toward creation positively influences purchase intentions (Yip, Bocken, 2020).

Since we live in a modern era brought about by the success of smartphones that have changed how billions of people work and live, especially during the Covid-19 pandemic.

The pandemic has tremendously changed the world economy entirely and impacted most businesses. The banking system plays an essential role in this situation because it is a crucial component from an economic point of view. In recent years, the banking system has adapted continuously – it has been reinvented to keep up with customer expectations and the need for cost reductions (Marcu, 2021).

However, remote access channels are increasing; we have already observed more significant increases long before the pandemic. From the beginning of April 2019 to the end of June 2020, the number of active internet banking users increased by nearly 140 thousand, i.e., 0.73% compared to the first quarter. For comparison, the quarterly increase in the previous period – from the beginning of January to the end of March 2020 - amounted to 3.56% (nominally 650 thousand). However, in Q2, the total number of active individual internet banking customers exceeded 19 million for the first time (Barbrich, 2021). Crises, such as a pandemic or the outbreak of war, contribute to the development of the banking system strategy in terms of meeting customer requirements.

The COVID-19 pandemic accelerated the digitization of the banking system, although the need for digital innovation and strategies was an essential factor in banking well before the pandemic outbreak.

An attitude of the bank toward innovation positively influences purchase intentions (Yip, Bocken, 2020). Bank managers need to focus on digital transformation and migrate traditional banking services as it does not come naturally from customers. Bank management must be accessible, transparent, and easy to use, with acceptable and lower costs (Marcu, 2021).

Customers need a friendly interface and security to take a step toward digitalization. They also want a particular bank with which to have a closer and more personal relationship and to be their partners (Filotto et al., 2020).

Some believe that technology and new trends will replace traditional banks, while others argue that technology will support and complement conventional banking systems. However, the banking system will move to another, more connected, digital form of organization. New digital processes are now changing banking processes (Khanboubi et al., 2020). Managers of banks need to continue developing these strategies, as the trend towards digitalization has also reached segments that were not as receptive, such as the elderly or the rural population. Asian banks have accelerated the launch and development of digital customer services and have not encountered significant customer communication problems (Dahl et al., 2020).

The results show that banks try to keep up with customer expectations and innovative products and services. Moreover, no one knows what tomorrow's future will look like. Still, those banks that will soon modernize their IT infrastructure and provide online access to banking products and services will enhance customer experience (Marcu, 2021).

Therefore, many processes have been digitized to retain customers in banks that bring benefits and new threats and challenges.

Adapting banks to new requirements is a growing challenge for bank managers, especially in times of emerging crises such as pandemics or the outbreak of war. In Poland, the relatively highest increase in activity was recorded in the case of mobile banking users. The number of users of banking applications for mobile devices at the end of June was 12.933 million and was higher by 556 thousand, or 4.49%, compared to the end of the first quarter of 2021. Over 6.48 million users from this group are mobile-only customers. This means that over 50% of mobile banking users were people logging in to the application at least once a month while not logging in to banking using a standard web browser. The number of people using mobile banking increased in the second quarter by 359 thousand users, while in the first quarter of this year, the growth of mobile-only customers amounted to 310 thousand people (Barbrich, 2021).

The number of active users using banking services in electronic access channels (internet banking clients and mobile-only clients) reached 25.5 million people in Q2, which, with the total number of electronic banking agreements at 37.59 million, already accounts for 67% of the current use the potential of remote access channels to banking services – undoubtedly the highest indicator in the current monitoring of the active use of electronic access channels to banking (Barbrich, 2021).

Therefore, considering the efficient tools necessary to provide services in applications, the banking system should consider customers' needs and expectations. It is essential to consider all customer requirements and expectations when creating or improving the tool and to ensure the availability and security of mobile applications to such an extent as to meet customer expectations fully. So far, no research has been conducted in Poland to assess the usability of mobile applications.

In response to the research gap, a study was conducted to assess the functionality of mobile applications in crises on the example of commercial banks operating in Poland.

## 2. Research Methodology

The methods of obtaining information on changes in the functionality of mobile applications were carried out by comparing the research conducted as part of the Institution of the Year project in 2020, 2021, and 2022. The study was carried out in 13 commercial banks, performing 390 complete tests of mobile applications by 30 clients (respondents). All application users

went through the individual tested processes and services themselves. The research design assumed long-term use of the application, the purpose of which was to simulate the processing of a new customer loan application in the bank. The study aimed to map customer service in the initial phase of using the services of a given bank to verify the effectiveness of activities along the entire path of service implementation. Clients activated access, systematically logged in, performing basic operations, and returned to the application over time to perform new tasks. Their task was to assess the access configuration and first impression and to form an opinion on the application's usability while performing subsequent tasks. The analysis carried out was based on customer experience and consisted of the assessment of the ergonomics of the application and expert analysis of the available functionalities. As part of the project, focus meetings of clients' testing applications were also held, during which, together with experts, observations and impressions during testing were exchanged. During these meetings, an indicator of the functionality of mobile applications was developed, a proprietary solution used as part of the Institutions of the Year project.

A study of mobile applications was conducted immediately before and at the beginning of the pandemic (in April and May 2020). A total of 650 mobile application tests were performed. The research methodology was the same, making it possible to compare these periods and evaluate additional functionalities in mobile banking.

During the research, answers were sought on whether the mobile application can provide remote customer service with the bank at the appropriate level.

The following research theses were formulated as part of the study:

1. The mobile application can replace personal contact in terms of service with the bank without needing additional support from an advisor in other contact channels.
2. The mobile application has become some banks' significant customer service channel.
3. Crises have a significant impact on the acceleration of the development of mobile applications.

An additional aspect of this study is the specific period in which it was conducted. The COVID-19 pandemic is of great importance for the development of the functionality of mobile applications. The inability to service many customers has become a genuine reason for the development of mobile applications, which were to take over some of the traditionally served customers in branches or other contact channels where interaction with an advisor is necessary. In addition, after the research, meetings were organized as part of focus groups, during which customers testing mobile applications shared their feelings resulting from this form of contact with the bank. Experts also took part in these meetings. These conclusions provide supplementary information for bank managers responsible for developing mobile applications and can significantly impact the design and improvement of many processes.

During the study, three elements were considered:

- an indicator of available functionalities (according to the methodology developed during meetings in focus groups),
- evaluation of clients' testing applications,
- assessment of the ergonomics of mobile applications.

During the meetings in focus groups, the weights of individual elements of the assessment for a global score were determined: the indicator of available functionalities of 70%, the evaluation of customers testing the applications at 25%, and the assessment of ergonomics of 5%.

## 3. Mobile app assessment areas

When surveying the functionality of mobile applications among users, several areas were taken into accounts, such as general customer assessment, application activation, logging into the application (functionalities and ergonomics), sending the account number, payment methods, transfer form, authorization, recipient management, standing orders, payments by scanning, BLIK functions, history, notifications, telephone payments, card management, contact with the bank, editing customer data, additional functionalities, additional products, application limits, and security.

### 3.1. The scope of the data provided

The direction of changes in the activation of the mobile application is simplicity and reduction of complicated procedures. This is to ensure the speed of activation of a new application without the need for help from bank employees. Banks generally require only a few selected data, such as PESEL, log-in, or PIN. In the case of three banks, the respondents were asked to provide their mother's maiden name. During activation, bank customers receive an activation code via SMS or an incoming phone with the code. Only in the case of two banks is it necessary to log in to internet banking to activate. However, there has been a visible trend to change this additional verification method in recent years. Reducing the data coverage is noticeable compared to the results of studies conducted in early 2020. These changes are mainly due to the pandemic and are consistent with customers' expectations. Data overload causes incorrect input or additional doubts and questions, which is associated with the need for further contact with the advisor through other access channels or, in many cases, resignation from using the mobile application. Customers who are not interested in switching to a mobile application in the face of a new pandemic threat are more likely to decide to use this channel remotely.

### 3.2. How to log into the application?

In the first activation activities, the clients determined the method of logging into the application. All surveyed banks offered to log in with biometrics, and 50% provided biometric acceptance of performed operations. Frequent logging into the application and performing various operations meant that customers increasingly chose this method of logging in and authorizing operations. In activating the application, there were no biometric authorization settings. Only Alior Bank provided this option. Considering the application activation process, the highest-rated bank was Alior Bank, while the logging-in rate was the highest at Credit Agricole.

Customers liked the functionality of personalizing the biometric reader call, which allows the user to log in to the application immediately after clicking the icon, skipping the first screen with shortcuts. This functionality was available only at Credit Agricole and mBank. Pekao clients had a problem with finding the option to enable/disable biometric login from the application menu. The system did not support the biometric login settings (it is missing in the activation process or during the first login). Finding this feature was difficult due to its position in the "personalization" - "change login method" section. Customers searched for "security and consent" and "passwords, PINs, and login," guided by the fact that there is a PIN in this section, which is also used for logging in. This path was the most intuitive for customers (respondents) because most applications on the market offered a choice of login method and PIN change in one place. This example shows that what matters dramatically is the intuitiveness of functionality, not the mere fact that a given application has it. The test results are shown in Figure 1.
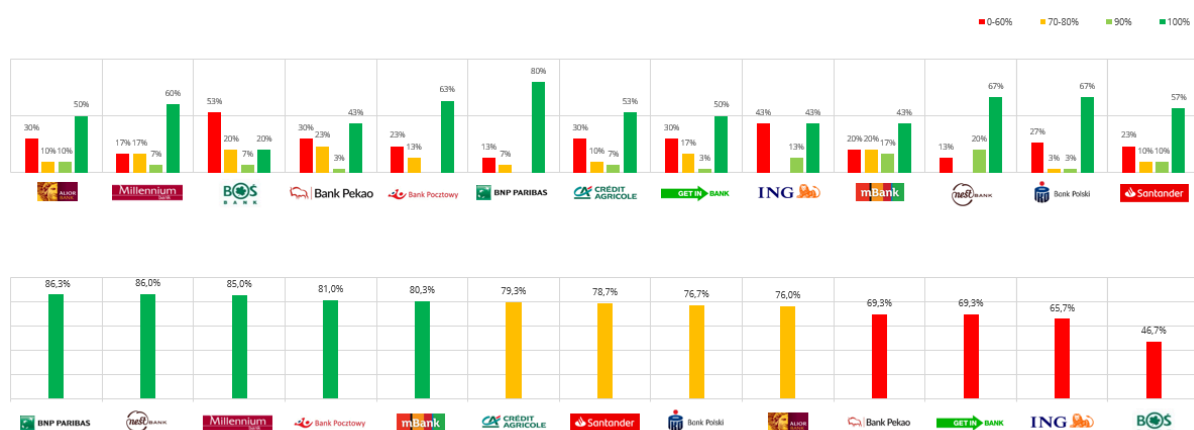


**Figure 1.** Answer to the survey question, how many % do you agree with the statement: "I found the option to enable/disable biometric login without any problems". Source: Own study based on the research carried out in the first quarter of 2022 as part of the Institution of the Year project (realized by mojebankowanie.pl).

### 3.3. Assessment of available payment methods

One of the elements of the assessment of mobile applications by testing customers is the first impression, which shows clarity and ease of navigation in customers' eyes. The highest-rated applications were those of Alior Bank, BNP Paribas Bank Polska, PKO BP, Bank Millennium, and ING Bank Śląski. Only two banks did not meet customer expectations, which is a 30% better result than a survey conducted two years ago.

A frequently used feature is finding and sending the bank account number. Most banks had no problems with this. Only two banks were assessed negatively by customers at 50%. In this case, a significant improvement is visible compared to the research carried out at the beginning of 2020, where this problem occurred in 6 banks. In two banks, none of the clients managed to send their account numbers directly. It should be noted that one bank (Bank Ochrony Środowiska) did not have such functionality at the time of the study.

During the tests, the payment methods available in the applications were verified. The client's (respondents) task was to find them in the applications. The assessment of available payments in applications is presented in Figure 2.
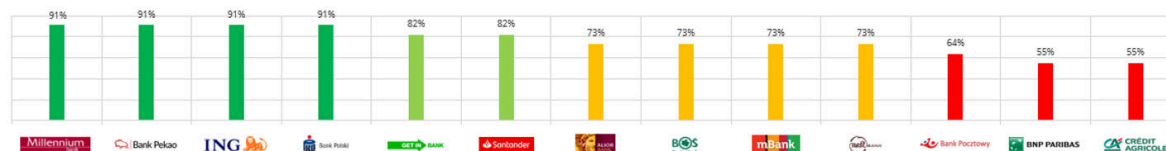


**Figure 2.** Assessment of available payment methods in mobile applications. Source: Own study based on a survey conducted in November and December 2021 as part of the Institution of the Year project (realized by mojebankowanie.pl).

Finding own, domestic, or instant transfer options were available in all banks and easy to find for customers in almost every application. The problem appeared when searching for an instant transfer in 3 banks. The transfer to the phone number was available in 9 banks. The essential BLIK function, which is the BLIK code, was already available in every mobile application, which is excellent progress compared to the results of the research conducted two years ago and following the basic need of customers to pay for online purchases. Other BLIK functionalities are no longer standard in mobile applications. BLIK checks were available only in 4 applications, a request for a BLIK transfer in 3, and a BLIK account division in 2 applications. Standing orders can be made in almost any mobile application. Only two banks do not offer standing orders. In the objective assessment of the BLIK function, the applications of PKO BP, Bank Millennium, and ING Bank Śląski were ranked very high.

The respondents had no problems with the implementation of basic instructions. The choice of the source account, the selection of the recipient from the list, or the pasting of the invoice is available in every application. For convenience, numeric keypads appear automatically in all applications when entering the account number and the transfer amount. The system also checks the available funds before authorization in almost every bank (only one does not have this

functionality yet). It was not difficult for our clients to make the first and subsequent transfers in all applications.

The study evaluated the transaction authorization process in several variants. Only five banks offer most of the available authorization methods. If the approval is done by entering the PIN, the keyboard should be substituted automatically, and after entering the last digit, the acceptance should be confirmed automatically. This is a great convenience when entering data. However, this happens only in half of the tested applications. Audience management was assessed in the same way. The ease of adding recipients is a valuable convenience for the customer. The best-rated applications in this dimension are Bank Millennium, BOŚ Bank, Bank Pekao, and ING Bank Śląski. The ability to add recipients to the list of recipients from the history of operations positively surprised customers in the ING application. Finding the list of recipients was not intuitive and fast everywhere, and in 4 applications, serious difficulties were encountered.

A prevalent form of payment is scanning a QR code available in 12 analyzed applications. Importing the code in the gallery is becoming a standard because customers often receive invoices electronically. Eight applications allow a customer to import a QR code.

The history of operations in the mobile application was assessed well in 9 banks, as shown in Figure 3.
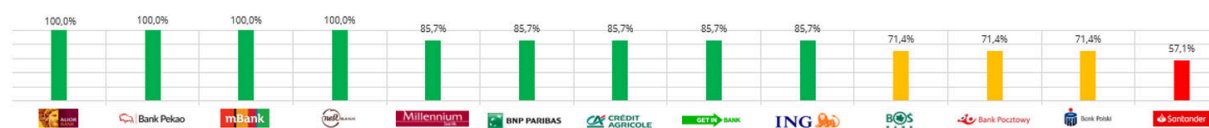


**Figure 3.** Objective assessment of the history of operations in banks' mobile applications. Source: Own study based on a survey conducted in November and December 2021 as part of the Institution of the Year project (realized by mojebankowanie.pl).

Alior Bank, Bank Pekao, mBank, and Nest Bank applications were rated the highest in this respect. Important functionalities appreciated by customers are extensive search filters, covering not only the amount and period but also the currency, type, and type of operation or category of expenses. Searching for a transaction with a phrase or searching for an amount by entering a word and automatic searching by entering characters is an additional convenience for customers. Most applications offered this functionality. Mobile applications also allow a user to push notifications, ranging from receipts and expenses to more complex information. Customers need to be able to configure them in different ways, depending on individual preferences. Sending a notification about each incident is burdensome, which was confirmed by our clients during meetings in focus groups.

For this reason, having more detailed settings for notifications is so essential. The proposed settings for push notifications based on the history of operations were a positive surprise at mBank. Only in the applications of 3 banks is it not yet possible to set push notifications, which was an example of a lack of adaptation to customers' needs.

An essential element of the app evaluation is the management of cards and payments by phone. The best applications give customers the ability to add cards for mobile payments. This functionality makes it possible to add a card without the need to use a card. In the study, customers testing the applications added cards in 3 banks: ING Bank Śląski, Alior Bank, and Getin Bank. The virtual contactless BLIK card was already available in the applications of 6 banks. Canceling the card allows for ten applications, but in the previous analyzed period (in 2020), banks already offered this functionality (it was added by one bank in this interval). Most applications also allow users to edit card limits, change PINs or order a new card. Half of the surveyed applications will enable clients to add a card to a foreign currency account, which is very important when traveling abroad. Skipping a visit to the bank or calling the hotline is a great help and allows the user to add a card even when abroad. mBank has distinguished itself with additional options, such as excluding foreign transactions, turning off the magnetic strip, turning off DCC transactions, or turning off surcharge transactions. However, as reported in a 2020 study, these options were available before.

The applications of many banks allow the customer to contact the bank: the "tap to talk" hotline is available in 7 banks, and the chat from the application level in 5 banks. This is the fastest way to interact with customers without additional customer identification. The assessment results are presented in Figure 4.
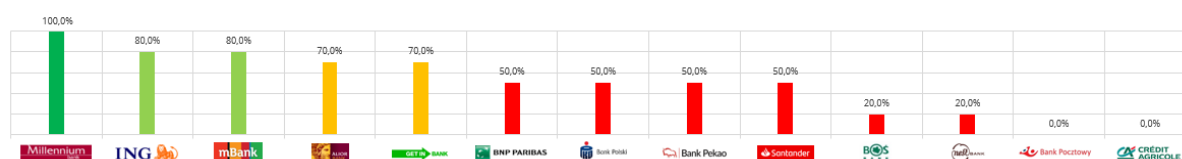


**Figure 4.** Assessment of contact with the bank after logging in to the mobile application. Source: Own study based on a survey conducted in November and December 2021 as part of the Institution of the Year project (realized by mojebankowanie.pl).

In addition, some applications allow the user to edit select customer data, such as data from an ID card, blocking an ID card, or changing a correspondence address or contact phone number. Only one bank – ING Bank Śląski – decided to change the phone application for authorization.

Mobile applications also provide additional options, such as purchasing tickets, paying parking fees, exchanging currency, or opening banking. PKO Bank Polski, ING Bank Śląski, Santander Bank Polska, and Bank Pekao stood out in this regard. Users could buy public transport tickets in half of the tested applications; in 5, they could pay for motorway travel and 8 for parking. The testing clients had no significant problems with paying for parking; in 4 banks, it was transparent and intuitive for everyone.

An essential element is the ability to personalize the application, such as choosing a default account, choosing a context, hiding selected products, changing the order of displaying products, adjusting shortcuts on the desktop after logging in, and the account balance in amount and percentage, selection of accounts to show the balance, language selection, etc.

The applications allow users to apply for additional products: personal, savings, and currency accounts, deposits, account limits, credit cards, insurance products, and even company accounts. Our sample clients applied for a foreign currency account to check these functionalities. It was possible in the applications of 10 banks and caused no problems to the testing clients.

Security is an essential topic in mobile applications. The change of data and available limits are confirmed differently in individual banks. In an objective assessment, Bank Millennium, Credit Agricole, BNP Paribas, Nest Bank, PKO Bank Polski, and Santander Bank Polska were rated the best in terms of security. The maximum transaction limits were imposed at many banks. Minor restrictions were imposed only on Bank Pekao, Nest Bank, and ING Bank Śląski.

### 3.4. Overall customer appraisal of the app

After analyzing mobile applications from 13 banks, considering their functionalities, ergonomics assessment, and evaluation during tests of real customers and their observations during meetings in focus groups, the best ones were selected. The results for individual criteria and the weighting of the assessment are presented in Figure 5. The results regarding the best mobile applications according to the respondents are shown in Figure 6.
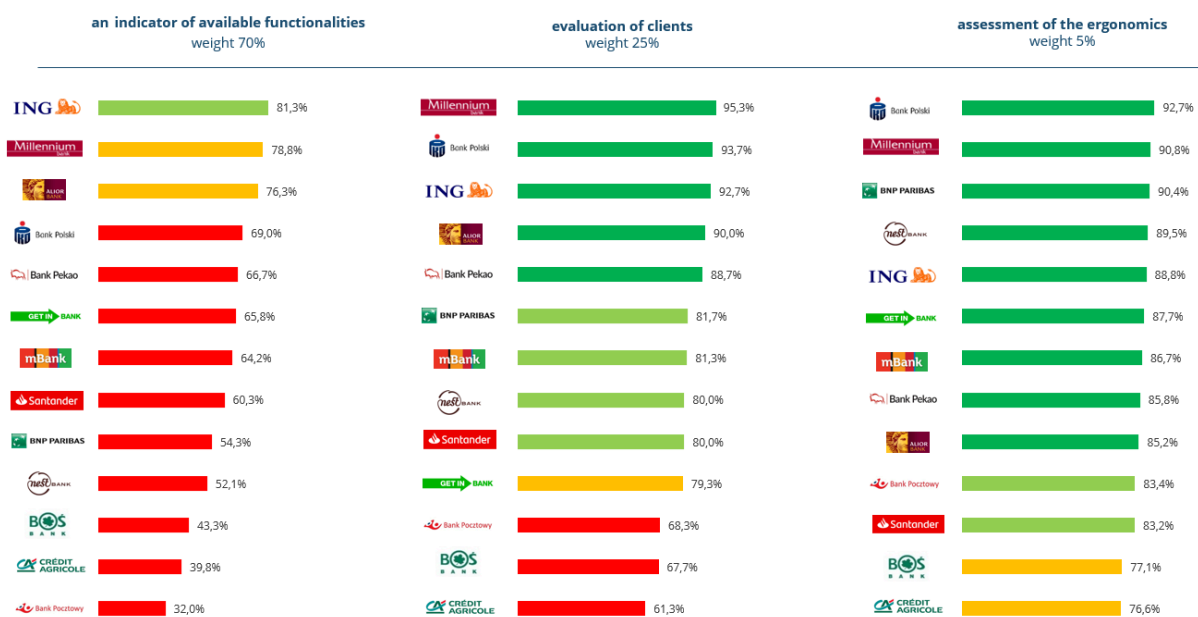


**Figure 5.** The results of the evaluation of the choice of the best mobile application. Source: Own study based on a survey conducted in November and December 2021 as part of the Institution of the Year project (realized by mojebankowanie.pl).

The best mobile applications are from ING Bank Śląski, Bank Millennium, and Alior Bank. In the period considered, the applications of these banks were also among the best on the market as assessed by the Institutions of the Year rankings. These banks systematically follow the market requirements and introduce improvements expected by customers.
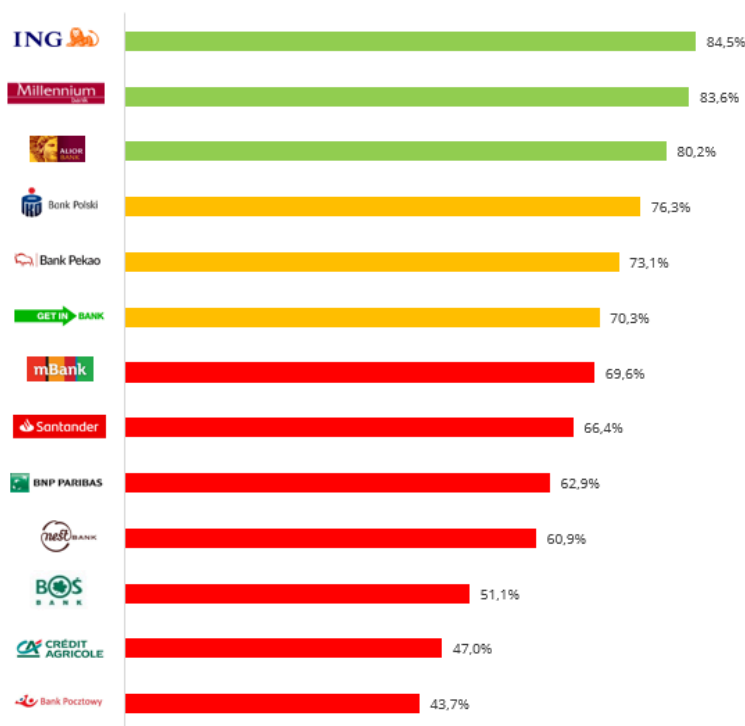
**Figure 6.** The best mobile applications – global evaluation results. Source: Own study based on a survey conducted in November and December 2021 as part of the Institution of the Year project (realized by mojebankowanie.pl).

## 4. Benefits of using mobile applications

Since the beginning of March 2020, banks have faced a new challenge related to customer service during the COVID-19 pandemic. Another element associated with securing contact with the bank was added to the research conducted periodically as part of the Institution of the Year project during the pandemic outbreak. The introduced facilitation in access to the application, requiring less data input at every stage of mobile applications, must go hand in hand with security. The pandemic has significantly impacted banks' functioning and mobile applications development because security is an additional argument for redirecting certain operations to this place. Even before the pandemic outbreak, banks tried to turn some functions into remote services, but from 2020 this trend has become faster than before. Typically, the direction of changes in mobile applications is determined by customers whose opinion is critical. At this time, clients and banks wanted to redirect as many operations as possible to minimize personal contact with the bank.

In customers' view, an excellent mobile application must be intuitive. Customers want to have many functionalities in the application so they do not have to return to online banking or other contact channels with specific functionalities. An important function is the ability to personalize the application. During focus group experiments, customers would even like to

adapt their application to current, often temporary, situations and do this smoothly and quickly using a minimum number of steps. During the focus meetings, clients noticed that not all banks quickly adapted the application to market requirements. The lack of basic functionality in some applications, mainly used by customers, was surprising during the focus meetings. In this case, listening to the voice of customers is especially important.

Looking at the speed and direction of the introduced changes, from the point of view of banks making improvements to their applications, an additional objective is reducing customer service costs in other contact channels. The simplicity of mobile operation results in fewer customer inquiries in other media. High functionality means a lower need to use traditional banking and additional products that clients can apply for through self-complementary data requests that the bank already has in the system. All these factors reduce the need for advisor participation, resulting in cost reductions for personnel and office space.

Because customers use applications frequently, logging in must be simple and quick. In this regard, customers appreciated the ability to use biometrics. Market forces the introduction of modifications expected by customers and following the changes already introduced by other banks, which customers demand.

During the meetings in focus groups, the authors were surprised that some applications have specific functionalities that customers did not find during testing, e.g., parking fees or purchasing public transport tickets, even though they had been introduced for at least a year. This shows the problem of communicating new or existing functionalities to customers. Reminding users about the availability of certain valuable functions would be advisable in customers' opinion. Such tips should be personalized, so they increase familiarity with the application and do not end up in the "trash."

The mobile application gives customers great freedom of access to their data and available functionalities, so they have access to banking on a 24/7/365 basis. Due to the pandemic, there was a significant increase in the use of mobile applications. Also, many functionalities planned to be introduced in the coming years appeared in applications earlier than anticipated. The leading banks will use this time window to improve their mobile applications. Others will have no choice but to follow.

Basic functionalities were available in all tested applications, also noted in the previous period. The best bank applications implement new solutions by listening to the customer's voice. Adapting the application to the customer's current needs is the only condition for moving from daily banking to mobile applications. Very often, limits on mobile transaction amount slow down the transition process because the customer is forced to make transfers in online banking and does not use the mobile application extensively in other areas. Banks that do not limit mobile transaction amounts will likely attract more attractive individual and corporate clients. When carrying out transfers, the best applications suggest when the amount transferred will be credited to the recipient's account and show the payment amount. If it is necessary to convert the amount, currency exchange windows are available in the application. Sometimes

the exchange rate in the application is more favorable than that offered in the branch. In such comparisons, customers can test all applications and see the differences that determine the transfer and staying in their banking in the mobile application.

The best applications also give users access to data from accounts held at other banks. It is becoming a standard to apply for government programs such as Rodzina 500+, Dobry Start (300+), and Family Caring Capital. Banks are constantly working to adapt them to new requirements so that customers can quickly and conveniently apply for available benefits.

## 5. The impact of crises on the introduction of new solutions by banks

The pandemic crisis has accelerated the growth rate of customers using mobile applications. In addition, the applications offer an immediate opportunity to apply for additional banking products "by click." The decision is made almost immediately. This significantly contributes to reducing the costs of handling applications by advisers in other contact channels and will become a new modus operandi. Additionally, one can notice the appearance of new language versions in the applications. The war influenced the acceleration of this process in Ukraine, where the need to extend the language version to include Ukrainian, Russian and English emerged almost immediately. This shows how banks smoothly adapt their applications to the market's current needs.

We live in a quickly changing environment and handle most of our affairs on mobile devices. The bank's mobile application should therefore support customers in dealing with financial issues and payments at every level.

Bank managers should consider the results of research on banks' mobile applications. They reflect trends in application functionality changes and show what functionalities are missing in individual banks that competitors' clients use. Academic studies should indicate the directions and magnitude of change in banks. After the survey was administered, meetings were organized as part of focus groups, during which customers testing mobile applications shared their feelings about the use of applications of all banks. They are a good reflection of the actual feelings because they are a group of customers who had the opportunity to verify all applications in the same way, following the same steps. A typical bank customer does not have such a comparison, so banks independently perform their customer satisfaction surveys regarding the use of a mobile application and do not give objective results due to a lack of knowledge of other banks' applications.

Additional conclusions from subjective customer assessments of the survey are also valuable supplementary information for bank managers in application design and improvement. This happens by supplementing the application with the possibility of applying for more and more banking products. Before the pandemic, these were mainly credit and debit cards and

savings accounts, but now the scope of offerings is much broader. These products include cash loans, changing overdraft limits, credit cards, personal and currency accounts, children's accounts, purchases of investment products, mortgage loans, travel, motor, property, and health insurance. These products are systematically supplemented by looking at competing banks and considering customer needs. Such rapid development in this area took place during the COVID-19 pandemic. During the pandemic, the ability to purchase non-banking products in mobile applications was also made available. e.g., Such products include public transport tickets or parking lots and highway payments. From the customer's point of view, this is a great convenience to which users quickly get used. These additional functionalities increase the frequency of daily application use and enhance customer loyalty to the bank.

This research focused on the opportunities created for banks resulting from developing and improving mobile applications. The development of mobile applications significantly accelerated during the pandemic. Currently, the enhancements in functionality are practically continuous. The last novelty that appeared after the survey was made available by Bank Pekao S.A. in the Qlips payment mobile application. It is a service that speeds up the payment of invoices and bills and was available in electronic banking at PKO Bank Polski, Bank Pekao S.A., mBank, and Bank Millennium. Other banks will likely replicate this. It is an excellent example of the speed of changes in banks' mobile applications. Managers face new behaviors (of employees and clients) and must adapt to the unique challenges as fast as possible. Banks need to build a reliable brand, especially in these times when customers are surrounded by fear and instability. The banking system needs to become more digital and more involved in understanding customer needs.

The pandemic has become a catalyst for changes, accelerating the processes of using new technologies, perpetuating specific behaviors, and increasing awareness in a more comprehensive group of users.

# 6. Conclusions

The crisis in the form of the COVID-19 pandemic limited direct contact between the customer and the bank, which made it difficult to maintain the bank's customer service at the current level and to achieve current business goals (sale of banking products, acquisition of a new customer). Therefore, banks very quickly focused on developing remote forms of contact and tools enabling remote conclusion of contracts without the need to visit the bank. Most banks quickly implemented remote account opening processes using the selfie method, which allows you to open an account without leaving your home using a smartphone (we take a few photos of the face, make specific gestures, take a picture of the ID card, fill out the application and even in a few minutes we are the holder of a personal account). The best banks allow you to

start and finish the entire account creation process immediately in the mobile application. As a result, the client completes creating an account logged in to his application, which he can use practically immediately. All you need to do is top up your account because the mobile payment options offered in the applications, payments with the BLIK code or BLIK contactless payments, give you the real possibility of managing your funds.

More and more matters can be dealt with on the hotline without visiting the facility. The continuous increase in the role of the telephone channel has also been visible in the recent period. Banks here make things easier by allowing the customer to log in to the mobile application and talk to the consultant about their products from its level. The best banking applications offer the "tap to talk" function, thanks to which a customer logged in to the application connects with the bank as an identified customer with one button. You do not need to log in with your customer number and password for telephone service. For verification, consultants only need to confirm primary customer data, such as the mother's first name, last name, or maiden name. However, this contact option has a downside – the call is made to a landline number. No bank met the expectations of a customer who may find himself in an emergency abroad, where there may be a problem with coverage, or the costs of calling Poland will be exceptionally high. The optimal solution would be to contact the mobile number, thanks to which it would be possible to connect, e.g., via WhatsApp.

Regardless of the development of the hotline and the support offered by consultants, the client needs independent remote servicing of the account and other products. Until now, most of the basic operations could be performed in online banking, but the dynamic development of the telephone market has almost completely replaced traditional telephones by introducing smartphones, which have become increasingly common. Thus, most companies (not only from the banking market) have started to submit mobile applications, which have replaced, e.g., loyalty cards. Banks have had mobile applications for a long time, but in the last few years, we have seen their dynamic development, and one of the accelerating factors was the COVID-19 pandemic. We have been observing the continuous development of new application functionalities for two years. Some of them are innovations, while many changes in applications involve the transfer of functionality from online banking to mobile applications. The constantly growing market share of "mobile only" customers forces the application to be adapted to full account service on the phone without using online banking. Hence such functionalities as, for example, changing the customer's address data or updating the ID card are more and more often visible in applications. The migration of functionality from one channel to another brings a considerable challenge in maintaining the intuitive use of the application and its navigation. A few years ago, the application on the phone was mainly used to check the account balance and history of operations, make a transfer, or generate a BLIK code. Today, in the application on a small screen, banks have to fit a much more comprehensive range of functionalities, presenting them so that the customer knows about their existence and wants to use them.

It is essential to position the functionalities that are used most often and to group those that are used less frequently intuitively. When assessing the application, customers most often refer to the convenience of using it. The best apps offer personalization of the app screen. Depending on the bank, some products or sections in the application may be hidden. The best applications allow you to change the order of products, mask product history, change product names as well as personalize shortcuts on the first screen, change the application wallpaper and dark/light mode, and even personalize the triggering of the biometric factor, thanks to which the customer decides whether he wants to log in immediately or use from shortcuts before logging in. In terms of personalization options, the most advanced applications offer much more than the non-banking applications used by the client. An important area to be developed is customer education in the field of knowledge, which is possible thanks to the application. While customer onboarding is standard in online banking, it is in vain to look for it in applications except for tutorials and laconic welcome information. The customer is on his own. If he properly scrupulously "clicks" the application, he will get to know its possibilities.

From the customer's point of view, an excellent mobile application has several possibilities by providing various functionalities in the field of handling your banking products, applying for new products, and even using other non-banking services, such as a trusted profile, public transport tickets, motorways, or parking lots. The best banks operate multi-threaded and develop the application in every respect. Still, today most banks are at the stage of chasing the leaders. Currently, it can be seen that a certain standard of mobile applications is being formed, but the actions of the leaders are still raising the bar. The application's user-friendliness is determined by the ease of performing basic operations, such as a domestic transfer, and by details that customers appreciate, such as the ability to search for a recipient from the history of functions without having to define it in advance. Compared to last year, biometric authorization, which six banks already offer, has developed significantly. Accepting the process takes only seconds; the customer does not have to enter a PIN or password. It is more common to facilitate the payment of bills in the form of the "Qlips" service or the possibility of scanning the entire invoice without entering the transfer details. However, in both cases, we discuss individual banks on the market.

Customers particularly appreciated the functions related to mobile payments and card support. Apart from BLIK, checking the balance and history and paying bills were the main functions they used daily. Both Apple Pay and Google Pay are not available in all banks, and although these are entirely isolated cases, they show a gap. Sound from the point of view of an emergency, e.g., loss of a card abroad, is the ability to add a card for payment by phone from the times after the reservation. Thanks to this, the customer can always use the funds abroad without possibly paying with the BLIK code. It is a pity that only three banks currently offer such a function. The customer buying online and paying with the card can see the card number and CVV code in the application only in two banks. Customers of other banks must find the card physically to provide the data. Also, only two applications offer to check if the card has,

for example, a Spotify subscription. The remaining customers only need to verify the account history.

An important issue is the security of the client's funds. The applications are very well secured, but the client is the weak point. Facilitating the use of the application carries with it risks. Logging in to the application and authorizing operations with the same PIN is, on the one hand, convenient to use, but on the other hand, the risk of losing funds in the form of losing the PIN and the device on which the application is installed. The best-secured applications for changing key payment-related settings require additional security, e.g., a phone with a code and add a password that only the customer knows and which is different from the PIN. Regardless of the shield itself, customer education is critical. There is a lack of action in this area in mobile applications today. Apart from developing functionalities, banks should also take care of this issue.

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# THE SPATIAL DIVERSITY OF SOCIO-ECONOMIC DEVELOPMENT IN UKRAINE

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**Purpose:** The processes of socio-economic development always take place in a specific space and are not uniform. The modern conditions of regional development vary a lot with regard to the socio-economic development of the particular territorial entities. This is also true for Ukraine, the subject of this study and a current candidate for the European Union. This paper will assess the diversity of socio-economic development of the Ukrainian regions in 2020 and rank these entities according to the level of their development.

**Methodology**: Z. Hellwig's method of development pattern, which helps to order the regions in terms of their development, is applied to the evaluation of socio-economic development of the Ukrainian entities. The indicators adopted are systematised by the following areas: Demographics and job market, Structure of regional economies, Innovation, research and development activities, Technical infrastructure, Social infrastructure, and Condition and protection of the natural environment.

**Findings:** The analysis helps to identify the levels of socio-economic development of Ukrainian regions and the region groups of the highest, high, low, and very low standards of development. The results suggest a great diversity of socio-economic development of these regions. Dnipropetrovsk, Zaporizhzhya, and Kharkiv experience the maximum, while Donetsk and Luhansk the minimum levels of development.

**Research limitations/implications**: The data published by the State Statistics Service of Ukraine for 2020 are used, excluding those for the temporarily occupied area of the Autonomous Republic of Crimea, the city of Sevastopol, and parts of the temporarily occupied areas of Donetsk and Luhansk regions. Further comparative research should estimate the effects of the changes on socio-economic development following the end of the Russian Federation's aggression against Ukraine. Continuing studies may also identify factors with a decisive impact on the regions' attribution to the particular groupings.

**Social implications:** The evaluation of the regional development levels may provide foundations for some strategies of socio-economic development, an explication of causes of regional variations, and a determination of potential for and ways of levelling down the existing inequalities. The diversity of development of the individual Ukrainian regions is important to its status of a candidate to the EU, granted on 23 June 2022. In connection with a closer cooperation between Ukraine and the EU, the results can provide knowledge about where to channel the EU funding aimed at the socio-economic development of the particular regions.

**Originality/value:** The determination of the diversity of socio-economic development and positioning of the Ukrainian regions in this respect. The study can also be seen as a contribution to the existing research and serve the purpose of comparative analysis.

**Keywords:** region; regional development; regional diversity; socio-economic development of regions; Hellwig's method.

**Category of the paper:** research paper.

# 1. Introduction

Socioeconomic development is a highly complex and multi-faceted phenomenon. It's not measurable directly and comprises a series of elements associated with both economic and societal development. The latter itself should be seen as a sequence of directed and irreversible changes in the structures of objects, i.e., systems (Krajewski, 1977).

The dynamics and nature of contemporary socio-economic development processes are determined by spatial and structural diversities. They are not barriers to that development, however, excessive imbalances of socio-economic development standards are problematic (Dominiak, Churski, 2012). Large differences among regions may have adverse effects on the development of a whole country. Supporting socio-economic development on a regional scale is an important issue, therefore, particularly in countries classed as 'emerging and developing economies'. Ukraine is one such country, which, faced with the aggression of the Russian Federation, applied for the membership of the European Union on 28 February 2022 and, on 23 June 2022, the European Council awarded it the status of a candidate country. In regional terms, Ukraine, in spite of efforts taken after it regained its independence in 1991, is characterised by a sharp spatial West-East dichotomy (Kallioras, Tsiapa, 2015).

This paper will assess the diversity of socio-economic development of the Ukrainian regions in 2020 and rank these entities according to the level of their development. Generally available data, chiefly those published by the State Statistics Service of Ukraine for 2020, are used. They fail to include any figures for the areas of the Autonomous Republic of Crimea, the city of Sevastopol, and some parts of Donetsk and Luhansk regions, occupied by the Russian Federation since 2014.

# 2. Literature review

Economic development comprises some structural as well as other changes that accompany economic growth (Kemerschen, McKenzie, Nardinelli, 1991). It's a process of quantitative and qualitative change in an economy (Gondek, 2016). The former are expressed with the rate of

economic growth, while the latter relate to the quality of goods and services produced, the structures of product ranges, labour, improvements to technology, management or human capital growth, among other things. Thus, an economy may exhibit growth without development, but not the other way round (Kemerschen, McKenzie, Nardinelli, 1991). Economic development defines overall changes in an economy in the long term (Bąkiewicz, Czaplicka, 2011). It's broader in scope than economic growth. Economic development is a 'historical (long-range) process of a country's internal economic and social change that produces a society looking for ways of improving its economic position and organised in ways allowing and encouraging citizens to invest in material, human, and intellectual capitals necessary for their uninterrupted accumulation' (Nasiłowski, 2004).

Social development, in turn, denotes a 'change in a system of societal relations, the structure of a society, its preferences, social criteria and rules of conduct, patterns of behaviour, attitudes, and awareness that serve to improve the coexistence and collaboration of people and their adequate participation in the effects of economic development' (Marciniak, 2005). This is therefore a process of important and irreversible transformations in social structures that has its dynamics and direction and is conditioned by, inter alia, specific natural, demographic, social, economic, and political factors (Dzieciuchowicz, 2011). The major elements of social development encompass: a diversity of scientific and cultural heritage, the quality and dynamics of its expansion, the availability of economic development effects, some changes in individual and group models, attitudes, and awareness (Marciniak, 2005).

An exploration of the development of a given country or region cannot be restricted to economic or social factors only. Both the aspects need to be addressed (Milenkovic et al., 2014). Socio-economic development offers a wider view of the development of an economy and society. It has already been mentioned this is a highly complex and multidimensional phenomenon. It's regarded as 'a systematic improvement to a population's living conditions, rising welfare and cultural benefits based on a comprehensive societal progress and a universal and equal access to social facilities, the provision of optimum conditions for individual and societal development as the forms and principles of societal living improve' (Piontek, 2006). The socio-economic development is a process of quantitative, qualitative, and structural changes as a result of actions undertaken as part of societal (economic) practice. These changes affect: material living conditions, economic structure and entrepreneurship, access to public goods and services, relations within a social system, the condition of the natural environment, and life satisfaction (Litwiński, 2017). Thus, the socio-economic development can generally be defined as a process of changes or improvement to social and economic conditions that affect an individual, organisation, or an entire country (Roztocki, Weistroffer, 2016).

In spatial terms, the socio-economic development can refer to a variety of territorial levels like local, subregional, regional or national. It should be stressed regions are integral parts of a country, thus the latter's socio-economic development is to a substantial extent determined by the development of its particular regions.

Regional development means a continued growth of economic potential and living standards on the scale of a given territorial unit (Szymla, 1994). It can also be treated as a set of changes in a given territorial unit resulting in an enrichment of its internal structural elements as well as relations among these elements. In other words, these changes bring social and economic progress to that area (Kocurek, 2013). It's also regarded as irreversible quantitative and qualitative changes which tend to produce a permanent growth of socio-economic and cultural potential of a region (Kudełko, 2005). In turn, T. Kudłacz defines regional development as a 'permanent growth of living standards and economic potential on the scale of a give territorial unit' (Kudłacz, 1999). A. Klasik (Klasik, 1997) expands on the above definition by pointing to the factor of competitiveness. In his view, regional development is a continuing growth of three elements: the economic potential of regions, their competitive power, the living standards and quality of life of residents that contribute to the socio-economic development of a country. The foregoing definitions identify the so-called components of regional development which can serve to determine the following areas of regional development (Strahl, 2006):

- The residents of a region.
- Regional ecosystem.
- Infrastructure.
- Regional economy.
- Space – the territory of a region.

The regional development comprises changes taking place at the same time in a number of overlapping and interacting areas. It's normally defined from the perspective of changes in its following components: economic potential and structure, natural environment, infrastructure, spatial order, living standard, and landscape planning. Therefore, the assessment of progress on the processes of socio-economic development of regions consists in the identification and measurement of changes in its component parts (Bell, Morse, 2008; Ginevičius, Gedvilaitė, Bruzgė, 2015).

## 3. Research method

The methods of linear ordering are among the ways of classifying or establishing an order of multidimensional objects. The methods, a branch of taxonometry, are largely achievements of the Polish econometric and statistical thought (Pociecha, 2008; Bąk, 2017).

Z. Hellwig's taxonomic method, also known as multidimensional comparative analysis (MCA) (Hellwig, 1968, 1981), is employed in the assessment of Ukrainian regions' socio-economic development. It helps to rank certain objects in a multidimensional space of characteristics (Pociecha, 2008). Such a ranking is based on a synthetic variable (indicator) (Hellwig, 1981). There are two groups of methods to estimate the synthetic variables, namely,

non-model and model methods (Bąk, 2017). The MCA is a model method as it relies on the design of an abstract object $P_0$, referred to as the development model (in particular, it may be a real object). The objects studied are ordered according to their distance from the development model, which allows to identify the level of their development (from 'the best' to 'the worst').

The taxonomic study consists of several stages. The first is designed to determine the goal and scope of the research. This paper aims to assess the diversity of socio-economic development of the Ukrainian regions in 2020 and identify some groups of regions with comparable levels of development.

The next, important stage is the selection of characteristics. To be precise, it's divided in two steps: a choice of characteristics on their merits and a formal application of the variation coefficient (Tarka, 2012). The characteristics (variables) chosen should (Tarka, 2012; Bąk, 2017):

- Well discriminate objects.
- Be weakly correlated with one another.
- Be strongly correlated with rejected characteristics.

Therefore, the study begins with a rejection of characteristics that are neither evidently or hypothetically related to a phenomenon examined, the so-called redundant characteristics, from a list of potential characteristics (the choice on merits). Based on the coefficient of variation, characteristics of a low variability are eliminated (the formal selection). Those for which the coefficient is below the threshold value of 0.1 are treated as quasi-constant and removed from the list (Hellwig, 1981). The coefficient of variation is calculated as follows:

$$V_j = \frac{s_j}{\bar{x}_j}$$  (1)

where:

sj – the standard deviation of jth characteristic,

$\bar{x}_j$ – the arithmetic mean of jth characteristic.


It should be stressed the socio-economic development is a multidimensional category and the final results of comparative analyses, beside the methods applied, are first of all determined by a list of diagnostic variables adopted for the purpose of study. With this in mind, a final list of characteristics is a compromise between the desire to represent the key aspects of a phenomenon under analysis, their overall consistency with the characteristics discussed by specialist literature and an author's experience of an aspect studied, and the availability of databases. An initial list for the study of the socio-economic development of Ukrainian regions comprises 51 characteristics. On the removal of those redundant and quasi-constant, 46 characteristics remain, grouped into six areas that reflect the following major aspects of:

- Demographics and job market.
- Structure of regional economy.
- Innovation and research and development activities.
- Development standard of technical infrastructure.
- Development standard of social infrastructure.

Condition and protection of the natural environment.

In the group describing the demographics and job market, the following characteristics are distinguished: X1 – population per 1 km$^2$, X2 – urban population as a % of total population (the level of urbanisation), X3 – the balance of migration per 1,000 population, X4 – professionally active population aged 15-70 per 1,000 inhabitants, X5 – disposable income per capita, X6 – the rate of unemployment as a % of working age population to the workforce of a given age, X7 – the working age unemployed, X8 – informal employment of population as a percentage of employed population aged 15-70. The group describing the structure of regional economy comprises the following research characteristics: X9 – the number of businesses per 1,000 population aged 15-70, X10 – industry and construction workers aged 15-70 per 1,000 population, X11 – a share in the national sold production, X12 – sold industrial production, X13 – industrial investment expenditure per 1 industrial worker aged 15-70, X14 – the proportion of industrial and construction investment expenditure to total investment expenditure, X15 – the share of agricultural plantation to the total area, X16 – the yields of cereals and leguminous crops, X17 – the yields of sunflower, X18 – per capita revenue of regional budgets. The characteristics of innovation and research and development activities include: X19 – R&D employment per 1,000 professionally active people aged 15-70, X20 – the innovation spending of industrial enterprises (employing more than 49) as a percentage (a region's share nationally), X21 – R&D expenditure per capita, X22 – the proportion of R&D expenditure to GNP, X 23 – innovative industrial enterprises per 10,000 population. The following are specified among the variables defining the development standard of technical infrastructure: X24 – the geographical density of hard surface public roads [km/100 km$^2$]; X25 – the demographic density of hard surface public roads [km/10,000 population], X26 – the geographical density of railroads [km/100 km$^2$], X27 – the demographic density of railroads [km/10,000 population], X28 – the percentage of population using water supply systems, X29 – the percentage of population using sewage systems, X30 – inhabitants of collective accommodation facilities per 1,000 population, X31 – transport accident casualties per 100,000 population, X32 – m$^2$ of housing resources per capita. The analysis of social infrastructure provision is conducted in consideration of the following characteristics: X33 – the mortality of infants below 1 per 1,000 of live births, X34 – the number of doctors (except dentists) per 10,000 population, X35 – the number of hospital beds per 10,000 population, X36 – nursing home places for the elderly and disabled per 1 disabled pensioner, X37 – the number of children in pre-school education (aged 1-6) as a % of children of the same ages, X38 – pupils at secondary educational institutions per 10 000 population, X39 – students

at universities per 1000 population, X40 – libraries and community centres per 1000 population. The following characteristics are utilised to analyse the condition and protection of the natural environment: X41 – air emissions from means of transport per 1 $km^2$, X42 – CO2 emissions per 1 $km^2$, X43 – the recovery of recycled polluted water, $m^3$ per capita, X44 – the disposal of recycled polluted water into surface water facilities relative to the yield of sewage treatment plants, X45 – the share of waste incineration and reused or recycled waste in the total amount of waste generation, X46 – investment expenditure on the environment protection per capita.

The procedure continues to remove the characteristics which don't contain sufficient information, since the similarity of some characteristics causes them to potentially carry the same information and form clusters, or subsets including a central and some satellite characteristics. A cluster consists of a central and a minimum of one satellite characteristic. Diagnostic variables not included in clusters are named isolated characteristics. A final list of characteristics to be analysed is constituted by central and isolated characteristics (Hellwig, 1981).

Hellwig's parametric method of classifying the variables serves to determine the base variables (the final list of characteristics). Its algorithm encompasses (Hellwig, 1981; Bąk, 2017):

- The creation of a correlation matrix $R_{mxm}$,

$$R = [r_{ij}] \begin{bmatrix} 1 & \cdots & r_{1m} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & 1 \end{bmatrix}, \tag{2}$$

where:

i, j = 1,2, ….m,

m – the number of variables (characteristics).

- The calculation of total coefficients of correlation for each column of R out of their absolute values:

$$R_j = \sum_{i=1}^{m} |r_{ij}|, \tag{3}$$

- Finding a column (k) with a maximum $R_j$:

$$R_k = max_j\{R_j\}, \tag{4}$$

- The identification of a central variable numbered (k) and of satellite variables, for which:

$$|r_{ij}| > r^*, \tag{5}$$

where:

$r^*$ – the threshold coefficient of correlation.

- The removal from matrix R of columns and lines corresponding to the identified central variable and satellite characteristics to arrive at a reduced square matrix.
- The repetition of the foregoing steps until the last reduced matrix is liquidated; the variables not included in any cluster are isolated characteristics.

Since the test applies to an entire set, not a random sample, the boundary coefficient of linear correlation r$^*$= 0.8 is adopted. Statistics textbooks treat this value as strong. The variables: X1, X4, X7, X9, X12, X13, X16, X18, X19, X20, X21, X27, X29, X30, X39, X41, and X42 are considered satellite characteristics. The remaining 29 characteristics are central or isolated and constitute the set of base characteristics (the final list of characteristics).

The procedure leading to the establishment of Z. Hellwig's synthetic measure of development proceeds to divide the characteristics into stimulants and destimulants. The former's growth is deemed positive and decline negative from the perspective of a system, phenomenon, or process studied. A characteristic whose absolute rise is found adverse and a reduction is found positive is termed a destimulant, on the other hand (Hellwig, 1981).

Stimulants prevail among the base variables adopted for the purposes of study. Only 4 out of 29 characteristics are destimulants, namely, the rate of unemployment as a % of working age population to the workforce of a given age, informal employment of population as a percentage of employed population aged 15-70, transport accident casualties per 100,000 population, and the mortality of infants below 1 per 1,000 of live births. The base characteristics adopted seem to provide the foundations for an accurate analysis of the diversity of socio-economic development of the Ukrainian regions.

The base variables are unit quantities. The variety of units and measures and the different natures of stimulants and destimulants cause characteristics to be normalised (standardised). The transformation follows the formula (Hellwig, 1981; Brzozowska-Rup, Czaja, Piotrowska-Piątek, 2020):

$$Z_{ik} = \frac{x_{ik} - \bar{x}_k}{S_k},$$                                                                                                      (6)

where:

$Z_{ik}$ – the standardised value of characteristic k for region I,

$x_{ik}$ – the value of characteristic k in region I,

$\bar{x}_k$ – the arithmetic mean of variable k,

$S_k$ – the standard deviation of variable k.

The subsequent stage consists in determining a development model defined as an abstract object P$_0$ characterised by the maximum values of stimulants and minimum values of destimulants and having standardised coordinates:

$$P_0 = [z_{01}, z_{02}, \dots, z_{0k}],$$                                                                                                      (7)

where:

$z_{0k} = \max\{z_{ik}\}$ – where $x_k$ is a stimulant,

$z_{0k} = \min\{z_{ik}\}$ – where $x_k$ is a destimulant.

Taxonomic (Euclidean) distances between the particular objects and the adopted model $P_0$ are then computed as follows:

$$c_{i0} = \sqrt{\sum_{k=1}^{m}(z_{ik} - z_{0k})^2}, \tag{8}$$

where:

i = 1, 2, 3, ..., n.

The final stage of linear ordering involves the calculation of the synthetic indicator. To normalise the values of di, a relative taxonomic measure of development is built and computed as:

$$d_i = 1 - \frac{c_{i0}}{c_0}, \tag{9}$$

where:

i = 1, 2, 3, ..., n,

$$c_0 = \overline{c_0} + 2 * s_0, \tag{10}$$

$\overline{c_0}, s_0$ − the arithmetic mean and standard deviation of the sequence $c_{i0}$ (i = 1, 2, 3, ..., n), respectively.

The calculated synthetic measure of development $d_i$ (9) equals [0;1]. The higher it is, the less distant a given object (region) is from the model and the greater its socio-economic development. The above approach helps to identify the levels of socio-economic development of Ukrainian regions and to divide them into four groups:

Group I:    the regions of the highest indicator of development level ($d_i \geq \overline{d_i} + S_{di}$).

Group II: the regions of a high indicator of development level ($\overline{d_i} \leq d_i < \overline{d_i} + S_{di}$).

Group III: the regions of a low indicator of development level ($\overline{d_i} - S_{di} \leq d_i < \overline{d_i}$).

Group IV: the regions of the lowest indicator of development level ($d_i < \overline{d_i} - S_{di}$).

where:

$d_i$ − the value of the synthetic indicator,

$\overline{d_i}$- the arithmetic mean of the synthetic indicator,

$S_{di}$ − the standard deviation of the synthetic indicator.

The study is based on the statistics provided chiefly by the statistical publication Regions of Ukraine 2020 Part I ('Статистичний збірник «Регіони України» 2020 Частина I', 2021) and Part II ('Статистичний збірник «Регіони України» 2020 Частина II', 2021), as well as the website of State Statistics Service of Ukraine (*Державна Служба Статистики України*, 2022).

## 4. Results and discussion

The Ukrainian regions are classified by means of a synthetic measure based on 46 characteristics adopted. The measure is designed to order the regions in respect of their socio-economic development. Thus ordered, the units are then grouped into four principal classes of similar development levels.

The Dnipropetrovsk region ranks first with an indicator of 0.444 (Table 1 and Figure 1). It's followed by Zaporizhzhya (0.405) and Kharkiv (0.384). The regions of a high development standard constitute the largest grouping. The regions of Donetsk and Luhansk, on the other hand, come last with Hellwig's indicators of (-0.081) and (-0.166), respectively.

**Table 1.**
*The levels of socio-economic development of Ukrainian regions in 2020 based on Hellwig's taxonomic measure of development*

| No. | Region | $d_i$ |
|---|---|---|
| **Group I** $di \geq 0.464$ | | |
| 1. | Dnipropetrovsk | 0.444 |
| 2. | Zaporizhzhya | 0.405 |
| 3. | Kharkiv | 0.384 |
| **Group II** $0.256 \leq di < 0.464$ | | |
| 4. | Kyiv | 0.354 |
| 5. | Poltava | 0.340 |
| 6. | Lviv | 0.320 |
| 7. | Khmelnytskiy | 0.318 |
| 8. | Sumy | 0.314 |
| 9. | Cherkasy | 0.291 |
| 10. | Vinnytsya | 0.285 |
| 11. | Ternopil | 0.281 |
| 12. | Mikolayiv | 0.278 |
| 13. | Chernivtsi | 0.273 |
| 14. | Ivano-Frankivsk | 0.266 |
| 15. | Kirovohrad | 0.266 |
| 16. | Odesa | 0.264 |
| 17. | Zhytomyr | 0.258 |
| **Group III** $0.128 \leq di < 0.256$ | | |
| 18. | Chernihiv | 0.249 |
| 19. | City of Kyiv | 0.245 |
| 20. | Rivne | 0.233 |
| 21. | Kherson | 0.206 |
| 22. | Volyn | 0.195 |
| 23. | Zakarpattya | 0.182 |
| **Group IV** $di < 0.128$ | | |
| 24. | Donetsk | -0.081 |
| 25. | Luhansk | -0.166 |

Source: The authors' own compilation.
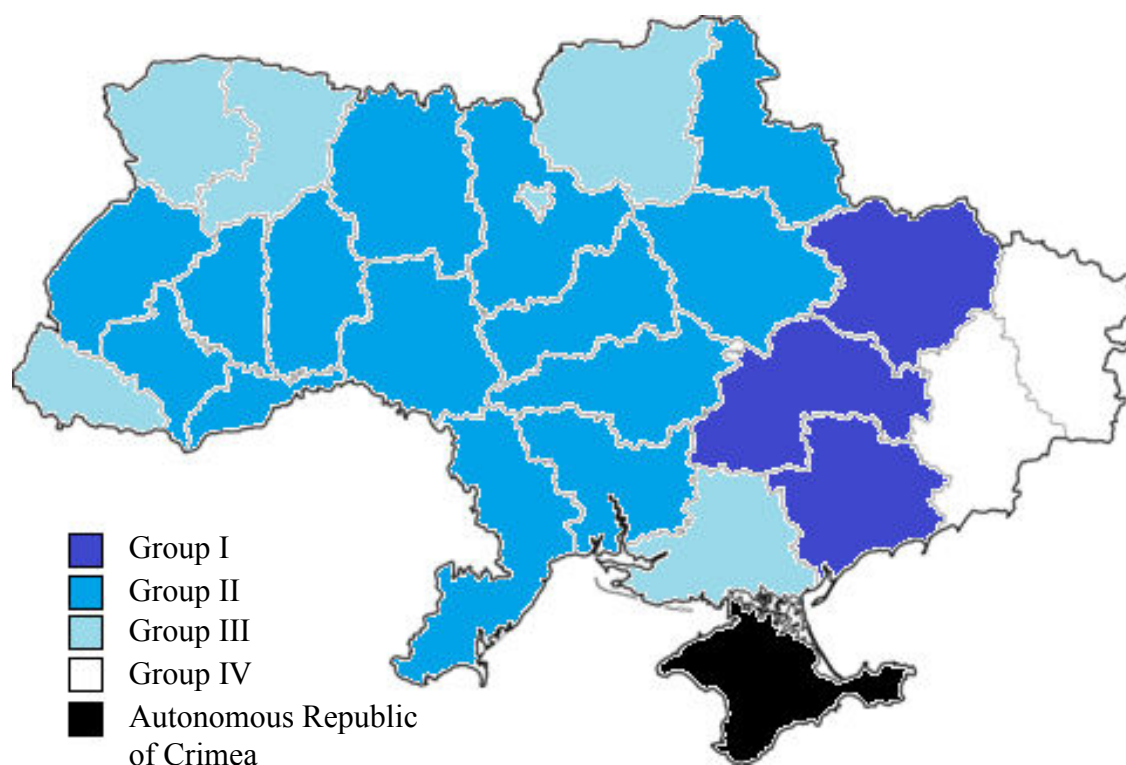
**Figure 1.** The socio-economic development of the Ukrainian regions in 2020.

Source: The authors' own compilation.

Dnipropetrovsk, Zaporizhzhya, and Kharkiv formed the group of maximum development in 2020. The distance between the region of Dnipropetrovsk and the leader is 0.03. The latter owes its position to the strongly developed metallurgy, chemical, and space rocket production industries as well as a number of natural raw material deposits and a key Ukrainian financial centre located there. The second, most numerous grouping (14 units) consists of the following regions: Kyiv, Poltava, Lviv, Khmelnytskiy, Sumy, Cherkasy, Vinnytsya, Ternopil, Mikolayiv, Chernivtsi, Ivano-Frankivsk, Kirovohrad, Odesa, and Zhytomyr. Its Hellwig's indicator is in the range $0.256 \leq di < 0.464$. It needs to be pointed out its leading region of Kyiv leaves its follower, Kharkiv, behind by 0.03 points. The third group of a low standard of development comprises six regions: Chernihiv, City of Kyiv, Rivne, Kherson, Volyn, and Zakarpattya. The group of minimum standard of development encompasses just two regions, Donetsk and Luhansk, in the year studied. They show negative synthetic indicators, denoting an extremely low level of development.

The classification of regions according to Hellwig's synthetic indicator points to large differences in the standards of socio-economic development. The gap between the maximum of 0.444 (Dnipropetrovsk) and minimum of -0.166 (Luhansk) is 0.610. The numbers of territorial units are well structured, that is, the regions of the highest and high development prevail (17), whereas barely 8 are in the groups of low and minimum levels of development.

Each region strives for economic growth, possible by effectively utilising competitive advantages and thus improving the level of socio-economic development. Any imbalances of economic and macroeconomic policies and decisions at the national level can also be felt on the regional scale (Chirinko, Wilson, 2008; Andrusiv et al., 2020).

Comparative analyses among the Ukrainian regions with regard to the levels of their socio-economic development serve to identify those most similar as far as the adopted assessment criteria are concerned. A number of publications corroborate differences in the development of territorial units, while the rankings of regions from the viewpoint of selected variables help to precisely designate those best developed (Kozyreva, Sagaidak-Nikituk, Demchenko, 2017; Kozyreva et al., 2017; Miłek, 2018; Tiulkina, 2019; Andrusiv et al., 2020; Пошивалова and Прошкіна, 2020). The results are comparable, except for position variables for some regions.

Some authors draw attention to connections between regional digital divides and the levels of socio-economic development, a problem for sustainable development, particularly in the 'backward' regions of Ukraine (Deineko et al., 2022). The paper analyses the international practices of digital divide management and offers recommendations for public policy to overcome digital inequalities. K.Tiulkina (Tiulkina, 2019) discusses the socio-economic development of Ukrainian regions considering sustainable development. Her results affirm the presence of the groups of leaders, medium, and low development level regions similar to the results generated in this article.

O. Kozyreva et al. (Kozyreva et al., 2017) corroborate our results. The transformation processes in Ukraine affect regional development in different ways. Some regions have mobilised the potential in place and gradually adapted to hard economic realities, whereas others are in a state of stagnation, which widens regional disproportions. The leaders in light of the synthetic social development indicator in 2014 included Kharkiv, Dnipropetrovsk, Zaporizhzhya, Odesa, and the City of Kyiv. The City of Kyiv, Dnipropetrovsk, Kyiv, Poltava, and Kharkiv scored best on economic development.

In general, the processes of socio-economic development are not homogeneous in terms of space. Due to a variety of historical conditions and the changes of internal and external factors, the development processes do not take place with the same intensity in every area. In order to remove the development disparities, the European Union pursues its cohesion policy, whose instruments are to prevent the differences from widening and to help reduce the disproportions in the socio-economic development of countries (Gawlikowska-Hueckel, Szlachta, 2014; Michoń, 2017). The potential joining of the EU by Ukraine offers an opportunity for bridging development gaps using the EU funds. In the situation of growing inter-regional disparities and seeking some ways of minimising the adverse effects of territorial disparities, therefore, an urgent need arises of assessing the levels of socio-economic development of Ukrainian regions in order to identify the development potential and improve the effectiveness of economic activity.

## 5. Conclusions

The level of socio-economic development of regions is of interest to economic and macroeconomic policies. Our results may serve the management of the Ukrainian regions' development. This study offers the following conclusions:

1. The Ukrainian regions exhibit some varied levels of development. The distance between the leader (Dnipropetrovsk) and the bottom region (Luhansk) suggests a considerable spatial differentiation (the divergence is 0.610). The level of development estimated by means of the synthetic indicator shows a nearly 3:1 distance between the ranking leader and the bottom region.

2. Most Ukrainian regions demonstrated the highest and high levels of socio-economic development in 2020. They are led by Dnipropetrovsk, which founds its advantage on a well-developed economy (including the industry) and innovation, research, and development activities. Kharkiv likewise generates high values for the characteristics of economy, innovation and R&D, though it comes second on the indicators of: R&D expenditure per capita in hry. − 1093.94 (the City of Kyiv is first with 2 844.00). Zaporizhzhya is in the first group with its high values of the following variables: X10, X14, X15, X22, and X23. The results fail to demonstrate a clear-cut split into the eastern and western Ukraine, but most region in groups I and II are situated in the eastern part of the country (with the exception of Donetsk and Luhansk). However, Kallioras and Tsiapa (Kallioras, Tsiapa, 2015) point out the spatial division into the eastern and western areas is profound, with some large divergences of their economic and production structures, although the dichotomy cannot be seen as unidimensional, purely economic or social; it is multidimensional.

3. The results of statistical analysis of socio-economic development levels in the Ukrainian regions provide national decision-makers with substantive knowledge needed to make decisions and finance actions to improve the development of Ukrainian regions and thus to improve the quality of life. They may also assist with decisions concerning financial support, i.e., EU funding to the particular countries. The development of Ukrainian regions is of importance to foreign investors' decisions associated with capital allocations. They are after all dependent on investment attractiveness, which consists in the development standard and innovativeness of an economy, human capital resources, the accessibility of economic and social (including telecommunications) infrastructure, the environment condition, the regions' attitudes to investors, and the standards of public security.

4.  This paper makes contributions of two types to the discussion of its subject matter. First, it provides a theoretical framework to socio-economic development. Second, it offers an empirical verification of the spatial diversity of the socio-economic development of Ukrainian regions. The assessment is based on the adopted characteristics using the multidimensional statistical analysis. The availability of data is a limitation of this study.

5.  This project identifies several areas for further research. It should aim to compare the development of Ukrainian regions to that of the European Union countries. A more in-depth analysis of the impact of the adopted factors on the socio-economic development of Ukraine is welcome. Since this study addressed data for 2020, the research may continue to determine the effects of the pandemic on the regional development of Ukraine in the context of its development potential, as well as the Russian Federation's aggression of 24 February 2022. The research should continue to identify any change tendencies of selected indicators following the start of military operations in February 2022, with a special focus on the balance of migration. Therefore, a comparative analysis of selected variables will be undertaken, in particular of the balance of population migrations in 2020-2022.

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# IDENTIFICATION OF LEADING FACTORS SUPPORTING DECISIONS IN PREVENTIVE QUALITY MANAGEMENT

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**Purpose:** The main aim of the article is to present the results of research of entrepreneurs who maintain a certified quality management system in terms of leading factors supporting decisions of a preventive approach to management.

**Design/methodology/approach**: Interview method conducted in manufacturing companies with an implemented and certified quality management system using CATI technique

**Findings:** Research has shown that in large industrial enterprises the key stimulants of preventive actions are, above all, efficient information flow, technical and organizational order, as well as consistent pursuit of the goal. Smaller enterprises put the main emphasis on maintaining good relations with the environment, safety and ergonomics of work, as well as skillful selection of suppliers.

**Research limitations/implications**: The authors of the paper see the need to continue research in the field of in-depth analysis of selected factors in relation to the effectiveness of the actions taken and the possibility of supporting information.

**Practical implications:** Entrepreneurs with knowledge of key stimulants will make decisions more consciously and focused on a targeted analysis of data in order to search for relevant premises to prevent non-compliance.

**Originality/value:** This paper concerns key factors influencing a preventive approach that can support decision-making. For the purposes of multicriteria decision-making processes, it is valuable to know the key stimuli characteristic of effective preventive actions. An additional value of the article is the showing of the factors with a differentiation by company size. This enables a more relevant focus of the research results.

**Keywords:** decision making, prevention of non-conformities, quality management.

**Category of the paper:** Research paper.

## 1. Introduction

Increased competitiveness, cost reduction, and greater satisfaction of internal and external customers are just a few of significant benefits of implementing a quality management system in an enterprise. The need to survive in a very demanding market and to ensure operation in accordance with international standards prompts enterprises to obtain quality certificates. However, it is not enough just to obtain them. It is important to monitor internal and external changes taking place in the enterprise and assess their effects. In companies with quality management systems, the manufacturer should establish processes, specifying when and how to make corrections, corrective or preventive actions. It is the ability to eliminate the threats and implement control mechanisms that prevents potential problems and is essential for continued customer satisfaction and continued effective business practice. Making decisions on preventive actions is extremely difficult due to the unavailability of premises and the reliance on risk estimation (Schätter et al., 2019, p. 12; Ivanov, 2020). An additional difficulty is determining the areas of threat seeking, which are diverse and translate to a different level as a result of product non-compliance.

Preventive actions are important for the functioning of quality management systems, however, they are discussed in only a few studies in the literature, and those that are available usually refer to selected aspects of management (Selvik, Bansal, Abrahamsen, 2021; Shojaie, Kahedi, 2019, pp. 35-43). This the more surprising that knowledge about management has a large set of methods and tools to support decision making. Unfortunately, the level of their use is still low, despite the fact that entrepreneurs more and more often see the need for risk analysis and a predictive management style (Misztal, Belu, 2016). There can be many reasons and conditions for insufficient use of management methods. Hence, there has been a need to conduct research covering both barriers and incentives for a preventive approach in enterprises.

The cognitive aim of the research was to assess the level of awareness and preventive approach in the quality management of production companies. The utilitarian goal of the research was to identify good practices in the use of a preventive approach in manufacturing companies. The main aim of the article is to present the results of research of entrepreneurs who maintain a certified quality management system in terms of leading factors supporting decisions of a preventive approach to management.

## 2. Literature search for premises for possible prevention

Preventive quality management in manufacturing companies has been an issue promoted for years by quality promoters, but still insufficiently defined in the literature. Undoubtedly, preventive actions constitute the most rational form of organizational improvement. It is due to their proactive, and not reactive nature that they are the most profitable and justified economically (Szkoda, 2012, p. 62). These actions are aimed at eliminating potential nonconformities in order to prevent their occurrence. Potential problems can be identified by applying methods such as extrapolating corrective actions for current nonconformities to other applicable areas with similar actions, trend analysis or research into operational risks. The main tasks of nonconformity management include identifying possible causes of nonconformities and developing the necessary corrective actions to prevent them. The ISO 9001: 2015 standard gives an important place for corrective actions to eliminate identified nonconformities. As it is known, there is no section in the current version of the standard where detailed requirements for preventive actions are formulated. However, this does not mean that preventive action should be rejected. As noted in on the contrary, preventive actions become an integral part of the risk management system. They become part of 'risk-based thinking' where risk comes to the fore (Ivanov, 2020; Ezrahovich, Vladimirtsev, Livshitz, Lontsikh, Karaseva, 2017, pp. 506-51).

The PDCA cycle is the starting point for considering preventive research in quality management systems. It was W. Edwards Deming who in the 1960s recognized that an effective method for continuous improvement is to prevent the occurrence of controlled variability, which can be limited by appropriate preventive actions resulting from the theses he cited. Actually, each of the following steps he has a message for continuous improvement through prevention. Continuous improvement of previously obtained results allows to increase the efficiency and effectiveness of the company's operations.

What is more, Juran found that in addition to not taking into account the total cost of these efforts, companies have invested far more money in dealing with external failures than in preventing them. Interpretation of selected theses of Deming and Juran and an attempt to characterize their preventive character is presented in Table 1.

**Table 1.**
*Selected theses of Deming along with their importance in preventing nonconformities and the connection with Juran's Principles*

| Deming's principle | Juran's principle | Importance |
|---|---|---|
| **1.** Creation and maintenance of company's orientation aimed at continuous product improvement, clearly defined management responsibility | **1.** Awareness of need and opportunities for quality improvement. **2.** Setting the goals of continuous improvement | Clearly defined direction of enterprise improvement related to a clear pattern of committed management – **prevention by motivating employees to act and strive for excellence** |

Cont. table 1.

| | | |
|---|---|---|
| **5.** Detecting and solving problems, aimed at continuous improvement of all elements of the production system, including planning, design, purchasing, technology and staff training | **8.** Announcement of results<br>**9.** Record of results | Awareness of the impact on the quality of all possible production factors, but also the human factor - prevention by the selection and improvement of employees - prevention by motivating employees - prevention by joint pursuit of a goal |
| **6.** Modern methods of vocational training in the workplace, both for management and workers, in order to acquire new skills to keep up with changes in materials, methods, product design, equipment, technology and service | **5.** Assignment of problem tasks | The importance of employees as a factor enabling flexible response to changes - **prevention by predicting controlled volatility, prevention by participatory management** |
| **7.** Pro-quality supervision over production - reacting to information about defects arising in the earlier stages of production, machine maintenance needs, bad tools, wrong instructions and other phenomena that cause poor quality | **6.** Informing about the course of work | Awareness of the importance of the quality of auxiliary processes and their impact on the quality of the final product - **preventing the consequences of detected non-compliance threats in the processes** |
| **9.** Team work integrating many units, greater efficiency through the occurrence of horizontal bonds | **6.** Informing about the course of work | The importance of internal communication as a factor enabling flexible response to changes - prevention through an efficient flow of information |
| **11.** Removal of labor norms and shortcomings as well as numerical productivity and piecework norms; standards lead to ineffectiveness and high costs and violate professional ethics - in their place, the introduction of support measures and methods supporting management | **7.** Incorporating authorizations into normally used systems and processes of the company, which maintains the enthusiasm of employees | Awareness of improving work efficiency through the use of selected methods and tools - **prevention with the use of proven management instruments** |
| **12.** Removing barriers that prevent you from doing work with pride, abolishing the job evaluation card, deviating from management by goals<br>**14.** The rank of competences and commitment of the top management in the pro-quality transformation of the enterprise; appointment and maintenance of such a board that would be able to consistently implement thirteen theses | **3.** Establishing an organization that will help achieve these goals by appointing a quality council, identifying problems, selecting the right project, creating teams and selecting coordinators | The importance of job satisfaction in creating product quality - **prevention through corporate culture**<br>The role of top management in conducting continuous improvement - **prevention through planning** |
| **13.** Continuous training and self-training program for employees and their retraining | **4.** Training of all employees | Awareness of the cyclical improvement of employees in conjunction with customer expectations - prevention through employee improvement |

Source: own elaboration based on Bank, 1996, pp. 76-78

What is more, also John Oakland, professor of the University of Bradford behind Deming, Juran, Feigenbaum, Crosby equates quality management with prevention, with activities undertaken before the implementation of the process, not after its completion. The importance of prevention was in fact that the second stage of the development of quality management techniques is defined as ensuring a specific, intended level of quality (Oakland, 2004).

Preventive actions, like corrective actions, should be adjusted to the scale of problems or effects of potential problems diagnosed during monitoring, audit, management review or as a result of decisions, orders, recommendations, etc. Establishing a preventive action procedure is aimed at: defining responsibilities and powers of those involved, identifying potential nonconformities and their causes, correcting potential nonconformities, assessing the need for preventive action, establishing and implementing the necessary actions, recording the results achieved, reviewing the effectiveness of the preventive actions taken. Taking preventive action may involve investigating several causes.

It is useful to distinguish between corrective actions and preventive actions. Corrective actions are steps taken to remove the causes of an existing nonconformity or undesirable situation. The corrective action process is designed to prevent recurrence of nonconformities or undesirable situations. He tries to make sure that existing inconsistencies and situations do not recur. It tries to prevent relapses by eliminating the causes. Corrective actions are based on real problems. In contrast, preventive actions are steps taken to remove the causes of potential nonconformities or potential undesirable situations. The preventive action process aims to prevent nonconformities or situations that do not yet exist, it tries to prevent the occurrence by eliminating the causes (Tashi, Mbuya, 2016). ISO 9001 and TQM force organisations to adopt structured procedures in order to implement corrective and preventive actions (Zhang, Zheng, 2015).

A set of instruments that can be used to support decision-makers in taking appropriate preventive actions comes out against the evolving approaches of preventive quality management. Methods for detecting and removing possible non-conformities, the effects of which could become apparent later, during production or operation, are called **preventive methods.**

Literature proves that there are currently no studies defining the state of a preventive approach in enterprises (Kaganov, 2001; Shojaie, Kahedi, 2019, pp. 35-43; Majanoja, Linko, Leppänen, 2017, pp. 528-549; Păun, 2019).

However, few scientific reports suggest that preventive actions in organizations are marginalized (Macot, 2003, pp. 349-357; Hardoroudi et al., 2011, pp. 177-181; Klimczak, 2014, pp. 16-21; Kovalyova, Zhdanov, 2018, pp. 28-39; Banerjee, 2019, pp. 542-595; Fraser, 2010; Kim, Lim, 2020, pp. 423-430; Zupanets, 2020; Chittipaka, 2020). At the same time, there are examples of searching for effective preventive actions. Most often they relate to:

- relationship with the environment (Junquera, Del Brío, 2016, pp. 1-17; Salem et al., 2016, pp. 755-769; Olszewska, Piwoni-Krzeszowska, 2014, pp. 45-53; Figge, 2005, pp. 19-30; Solana-Ibáñez, Caravaca-Garratón, 2021; Walecka, 2018, pp. 25-41; Katsuki, Miriam, 2017, pp. 1080-1097),

- relationship with employees (Bjerke, 2020, pp. 1-20; Ladegaard, Skakon, Elrond, Netterstrøm, 2019, pp. 44-52; Biggs et al., 2016, pp. 2-12; Sahoo, Sahoo, 2019, pp. 783-799; Greguras, Diefendorff, 2010, pp. 539-560; Zhang et al., 2019, pp. 369-395; Beltrán et al., 2017, pp. 403-422; Thomas et al., 2010, pp. 275-300),

- information management (Chun, 2002; Czekaj, 2012; Nowduri, 2019, pp. 2-6; Nkosi, Sukdeo, Bakama, Molefe, 2020, p. 1028-1038; Lis, Tomski, Bajdor, 2014, pp. 55-60),

- innovation in data analysis (Chluski, Ziora, 2015, pp. 1006-1012; Edmunds, Morris, 2000, pp. 17-28; Lönnqvist, Pirttimäki, 2006, pp. 32-40; Mantura, 2012, pp. 7-30; Yeoh, Koronios, 2010, pp. 23-32; Wójcik, 2016, pp. 61-70),

- modern solutions in the field of maintenance (Lamptey, Labi, 2008, pp. 376-387; Palmarini et al., 2007, pp. 23-28; Vilcu et al., 2017, pp. 656-660; Franciosi, Lambiase, Miranda, 2017, pp. 13692-13697; Barbu, Andreica, Popescu, 2018, pp. 53-58; Shahin, Aminsabouri, Kianfar, 2018, pp. 1296-1315; Alvarez-Alvarado, Jayaweera, 2019; Zhang, Jia, Wu, Yin, Ding, 2020; Larbi Rebaiaia, Ait-kadi, 2020; Wakiru et al., 2020; Wang et al., 2020, p. 123365).

It is noteworthy to develop a simple and efficient tool to understand corrective/preventive action, facilitate follow-up and ensure the availability of appropriate documentation. By means of brainstorming, 5W method, Pareto principle, root cause analysis: it was possible to create such a tool. Essentially, it is a system that allows to get a clear vision of a situation and act on it in an effective way that produces important results. It is simple to explain, simple to use, and anyone involved in corrective action can benefit from it in no time (Macot, 2003; Seo, 2017). A modified quality function implementation technique is then used to evaluate and classify alternatives against three different parameters: benefits, costs and impact. A personalized and modified version of the QFD technique is proposed to perform the most important phase: the selection of solutions and the most appropriate corrective actions. This methodology allows to evaluate the possible outcomes of various alternatives to eliminate the root causes. Finally, a modified QFD can be developed to obtain quantitative results in the form of benefits and costs, not just qualitative results (Carmignani, 2009). Among the risk assessment methods, the example of the FMEA method is outstanding. The use of this method is aimed at identifying the causes of potential non-compliance and planning solutions that first limit their occurrence (Mohanty, 2020). The method can also be treated as an important element of the company's continuous improvement strategy. When applying the FMEA method, it should be assumed that the commitment of the management is necessary to ensure the effectiveness of the proposed improvement solutions (Askari, 2017).

The conducted literature search showed a clear gap in knowledge about the areas and methods of preventing non-compliance in enterprises. The need for a preventive approach is unquestionable, but there is no scientific basis for determining effective methods of their implementation. The established five areas of positive non-compliance prevention defined the basis for the development of the research questionnaire, where these areas were detailed. Thus, the need to examine the leading factors supporting the decisions of a preventive approach in the quality management of manufacturing enterprises was addressed.

## 3.  Stages of the research process. Selection of the research sample

The diagnosis of the preventive approach in quality management in manufacturing companies was conducted in accordance with the typical research process presented in Figure 1. The main purpose of these activities was to assess the general state of the preventive approach level in the surveyed companies and to determine the key factors influencing it.

| Designing the study | • **The research problem:** To what extent are preventive measures important in production companies?<br>• **The scope of research:** preventive approach in production companies that manage quality systemically<br>• **The aim of research:** assessment of the general state of the level of the preventive approach in the surveyed enterprises, determination of key factors affecting it, recognition of the correlation between the identified factors and the size of enterprises<br>• **The research method:** interview method using CATI technique |
|---|---|
| Selection of the sample | • **There has been established quota-random sampling** of companies for quantitative research, due to the leading criterion, belonging to the production industry, having an implemented QMS compliant with the ISO 9001 standard |
| Construction of the measuring instrument | • an interview questionnaire was built |
| Collecting data | • 79 interviews with the use of CATI technique were conducted |
| Reducing data | • Having verified the answers, it was finally decided to take into account all the answers obtained from the respondents |
| Data analysis | • statistical analysis (basic statistics and correlation coefficients) |
| Presentation and evaluation of research results | • development of graphs presenting the percentage distribution of responses along with the variability of selected ratings around the median<br>• assessment of the general state of the level of the preventive approach in the surveyed enterprises<br>• determining the key factors influencing the state of the preventive approach<br>• analysis of correlation between the factors of the preventive approach and the size of the enterprise |

**Figure 1.** Stages of the research process carried out during quantitative research.

Source: own elaboration based on (Kaczmarczyk, 2003).

In order to implement the research program, the authors have conducted quantitative research using the interview method, with the use of the CATI technique (computer-assisted telephone interviews). The interviews were conducted in manufacturing companies with an implemented and certified quality management system compliant with the ISO 9001 standard. The questionnaire used in the study consists of:

- the record containing information provided by the respondent on: company name, size of the enterprise, number of years on the market, and the position held by the respondent,
- one question regarding the general assessment of the level of the preventive approach in quality management in the represented enterprise, specified by the respondent on a five-point scale, i.e. very unsatisfactory, poorly satisfactory, average, satisfactory, very satisfactory,

- 23 questions to which the respondent answered in two planes. First, it was assessed to what extent the prevention in various spheres of the company's operations is implemented in the company represented by the surveyed company. Then, the respondent assessed the extent to which prevention is important for the enterprise in terms of the assessed aspect. In answering these questions, a five-point scale was used, organized according to the so-called Likert scale,
- for the assessment of the importance of a factor in preventive quality management: 1 it does not matter at all, 2 it has a low impact, 3 it has an average effect, 4 it is quite important, 5 is of great importance,
- for the assessment of the degree of implementation of an aspect in the enterprise: 1 completely no, 2 no, 3 medium, 4 rather not, 5 completely not.

In order to obtain answers to the questions prepared by the authors, the services of a research company specializing in the provision of Business Process Outsourcing, call and contact center services were used.

The sample size was determined on the basis of the minimum (required) sample size criterion. When planning the research, we had data on the number of companies from Greater Poland that have ISO 9001 certificate, which in 2019 was 492. Thus the sample size was computed using the formula 1 (Oribhabor, Anyanwu, 2019):

$$n = [(N)\,(p)\,(1-p)] / [(N-1)\,(B/C)\,2 + (p)\,(1-p)] = 215{,}97 \tag{1}$$

where:
N is the population size (N = 492),
p is the proportion of population expected to choose (p = 0,5),
B is acceptable amount of sampling error (B = 0,05),
C is Z statistic associated with the confidence level which is 1.96 that corresponds to the 95% level.

The sample size was estimated at 216 companies. A randomized sample selection was used. The amounts are set according to the size of the enterprises (micro, small, medium and large). Due to the specificity of the industry and the small percentage of micro-enterprises in the pool of all production enterprises, this group was merged with small enterprises.

The structure of the population and the research sample are summarized in Table 2.

**Table 2.**

*Structure of the population and research sample*

| | | Percentage share in: | | |
|---|---|---|---|---|
| | | Population in general | A computation trial | Samples study |
| **Enter- prises** | **micro and small** | 36,79 | 36,97 | 32,91 |
| | **average** | 47,97 | 47,97 | 49,37 |
| | **big** | 15,24 | 15,24 | 17,72 |
| **TOTAL** | | **100,00** | **100,00** | **100,00** |

Source: own elaboration.

By selecting a group of enterprises belonging to the SME category (micro, small and medium-sized enterprises) from the research sample, it was determined that it constituted 82%. In the population of manufacturing companies from Greater Poland, the group of SMEs accounts for 85%. Thus, the pilot sample reflects the percentage structure of the population. The respondents were classified into four groups due to their position:

- quality representatives (36,7 %),
- employees in managerial positions (specialists) (27,8 %),
- owners / management representatives (22,8 %),
- administrative staff (12,7 %).

On the basis of the provisions of ISO 9001: 2015, the companies that would like to certify a quality management system no longer have to select the position of a quality management representative in their organizational structures. This function is often taken over by the management team that was represented in the research by 40 representatives.

## 4. Research results

### 4.1. General level of a preventive approach in quality management

Before starting the main part of the research, the respondents were asked a question concerning the assessment of the general level of the preventive approach in quality management in the represented enterprises (Fig. 2).
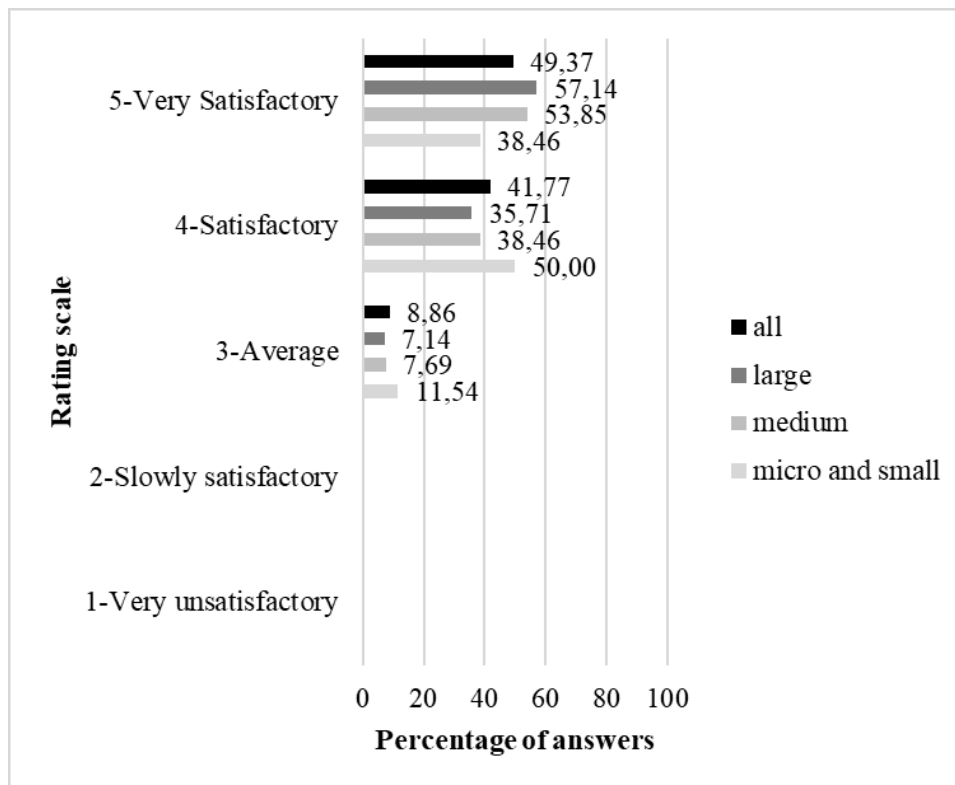
**Figure 2.** Percentage share of answers to the question regarding the assessment of the general level of the preventive approach in quality management in manufacturing enterprises.

Source: own elaboration.

Due to their function, the respondents should be aware of the issues raised in the research. According to Fig. 2, over 90% of the respondents noted that the level of a preventive approach to quality management in the production companies they represent can be considered very satisfactory or satisfactory, and only 8.86% were responses indicating an average rating.

By analyzing in detail the distribution of responses regarding the general assessment of the level of the preventive approach in quality management in individual groups of respondents, it can be initially concluded that the size of the enterprise does not have a significant impact on the responses obtained. This was confirmed by determining the value of Pearson's correlation, which was 0.14. Therefore, this level proves a weak degree of interdependence of the analyzed variables. Due to the positive value, it can be indicated that this tendency is directly proportional, i.e. the level of a preventive approach in quality management increases slightly with the growth of the company.

Table 3. summarizes the basic statistical data necessary to graphically present the variability of assessments of the level of implementation of the preventive approach in quality management in manufacturing companies (see Fig. 3).

**Table 3.**
*Basic statistics for the assessment of the level of the preventive approach in quality management*

| Statistics ╲ Company | Medium | Median | Minimum | Maximum | The lower quartile | The higher quartile | Standard deviation |
|---|---|---|---|---|---|---|---|
| Total | 4,41 | 4,00 | 3,00 | 5,00 | 4,00 | 5,00 | 0,65 |
| Micro and Small | 4,27 | 4,00 | 3,00 | 5,00 | 4,00 | 5,00 | 0,67 |
| Medium | 4,46 | 5,00 | 3,00 | 5,00 | 4,00 | 5,00 | 0,64 |
| Large | 4,50 | 5,00 | 3,00 | 5,00 | 4,00 | 5,00 | 0,65 |

Source: Own elaboration.
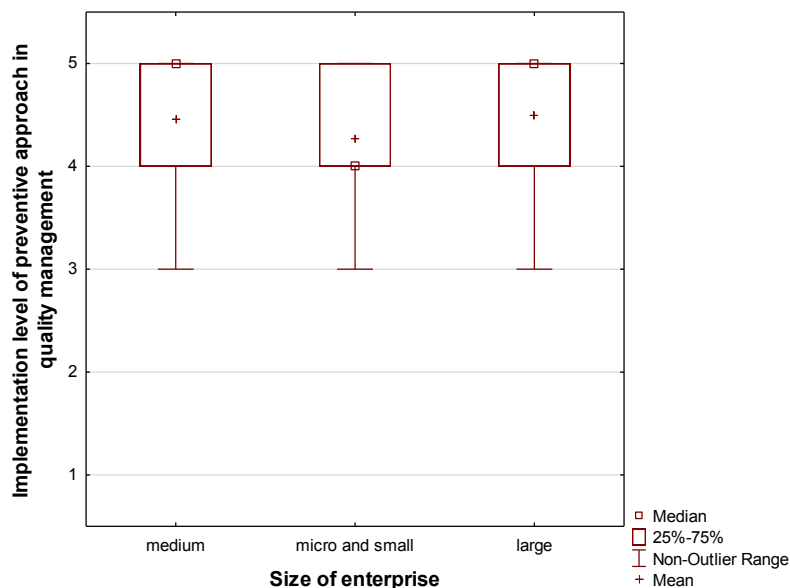


**Figure 3.** Variability of assessments in the level of the preventive approach implementation in quality management of manufacturing companies around the median.

Source: own elaboration using Statistica software.

In the data set from large and medium-sized enterprises, the median reached the highest value of 5, which means that 50% of respondents admitted that the level of implementation of the preventive approach in quality management is very satisfactory (Fig. 3). In small enterprises, the median decreased slightly and reaches the value of 4.0. The distribution of answers is the same in each group of organizations, both in small, medium and large enterprise. Ratings of 4 and 5 were most often given because they belong to the interquartile distribution. Among the companies which gave a rating of 3, there were 87% that had been operating on the market for over 20 years, and the remaining companies, i.e. 13%, belonged to the group existing for over 11 years. Average rating was given by management or quality representatives' respondents.

### 4.2. Analysis of factors influencing the level of a preventive approach in quality management

The main part of the research consisted of 23 questions concerning the degree of implementation and significance of the assessed factor, which influences the level of a preventive approach to quality management in manufacturing companies. These questions are summarized in Table 4.

**Table 4.**
*List of the assessed factors*

| The determination of a factor | Factor |
|---|---|
| K1 | Constant tracking of the requirements of the interested parties (customers, consumers, suppliers, industry groups) |
| K2 | Maintaining good relations with the environment |
| K3 | Skillful selection of suppliers and continuous evaluation of cooperation |
| K4 | Consistent pursuit in implementation of the set goals |
| K5 | Selection of employees based on their competences |
| K6 | Participatory management (i.e. involving lower-level employees in decision-making processes) |
| K7 | Raising the qualifications of employees and improving their skills |
| K8 | Ensuring safety and ergonomics at work |
| K9 | Leading employees (leaders giving direction) |
| K10 | Shaping the corporate culture (creating an atmosphere conducive to achieving goals) |
| K11 | Efficient flow of information (informing employees about the course of work) |
| K12 | Improving data processing and analysis techniques (digitization of processes, documentation, communication, reporting, etc.) |
| K13 | Rationalization of work time and its content (implementation plans based on resource availability) |
| K14 | Use of proven methods and management tools (e.g. control sheets, volatility charts, diagrams such as Pareto, Ishikawa, FMEA method, QFD, 5Why) |
| K15 | Technical and organizational order (creativity, accuracy of designers, diligence in workmanship and control, compliance with standards, the use of procedures, economy, care for the maintenance of machines, devices, instrumentation, care for tools, neatness and order) |
| K16 | Standardizing of ways of treatment of technical problems |
| K17 | Providing infrastructure appropriate to the assumed characteristics of processes and products |
| K18 | Forecasting maintenance (use of risk analysis, preventive inspections, technical condition monitoring, participation of equipment and machine operators in maintenance, use of TPM and RCM, 5S methods and independent inspections) |
| K19 | Improving quality control methods (e.g. improving accuracy, changing measuring instruments, measuring frequency, reporting method, etc.) |
| K20 | Technological innovation |
| K21 | Tracking and using the state of technology standardization |
| K22 | Predicting controlled variability (recognizing disturbances and being able to monitor them) |
| K23 | Knowledge exchange as part of economic cooperation (industry associations, chambers of commerce, capital groups, clusters, alliances, holdings, etc.) |

Source: Own elaboration.

Searching for good practices in the preventive approach, the authors analyzed in detail the responses of the respondents, who generally assessed the level of implementation of the preventive approach in management in the represented enterprises as very satisfactory.

Due to the fact that two of the respondents representing medium-sized companies did not answer all the questions, the decision was taken to reduce the data and not include these interviews in further analysis. Figure 4 presents the percentage distribution of the answers given in the discussed topic, taking into account the size of the organization.
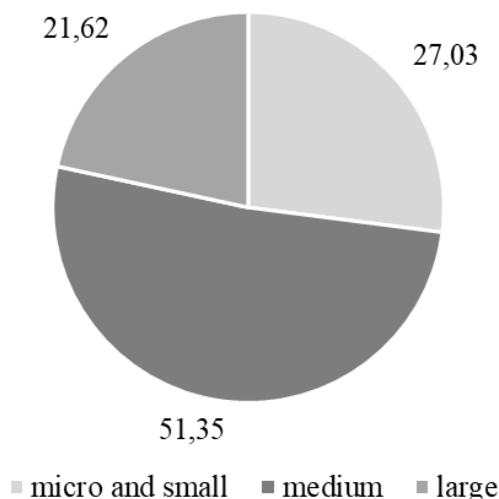


**Figure 4.** The percentage share in terms of the size of enterprises that assessed the level of implementation of the preventive approach in quality management as very satisfactory.

Source: own elaboration.

The respondents on a 5-point scale determined the importance of individual factors in a preventive approach to management. Basic statistics concerning the assessment of the importance of the factors listed in Table 4 are presented in Table 5.

**Table 5.**
*Basic statistics of the importance of individual factors (decreasingly according to the mean)*

| Statistics / Factors | Mean | Standard deviation | Median | The higher quartile 75 | The lower quartile 25 |
|---|---|---|---|---|---|
| K2 | 4,973 | 0,162 | 5 | 5 | 5 |
| K8 | 4,973 | 0,162 | 5 | 5 | 5 |
| K11 | 4,919 | 0,273 | 5 | 5 | 5 |
| K15 | 4,919 | 0,273 | 5 | 5 | 5 |
| K5 | 4,892 | 0,311 | 5 | 5 | 5 |
| K3 | 4,865 | 0,342 | 5 | 5 | 5 |
| K4 | 4,865 | 0,342 | 5 | 5 | 5 |
| K7 | 4,865 | 0,342 | 5 | 5 | 5 |
| K1 | 4,838 | 0,436 | 5 | 5 | 5 |
| K10 | 4,811 | 0,456 | 5 | 5 | 5 |
| K19 | 4,811 | 0,392 | 5 | 5 | 5 |
| K18 | 4,784 | 0,412 | 5 | 5 | 5 |
| K13 | 4,73 | 0,444 | 5 | 5 | 4 |
| K20 | 4,676 | 0,523 | 5 | 5 | 4 |
| K9 | 4,676 | 0,523 | 5 | 5 | 4 |
| K12 | 4,622 | 0,672 | 5 | 5 | 4 |
| K14 | 4,595 | 0,715 | 5 | 5 | 4 |
| K16 | 4,568 | 0,679 | 5 | 5 | 4 |

Cont. table 5.

| K17 | 4,541 | 0,55 | 5 | 5 | 4 |
|-----|-------|------|---|---|---|
| K21 | 4,46 | 0,641 | 5 | 5 | 4 |
| K22 | 4,46 | 0,682 | 5 | 5 | 4 |
| K23 | 4,162 | 0,916 | 4 | 5 | 4 |
| K6 | 4,054 | 0,899 | 4 | 5 | 4 |

Source: own elaboration.

The highest mean results were obtained for the following eight factors:

- K2 Maintaining good relations with the environment.
- K8 Ensuring safety and ergonomics at work.
- K11 Efficient flow of information.
- K15 Technical and organizational order.
- K5 Selection of employees based on their competences.
- K3 Skilful selection of suppliers and continuous evaluation of cooperation.
- K4 Consistent pursuit in implementation of the set goals.
- K7 Raising the qualifications of employees and improving their skills.

A detailed analysis of statistical data was carried out for these factors. Figure 5 graphically shows the variability of the importance ratings in the range of the eight highest rated factors around the median as the midpoint, taking into account the size of enterprises.



a) K2 Maintaining good relations with the environment



b) K8 Ensuring safety and ergonomics at work
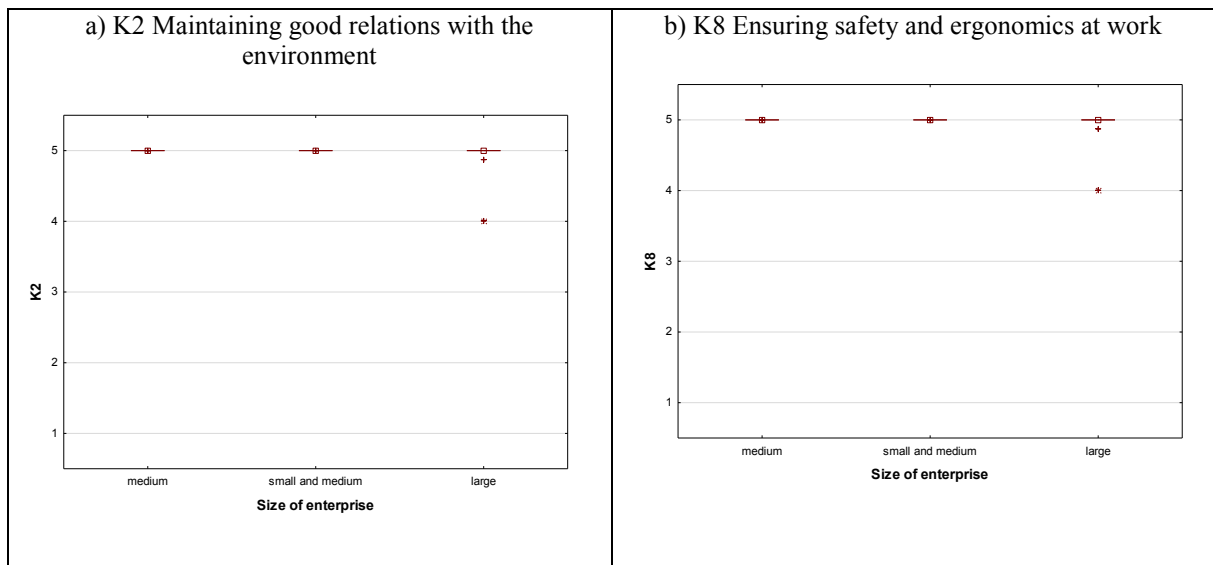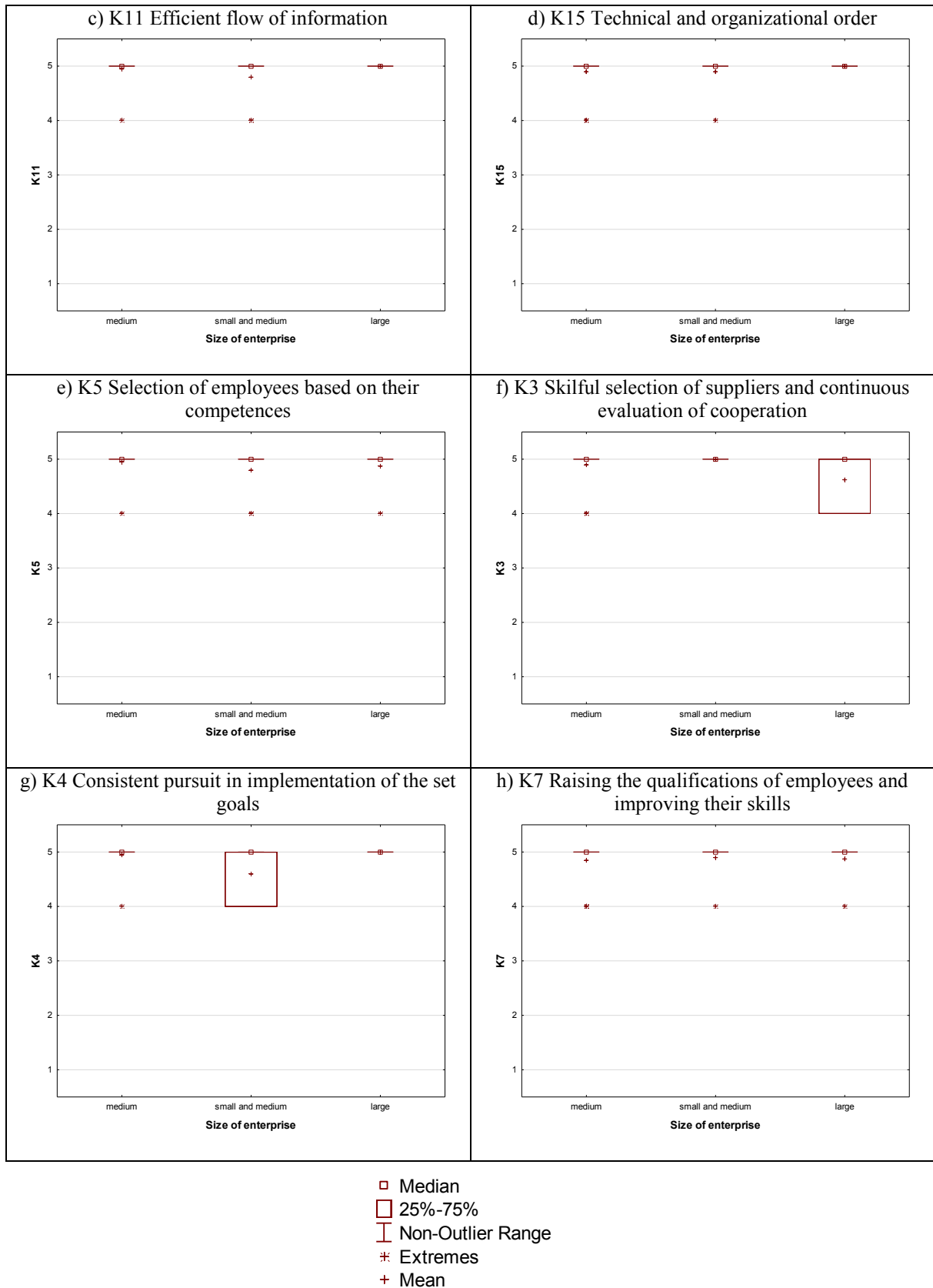
**Figure 5.** Variability of assessments of the importance of the most important preventive factors, taking into account the size of enterprises.

Source: own elaboration.

Based on the data analysis (Fig. 5a), it can be concluded that, among both small and micro-enterprises as well as medium-sized companies, the factor K2: Maintaining good relations with the environment was assessed by all respondents as having a huge impact on quality management in manufacturing companies. The fifth grade assessment was also most often assigned by representatives of large companies. In this group, the assessment graded 4 belongs to extreme assessments (it was only confirmed in 12.5%).

When analyzing the variability of the importance ratings assigned to the K8 factor: Ensuring safety and ergonomics at work (Fig. 5b), it can be concluded that this distribution was identical to the K2 factor assessment. Both among small, micro and medium-sized enterprises, it was assessed by all respondents as having a huge impact on quality management in manufacturing companies. The majority (87.5%) of representatives of large enterprises also assigned a grade at the fifth level. A grade four was rare.

Analyzing the responses to factor K11: Efficient flow of information in quality management (Fig. 5c), it can be concluded that they are similar for all enterprises. Enterprises rated this factor as being of great importance or quite important. The answer is of great importance, it was provided by 100% of large enterprises, 95% of medium-sized enterprises and 80% of small and micro enterprises.

Also factor K15: Technical and organizational order (Fig. 5d) was assessed as being of great importance or quite important in quality management. The answer is of great importance, it was provided by 100% of large enterprises, 89% of medium-sized enterprises and 90% of small and micro enterprises.

For factor K5: Selection of employees based on their competences (Fig. 5e), the distribution of responses also falls within two levels of the Likert scale, *i.e.* the factor is of great importance in quality management or is quite important. The answer is of great importance, from 78% of large enterprises, 95% of medium-sized enterprises and 80% of small and micro enterprises.

Among micro and small enterprises, the factor K3: Skilful selection of suppliers and continuous assessment of cooperation (Fig. 5f) was assessed by all respondents as having a huge impact on quality management in manufacturing enterprises. The fifth grade was also indicated by 89.5% of respondents representing medium-sized companies, and the fourth grade was indicated by 10.5%. In large enterprises, 62.5% of the respondents treated the assessed factor as very important.

Based on a detailed analysis of the data on the assessment of the K4 factor: Consistent pursuit of the set goals (Fig. 5g), it can be concluded that by micro and small enterprises this factor is treated as very important - 60% of responses or as quite important - 40% answers. By 95% of medium-sized enterprises, this factor is considered of great importance in quality management, and only for the rest as quite important. The K4 factor was rated as having huge impact by all respondents representing large companies.

When considering the distribution of responses in terms of factor K7: Upgrading employees' qualifications and improving their skills (Fig. 5h), it ought to be noted that 78% of large enterprises, 89% of medium-sized enterprises and 100% of small and micro-enterprises consider this factor to be of great importance in quality management. The remaining companies belonging to the research sample indicated the fourth grade on the Likert scale, i.e. quite important.

In the data set from large enterprises, only with regard to the K3 factor (skilful selection of suppliers) the interquartile range is between the answers 4 and 5, hence it is precisely for this factor that the average value reached the lowest value among all the analyzed factors. For factors K2, K8, K5 and K7, the answer at the level of 4 in this group of enterprises belonged to extreme values, i.e. it was assigned very rarely. The factors K11, K15 and K4 were rated the highest by representatives of large companies (an unequivocally assigned grade equal to 5).

By analyzing the box-and-whisker plot, it was shown that in the set of responses provided by representatives of medium-sized enterprises there is the smallest dispersion, as evidenced by the interquartile range for all the eight factors considered, equal to 5. For factors K2 and K8, the preventive awareness was the highest, for the remaining six factors there were answers with a level of 4 belonging to the extreme range.

On the other hand, in the group of micro and small companies, the factor K4 was rated the lowest, as evidenced by the largest interquartile range between 4 and 5. For this factor, the average value was at the lowest level. For factors K 11, K15, K5 and K 7, there were four responses (they were classified as extreme responses). In this group of respondents, the highest scores were obtained by factors K2, K8 and K3.

However, the differences in average ratings do not differ significantly in individual groups of enterprises, however, in order to deepen the analysis, it was decided to check the correlation coefficient in the discussed scope.

The lowest average value was obtained for the factor K6: Participatory management and it amounted to 4.054, which is not a low result, but in the ranking of initiating preventive actions it is the weakest factor. This means that all signalled areas are taken into account, there is no reason to reject any of them.

### 4.3. Analysis of the correlation of the importance of factors influencing the preventive approach depending on the size of the enterprise

In addition to identifying the key factors, it was also diagnosed whether the size of the enterprise had an impact on the assessment of individual aspects. Table 6 presents the results of correlation of the assessment of the importance of the eight analyzed factors with the size of the enterprise among those respondents who assessed the general level of the preventive approach as very satisfactory.

**Table 6.**
*Correlation of the importance of factors K1- K23 with the size of the enterprise*

| Factor | Pearson's correlation coefficient between a given factor and the size of the enterprise |
|--------|-----------------------------------------------------------------------------------------|
| K2 | -0,253 |
| K8 | -0,253 |
| K11 | 0,262 |
| K15 | 0,119 |
| K5 | 0,098 |
| **K3** | **-0,372** |
| **K4** | **0,424** |
| K7 | -0,031 |

Source: own study based on the Statistica program.

Based on the data in Table 6., it can be concluded that for factor K3: Skilful selection of suppliers and continuous evaluation of cooperation and K4: Consistent pursuit of the goals set, the value of the correlation coefficient indicates a moderate strength of the relationship (the strength of the relationship is in the range (0, 31-050) and it is therefore possible to define the direction of the relationship. Due to the fact that the correlation is a symmetrical measure, for the K3 factor there is a relationship that the smaller the enterprise, the greater the essence of skilful selection of suppliers, and for K4: Consistent pursuit of the set goals is directly proportional, i.e. the larger the enterprise, the greater the score the importance of consistent pursuit of goals.

For the remaining factors, the correlation coefficient is in the range (0,00-0,30), which means that the correlation does not exist or is very weak. On this basis, it can be concluded that the size of the enterprise does not matter if the key factors supporting decisions regarding the preventive approach in quality management are selected.

## 4.4. Discussion

The conducted research on the preventive approach in quality management allowed for: assessment of the general state of the preventive approach level in the surveyed enterprises, identification of key factors influencing the preventive approach and recognition of the correlation between the identified factors and the size of enterprises.

Over 90% of respondents considered that the level of a preventive approach to quality management in the production companies they represent can be considered very satisfactory or satisfactory. This provided the basis for in-depth research with regard to identifying leading factors that drive decisions about taking preventive action.

Half of the respondents belonging to the group of large and medium-sized enterprises admitted that the level of implementation of the preventive approach in quality management was very satisfactory (the median reached the highest value of 5). In small enterprises, the median dropped slightly, reaching a value of 4.0. Among the companies that assessed the level of implementation of the preventive approach in quality management as average, there were 87% of companies operating on the market for over 20 years, and the remaining companies, i.e. 13%, belonged to the group existing for over 11 years. The authors suppose that

the long-term operation of enterprises on the market is associated with the inevitable development of technology and employee experience, which contributed to the standardization of basic processes. Long-term orientation of enterprises towards the purpose of their functioning may, therefore, result in undertaking unconscious actions for prevention - e.g. in the scope of the aforementioned standardization.

Based on the conducted research, the key factor influencing the preventive approach in quality management turned out to be maintaining good relations with the environment, which was confirmed both in the elections of SMEs and large enterprises. The authors see the basis of the research results in the commonly used approach of enterprises to taking into account both the needs of internal stakeholders and, above all, of external stakeholders. It is undoubtedly related to the current business approach, in which both the analysis of the needs of interested parties and the context of the company's functioning constitute the basis for effectively undertaken activities in all spheres of the company's operation. The second most important factor is ensuring safety and ergonomics at work. The distribution of answers can be justified by the legal regulations in force in Poland, according to which each entrepreneur is responsible for the life and health of his employee. The basic provisions in this matter can be found in the Constitution of the Republic of Poland, as well as in the Labor Code.

When assessing the following factors: efficient information flow, technical and organizational order, selection of employees based on their competences, and improvement of employees' qualifications and improvement of their skills, the respondents indicated that they are of great importance or are quite important in quality management (fifth or fourth level of the Likert scale). It should be emphasized that the size of the enterprise was not significant in the distribution of responses.

Based on the analysis of the box-and-whisker plot, it has been shown that in the group of large enterprises the following factors were assessed the best:

- K11 Efficient flow of information.
- K15 Technical and organizational order.
- K4 Consistent pursuit of the set goals.

In the group of respondents representing medium-sized enterprises, the highest scores were given to:

- K2 Maintaining good relations with the environment.
- K8 Ensuring safety and ergonomics at work.

In turn, among the micro and small, the highest scores were also given for factors K2 and K8, and also for K3 Skilful selection of suppliers and continuous evaluation of cooperation.

The essence of the above-mentioned factors can be justified by the specificity relating to the size of each of the separated groups of researched enterprises. In large enterprises, the essence is undoubtedly, among other things, to take care of the flow of information. Entrepreneurs unequivocally confirmed in these companies the highest level of awareness with regard to the free flow of information. Therefore, they have shown their weakness in this area

and at the same time know that the need for improvement should be critical in this area. In turn, in the group of enterprises with small and medium-sized enterprises, it is important to take care of, inter alia, relations with the environment (both external and internal stakeholders). In micro companies, the awareness of special care for relationships with suppliers is also growing.

Figure 6 presents the essence of the preventive approach in quality management, taking into account the identified key factors that act as stimulants in this regard.
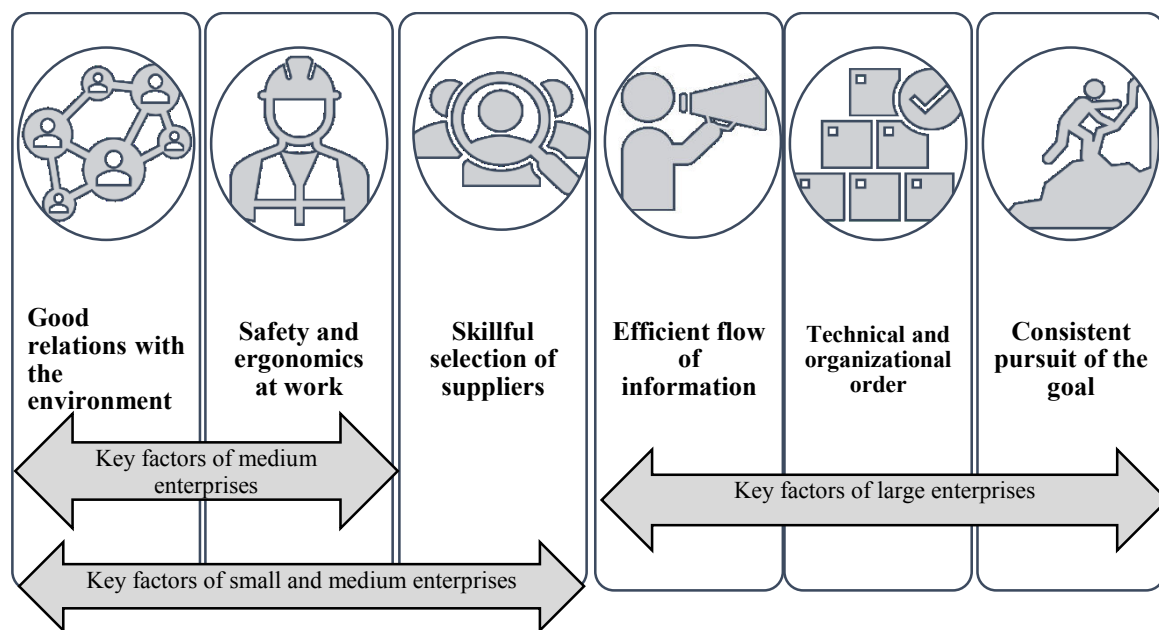


**Figure 6.** The key factors of a preventive approach in quality management due to the size of the enterprise.

Source: own elaboration.

However, the differences in the ratings assigned to individual groups of enterprises are not significant. In an in-depth way, the authors recognized the correlations between the identified factors and the size of enterprises, determining the strength of the relationship between the factor and the size of the enterprise. Due to the fact that the correlation is a symmetrical measure, for the factor K3 the dependence was recognized that the larger the enterprise, the lower the assessment of the importance of skilful selection of suppliers, and for K4 the consistent pursuit of the set goals is directly proportional, *i.e.* the larger the enterprise, the greater assessing the importance of consistent pursuit of goals. The dependence on K3 may result from the long-term cooperation of enterprises with the same suppliers or the suppliers providing evidence that the requirements, *e.g.* certificates of the supplied materials, semi-finished products have been met. It is possible that the lack of problems with the continuity and quality of supplies resulted in respondents giving answers that seemed inconsistent with the actual state. On the other hand, the increase in the importance of consistency in achieving goals in larger enterprises probably results from the division of responsibilities in these enterprises in accordance with extensive organizational structures. In this case, consistency in making

decisions and timely implementation of them are of particular importance for the effective functioning of the company. In flat organizational structures it is easier to ensure consistency in achieving goals, therefore this factor is less important for smaller enterprises.

## 5. Conclusion

This article makes important contributions to understanding and initiating preventive action. First, the areas, issues and criteria have been identified that essentially stimulate the prevention of non-conformities of products and processes. Moreover, based on empirical research, the expected essence of these factors was indicated. Similarities and differences between importance in small, medium and large enterprises were also shown.

For the purposes of multi-criteria decision-making processes, it is valuable to know the key stimuli characteristic of effective preventive actions. The complexity of the process also requires taking into account the size of the enterprise. Research has shown that in large industrial enterprises the key stimulants of preventive actions are, above all, efficient information flow, technical and organizational order, as well as consistent pursuit of the goal. A different situation occurs in smaller enterprises, which put the main emphasis on maintaining good relations with the environment, safety and ergonomics of work, as well as skilful selection of suppliers. Such an approach of entrepreneurs means that decision-making becomes to a greater extent conscious and focused on a targeted analysis of data in order to search for relevant premises to prevent non-compliance.

To sum up, the essence of the preventive approach in the quality management process should be the broadly understood decision support system for quality managers. The results of research related to the identification of key factors influencing the preventive approach may act like such a support system. The authors of the paper see the need to continue research in the field of in-depth analysis of selected factors in relation to the effectiveness of the actions taken and the possibility of supporting information.

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# APPLICATION OF LASER BARCODE TECHNOLOGY TO SHEET METAL PARTS IDENTIFICATION

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**Purpose:** In the development of ideas for Industry 4.0, information about the element production cycle has become more and more important. Knowledge of the subsequent forming processes, determination of the machine on which the process has been carried out and of the type and wear of the tool, leads to smart production management, which plays an increasingly important role in the metal forming industry. To meet the current expectations for these challenges, an advanced technology needs to be introduced for monitoring the manufacturing processes by deploying flexible solutions. This technology must include, but not be limited to, identifying and tracking the product using laser marking.

**Design/methodology/approach**: Laser marking allows a permanent mark in the form of a barcode to be applied to the sheet metal surface. Commonly used marking methods and the condition of the sheet metal surface can affect the marking contrast. This paper presents a concept for recording individual stages of sheet metal forming and determination of the impact of the laser marking technology on the contrast of the applied barcode. To ensure accurate control of the deformation stages, the bulging process of the spherical dome has been used as an example.

**Findings:** Analysis of the influence of laser marking method on the barcode recognition accuracy can contribute to the development of smart management of the production process according to the idea of Industry 4.0.

**Research limitations/implications**: A large plastic deformation has been applied to the sheet metal surface and no limitation in a barcode reading process (using vision scanning technology) was indicated. Also, the geometry deformation (different angle view of the CCD camera) of the barcode image has introduced no additional problems with a barcode reading.

**Originality/value:** The optimal parameters of a laser marking technique for barcode marking, which are critical for the material that is subjected to metal forming operations that deform it, have been studied. The results shows that traceability is an attractive solution for tracking technological data in the production chain for a single-shaped product.

**Keywords:** manufacturing control, laser marking, vision analysis, sheet metal forming, barcode quality.

**Category of the paper:** Technical paper.

## 1. Introduction

Numerous manufacturing support systems, including Smart Technology or Flexible Manufacturing, enable the production of different products on the same line, minimizing the unavoidable delays caused for example by tool changes (Peters et al., 2014). The rapid adaptation of the production chain to new purposes can be supported using robotic stations and computer systems to supervise the production. The great interest in improving the production means that software solutions for monitoring the manufacturing process are sought to meet the growing need for flexible solutions. The complexity and diversity of these software solutions to be adapted in production conditions has been noted for a long time. Moreover, the adaptation of algorithms to frequent changes required a systematic approach (Chaar et al., 1993). The important role of production process monitoring methods, which cover a very wide range of tasks, is invariably emphasized (Ho et al., 2003). Such methods make it possible to collect information aimed at determining the current state of a production system, verifying the correct implementation of ongoing operations, and controlling a series of related operations in real time. In practice, detecting and correcting undesirable events that may occur while planned technological operations are underway is the key to achieving more efficient work and better product quality. To this end, a set of methodologies (Lechmann, Kuhn, 2020) can be used to support the development of real-time monitoring techniques. These methodologies directly improve manufacturing processes on production lines. This paper proposes further improvement of manufacturing processes by introducing the optimized barcode marking technique for process monitoring. This solution includes elements of the technology information management strategy that leads to higher quality in obtained products, in accordance with the assumptions of Industry 4.0 (Chozdić, 2015).

In the development of the idea of Industry 4.0, which aims at smart management of the production process, information about the production cycle becomes very important. Knowledge of the technological aspects of manufactured products – such as parameters of all operations, material supplier, type and material properties, type and wear of the tool and determination of the machine on which the process was carried out – plays an increasingly important role, and it also affects the final cost and quality of the product. Identification codes can be affixed to products or printed onto them. There are various methods for collecting such information, the most widespread of which is the use of barcodes, which are currently a primary method of identifying and tracking a product simultaneously (Chowdhury et al., 2019). The popularity of barcodes led to the development of one-dimensional reading technology based on lines of different thickness (barcodes). Later, two-dimensional codes (2D codes) represented by rectangular type objects called matrix codes (QR) were also utilized. The one-dimensional barcode reading method consists in detecting and identifying the sequence of lines. The biggest advantage of barcodes is their low price, as well as widespread knowledge

and dissemination of them (Shejwal et al., 2016). While the barcodes can also be affixed to products or printed onto them, they can also be applied on various surfaces using laser marking.

Generally, two principal groups of devices related to the direct part marking technology can be utilized: monochrome and colour laser engravers. The potential application of these engravers is closely related to the capabilities of their implementation, in which the repeatability of results, process stability in the industrial environment, and productivity are the major factors. However, the basic limitation in using the colour laser marking (CLM) method in this area (despite numerous advantages) is low productivity, which may be critical for large production volume. Recently Odintsova (Odintsova et al., 2019), proposed a new approach to increase CLM productivity by up to 40 times, thanks to the use of high pulse rate frequency (up to 1 MHz) fibre laser. Despite this, monochrome technology (YVO4 lasers) continues to be a laser market leader in industrial applications due to the much better performance parameters, with pulse repetition rates of up to hundreds of GHz.

The demand for traceability is growing in the manufacturing industry. For example Fraser (Fraser et al., 2016) showed that laser marking seems to be the optimal technology in the forging industry to satisfy hot, dirty and rough conditions as well as large deformations and subsequent surface or heat treatment of aluminium in the temperature range between 25 and 400°C. Generally, laser marking has been carried out on various metals, such as stainless steel, nickel and aluminium alloys, and on titanium coatings. Li (Li et al., 2016) investigated the effects of laser processing variables on the quality of the laser-marked barcodes on the surfaces of aluminium alloys using a diode pumped Nd:YAG laser and found that barcodes with higher surface roughness could be more easily identified. Velotti (Velotti et al., 2016) characterized the laser marking process on aluminium sheet with Cold Spray Deposition Ti coating for aerospace applications. Investigating the influence of the laser marking process parameters on the groove geometry of the marking, the researchers showed that laser marking was governed mainly by the heat input and that the penetration depth was higher than that obtained on solid material. Astarita (Astarita et al., 2016) also studied the maximum penetration depth and width of the marks as well as internal damages induced by the laser marking tests of cold sprayed titanium coatings. To report and discuss the results of the width and depth peaks measurements, both a surface 3D reconstruction and a cross-section presentation of the laser marks were carried out. Leone (Leone et al., 2018) performed laser marking tests on AISI 304 steel, using a diode-pumped Nd:YAG laser to determine the correlation occurring between working parameters and resulting mark visibility. In particular, changing the working parameters such as variation of the pulse frequency significantly altered the appearance of the upper surface of the groove, as demonstrated by the results on the cross-section of the laser marks. Bassoli (Bassoli, 2018) established the relationship between the process variables used in laser marking of Inconel alloy 718 and both the geometrical and the optical characteristics of the mark, and similarly presented all these geometrical features (e. g. width and height of the peaks, depth of the groove and distance between the peaks) on the outline of the sample cross-section. However, another

technique has also been reported for engraved surface measurement. Sobotova and Badida (Sobotova, Badida, 2017) evaluated the roughness of aluminium samples to show how different laser variables affect the surface texture and colour change while creating minimal waste as compared with other marking methods.

Laser marking, unlike sticky labels or ink printing, introduces not only geometric but also structural changes in the top layer of the sheet metal. Guk (Guk et al., 2016) reported that the inhomogeneity of the microstructure had no significant effect on mechanical properties, while the induced geometric inhomogeneity markedly influenced material formability. This was determined using the Erichsen cupping test for cold-rolled and zinc-coated dual-phase steel sheets with a thickness of 1 mm. Guk (Guk et al., 2017) showed that these conclusions also concerned multiphase steel sheets with high strength. Fraser (Fraser et al., 2016) claimed that laser marking is usually the only possible technology for permanent marking of die castings to ensure traceability of the component from casting to final assembly and even in the life cycle phase. Li (Li et al., 2016) found that one of the most important factors affecting the effectiveness of the barcode identification is the contrast between the marker and the surface of the sheet. Therefore, since a high contrast laser marking is critical, Penide (Penide et al., 2014) proposed to carry out a colorimetric analysis to compare the resulting marks and their contrast on alumina plates. It was concluded that the atmosphere was the key variable in producing the darkest marks.

As shown above, there are various problems related to the quality and identification of barcodes on various surfaces. Assessing the impact of the marking method on the later possibilities of effective detection of the applied markings on a given surface is very important and especially crucial with regard to industrial requirements and environments. In accordance with such demands, this paper presents some concept of recording individual stages of the sheet metal forming process and determination of the impact of laser marking technology on the contrast of the applied markings. By introducing an appropriate barcode marking technique for process monitoring, manufacturing on production lines can be improved. Hence, this solution also includes some elements of the technology information management strategy intended to increase the quality of obtained products, according to assumptions of Industry 4.0 as presented by Hozdić (Hozdić, 2015).

## 2. Material identification and traceability

The discussion on launching monitoring systems to collect manufacturing data has been initiated in recent years and has also influenced the creation of numerous marking techniques. One such solution is a system to apply marks using a laser. In particular, the automotive industry has found a wide application for this solution, currently used to designate numerous

components, which include mechanical parts (crankshafts, engines and gearboxes, bearings, bolts), equipment parts (plastic buttons, control panels, mirrors), electronic parts (printed circuit boards, electronic circuits), and plastics (wipers). At one time, Świłło (Świłło et al., 2016) suggested a modified method of identifying metal forming tools based on an existing solution of applying laser tags. It is now therefore proposed in this paper to extend the application of permanent marks to car body parts. Moreover, it is proposed to apply patterns before the forming of these parts, but not after any deformation processes. This, however, can lead to great identification difficulties because of the negative impact of sheet metal deformation and curvature of the marked steel sheet surface. In the next part of the paper, the authors will deal with the explanation of these problems.

The growing expectation regarding the final product quality and their tracking within production areas have led to a new concept of material traceability (Krivács et al., 2010). This type of function includes linking the product with the supplier and all the technological parameters within the production process for a single product. The aim of the authors was therefore to propose a general concept of system traceability for a manufactured product using the barcode method and laser technology. Applying recognition marks at the outset of the product manufacturing process considerably extends traditional solutions and provides a wide range of data storage options, creating, among other things, the possibility of combining the quality with the manufacturing history of the product. The proposed concept of recording individual stages of sheet metal forming process is shown on the simplified example (one sequence only) of a car trunk floor-stamping (Figure 1). In this concept, a sheet with a barcode is identified before the production cycle begins (Stage 1). Collected data on the production line (Stage 2) will be assigned to the obtained product after scanning the barcode at the end of the line (Stage 3). This concept could be easily applied to manufacturing processes with a greater number of sequences.
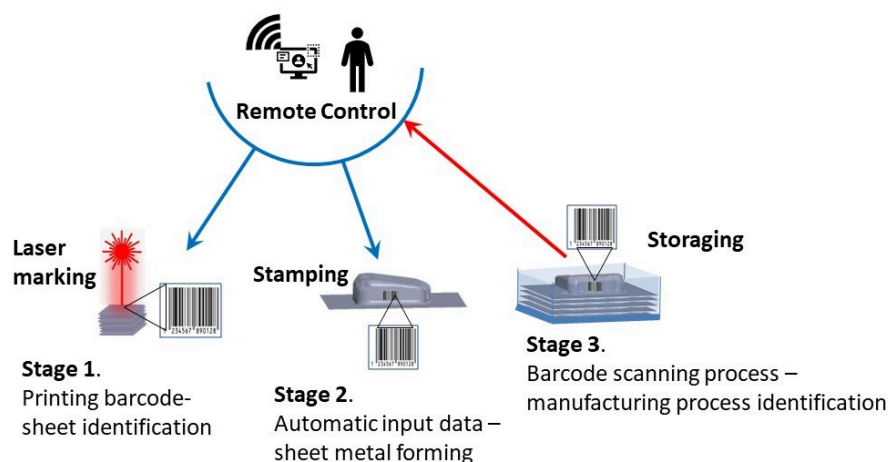


**Figure 1.** The proposed concept of using laser barcode technology for car body sheets identification and tracking.

Source: own elaboration.

## 3. Laser processing parameters

The proposed laser marking method is based on a unique solution, taking into account the mutual influence of the three light effects on an object: reflection, aberration, and transmission. The key to applying patterns to an object correctly is to achieve high absorption, which is a function of the temperature increase. Otherwise, the reflection and transmission will be increased, detracting from the beam power needed to make the mark. For this purpose, a special type of hybrid laser Keyence MD-X1500C was used to apply the barcodes, whose operating characteristics differ from the classic solutions. The high power of laser light (peak power) was compensated by short pulse duration, which allowed the intensity (temperature) of the laser beam to be controlled. The solution gives the possibility of choosing the device's operating variables (power, time, speed, beam focus) for any material, which are determined by the calibration pattern.

In this research two parts of the study are foreseen: applying the calibration patterns (reference fields) and applying the appropriate patterns in the form of barcodes on the surface of the deep-drawing DC04 steel sheet (0.017% C, 0.096% Mn, 0.006% P, 0.032% S) with a thickness of 1 mm. Next, it is planned to examine the influence of sheet metal deformation on the quality of patterns (their readability) and the potential decrease in the material formability.

The marking process variables influence the obtained surface geometry structure and the contrast of markers applied to the sheet surface. The contrast between the marked and native surfaces of the sheet metal is crucial for correct detection and recognition of the barcode. It is important, therefore, to examine the impact of laser marking technology on the contrast of created barcodes, which directly affects their correct identification. As part of the research, reference patterns in the form of square fields with selected parameters were applied on flat steel sheet by the laser technology (Figure 2a).
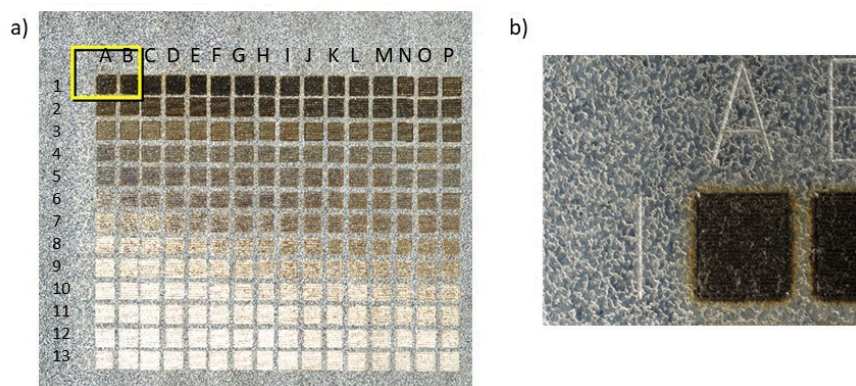


**Figure 2.** The reference patterns made with selected laser marking parameters (a), and the example of laser burnt field (b), shown by green circle in the reference pattern.

Source: own elaboration.

The reference patterns were used to determine the effect of the laser frequency $f$ and the beam speed $v$ on the sheet surface contrast. The beam focus s was set to the maximum value. Table 1 shows laser marking parameters corresponding to the reference fields presented in Figure 2a. There are two values, $f/v$, in the table cells: the frequency $f$ and the speed $v$. The black lines of the common barcode should have the darkest tonal value. This tonal value can be quantified by recording these images using vision system. Then, the tonal value – also called the shade or brightness of the pixel of the image – is recorded. To achieve the highest contrast in relation to the sheet surface, the difference in tonal values between the background and the black lines of the code should be as large as possible. At the beginning, a preliminary qualitative assessment of the reference patterns was carried out. Visual assessment showed that the darkest fields were plotted at low speeds $v$ and high laser frequencies $f$. At the same time, it was noted that laser burns appeared at the lowest laser beam speed, $v = 100$ mm/s, as shown at the left-hand side boundary of the reference pattern area. The sample pattern with a burn (Figure 2b) is marked with a green circle in Figure 2a; i.e., for $v = 100$ mm/s and $f =140$ kHz. Visible burns can cause problems when detecting and identifying barcodes.

**Table 1.**

*Parameters of reference patterns for the set shown in Figure 2a*

| | | beam speed v [mm/s] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
| | 1 | 80/100 | 84/100 | 88/100 | 92/100 | 96/100 | 100/100 | 104/100 | 108/100 | 112/100 | 116/100 | 120/100 | 124/100 | 128/100 | 132/100 | 136/100 | 140/100 |
| | 2 | 80/200 | 84/200 | 88/200 | 92/200 | 96/200 | 100/200 | 104/200 | 108/200 | 112/200 | 116/200 | 120/200 | 124/200 | 128/200 | 132/200 | 136/200 | 140/200 |
| | 3 | 80/300 | 84/300 | 88/300 | 92/300 | 96/300 | 100/300 | 104/300 | 108/300 | 112/300 | 116/300 | 120/300 | 124/300 | 128/300 | 132/300 | 136/300 | 140/300 |
| laser frequency f [kHz] | 4 | 80/400 | 84/400 | 88/400 | 92/400 | 96/400 | 100/400 | 104/400 | 108/400 | 112/400 | 116/400 | 120/400 | 124/400 | 128/400 | 132/400 | 136/400 | 140/400 |
| | 5 | 80/500 | 84/500 | 88/500 | 92/500 | 96/500 | 100/500 | 104/500 | 108/500 | 112/500 | 116/500 | 120/500 | 124/500 | 128/500 | 132/500 | 136/500 | 140/500 |
| | 6 | 80/600 | 84/600 | 88/600 | 92/600 | 96/600 | 100/600 | 104/600 | 108/600 | 112/600 | 116/600 | 120/600 | 124/600 | 128/600 | 132/600 | 136/600 | 140/600 |
| | 7 | 80/700 | 84/700 | 88/700 | 92/700 | 96/700 | 100/700 | 104/700 | 108/700 | 112/700 | 116/700 | 120/700 | 124/700 | 128/700 | 132/700 | 136/700 | 140/700 |
| | 8 | 80/800 | 84/800 | 88/800 | 92/800 | 96/800 | 100/800 | 104/800 | 108/800 | 112/800 | 116/800 | 120/800 | 124/800 | 128/800 | 132/800 | 136/800 | 140/800 |
| | 9 | 80/900 | 84/900 | 88/900 | 92/900 | 96/900 | 100/900 | 104/900 | 108/900 | 112/900 | 116/900 | 120/900 | 124/900 | 128/900 | 132/900 | 136/900 | 140/900 |
| | 10 | 80/1000 | 84/1000 | 88/1000 | 92/1000 | 96/1000 | 100/1000 | 104/1000 | 108/1000 | 112/1000 | 116/1000 | 120/1000 | 124/1000 | 128/1000 | 132/1000 | 136/1000 | 140/1000 |
| | 11 | 80/1100 | 84/1100 | 88/1100 | 92/1100 | 96/1100 | 100/1100 | 104/1100 | 108/1100 | 112/1100 | 116/1100 | 120/1100 | 124/1100 | 128/1100 | 132/1100 | 136/1100 | 140/1100 |
| | 12 | 80/1200 | 84/1200 | 88/1200 | 92/1200 | 96/1200 | 100/1200 | 104/1200 | 108/1200 | 112/1200 | 116/1200 | 120/1200 | 124/1200 | 128/1200 | 132/1200 | 136/1200 | 140/1200 |
| | 13 | 80/1300 | 84/1300 | 88/1300 | 92/1300 | 96/1300 | 100/1300 | 104/1300 | 108/1300 | 112/1300 | 116/1300 | 120/1300 | 124/1300 | 128/1300 | 132/1300 | 136/1300 | 140/1300 |

Source: own elaboration.

## 4. 3D microscopy measurement of the calibration pattern

In the next stage of experimental investigation, the authors intended to verify the concept of laser overheating, which results in a low surface quality. Therefore, a topography measurement for selected reference patterns with an extreme range of parameters using advanced scanning technology has been proposed. In this experimental investigation, a recently developed confocal microscope VK-X Series (Figure 3a) was utilized, equipped with two type

of light sources: laser light and white light. To satisfy all the measurement requirements, both options – a 3D high-speed laser light together with high-accuracy scanning – were chosen to measure selected surfaces areas with references patterns before deformation.
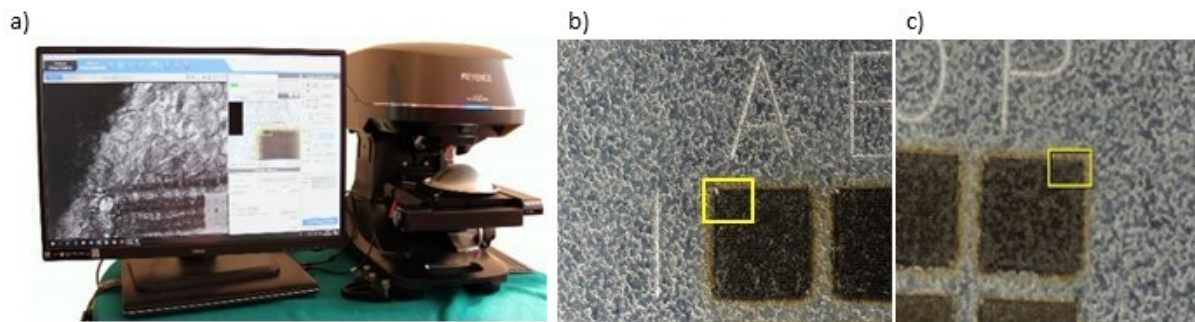


**Figure 3.** Topography measurement using advanced scanning technology: 3D laser confocal microscope. Type: VK-X Series (a), selected and zoomed reference patterns subject to measurement (b, c).

Source: own elaboration.

The results show that both the measured topography and the surface quality are varied. The largest elevation (height) for both selected reference patterns (Figure 3b, 3c) however, is approximately 50 μm (Figure 4). This can be accepted as a limit at which surface quality decreases as a result of increasing the burn depth. The deterioration of the surface quality understood in terms of light reflected from the barcode scanning device may be due to changes in the properties of the surface layer under the influence of high temperature. The presented methodological approach and the detailed results for the topography measurement have been used for a precise determination of an optimal burn size.
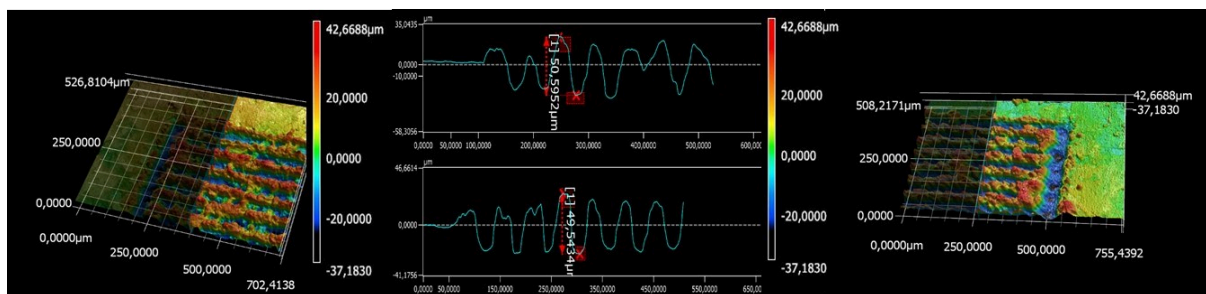


**Figure 4.** Surface topography and height for selected and zoomed area as shown on Figure 3(a, b).

Source: own elaboration.

## 5. Measurement of the contrast for the calibration pattern

One of the most important factors affecting the effectiveness of laser mark identification is the contrast. Contrast is the difference in tonal value (brightness of pixels) between neighbouring objects, e.g., barcode lines. The higher the contrast value, the easier it is to detect and read the barcode. To check the impact of laser marking variables on the tonal value, the images obtained from the experimental vision system set-up were used (Figure 3a).
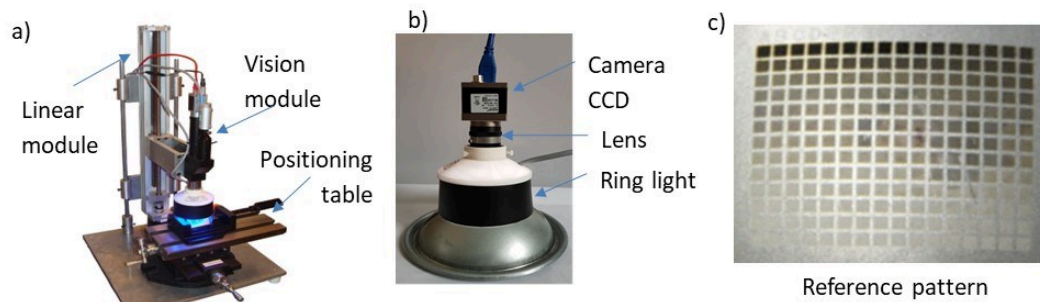


**Figure 3.** Experimental set-up (a), vision unit (b), measured area of the reference pattern (c).

Source: own elaboration.

The vision system consists of a CCD camera with a resolution of 4096 x 3000 px, lens with 25 mm focal length, 5 mm extension ring, and a specially prepared ring lamp. The extension ring reduces the minimum working distance of the lens, thus enabling marker registration at close range. Specimens shown in Figure 3a and Figure 4b were obtained by hydraulic bulging of flat circular blanks (Figure 4a). A detailed description of the bulging process was presented by (Świłło, 2013). More recently, however, (Kocańda, Jasiński, 2016) extended the evaluation of the similar Erichsen cupping test by laser speckle imaging. The resulting dome shape can cause an uneven distribution of light on the specimen surface without a specialized arrangement of lighting. The ring light ensures an even distribution of illumination in the recorded area of the specimen shown in Figure 3b and Figure 4b.
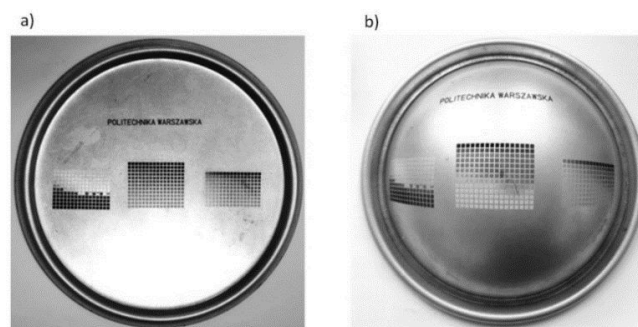


**Figure 4.** Sheet metal samples with the applied reference patterns before (a), and after the hydraulic bulging (deformation) process (b).

Source: own elaboration.

Before the bulging process, three sets of patterns were applied to the flat surface of the circular blank of sheet metal. All tests were performed at the same exposure time and light intensity. Additionally, it was decided to verify the effect of sheet metal deformation on the obtained results. For this purpose, the measurement of the mean tonal value on the specimen surface was performed by experimental set-up before (Figure 4a) and after the hydraulic bulging process (Figure 4b). Among the three reference patterns shown in Figure 4a, only the middle one (subjected to the highest deformation) was chosen for further research, which corresponds to the parameters shown in Table 1.

Figure 5 shows the effect of the laser frequency $f$ and the beam speed $v$ on the pixel brightness before (Figure 5a) and after (Figure 5b) bulging process. The main purpose of the tonal value measurement was to indicate the marking variables that will ensure the darkest and lightest areas possible on the surface of the sheet and the highest barcode contrast. The graphs obtained show that decreasing the speed $v$ considerably reduces the brightness of marks in the recorded image. On the other hand, increasing the frequency $f$ of the laser beam also reduces brightness of marks but to a much smaller extent. To sum up, the correct marking technology for 1 mm thick DC04 sheets that ensure the darkest marks without burns were obtained for $v = 300$ mm/s and the highest frequency $f$=140 kHz. To obtain the brightest surface, the highest speed and the lowest laser frequency indicated in Table 1 were used. The original average tonal value of the sheet surface was 129. Applying black lines on a bright background increases the contrast tonal values to 135. The maximum contrast that is possible to obtain in a camera with a dynamic range of 8 bit is 255, but this contrast could be obtained only theoretically due to problems related to noise on the camera matrix or to changes in lighting. In any case, obtaining more than half of the maximum contrast is a very good result, which ensures the correct reading of the barcode.
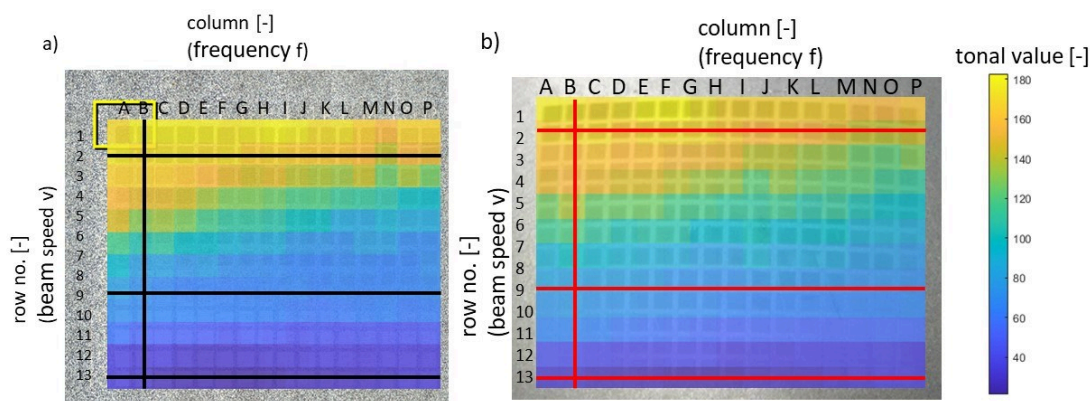


**Figure 5.** Effect of laser frequency $f$ and beam speed $v$ (as related to rows and columns in Table 1, on the pixel brightness before (a), and after the bulging process (b).

Source: own elaboration.

Figure 6 shows the markers' tonal values before and after the process for column "B" (Figure 6a) and row 2,9 and 13 (Figure 6b) with the approximation. The study showed that the level of brightness of the surface of the analysed reference pattern did not change noticeably after the deformation of the sheet. The differences were within tonal values of around 5%, which corresponded to the measurement error.
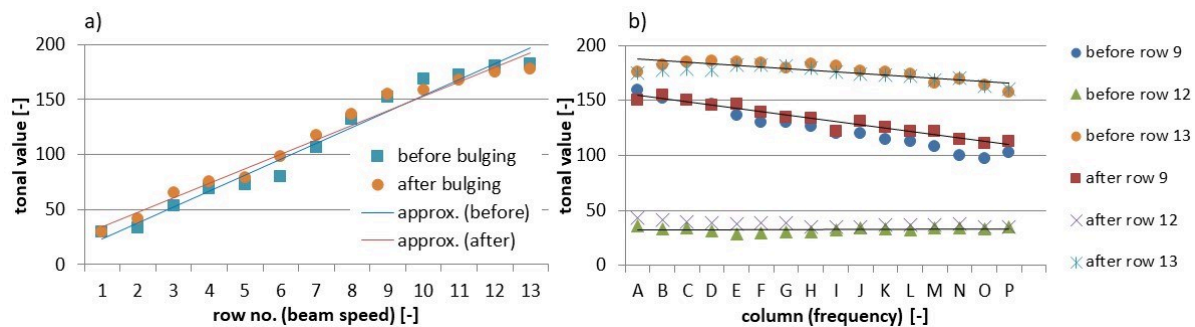


**Figure 6.** Tonal values before and after the bulging process for column "B" (a), and row 2,9 and 13 (b) from Table 1.

Source: own elaboration.

The results of measuring the tonal values have shown that as the frequency increases and the speed decreases, the tonal value of the markers decreases. The beam speed has a greater impact on the tonal value than the frequency (Figure 5, 6). At high values of the beam speed and low frequency, tonal values of the mark that are higher than those of the sheet surface are obtained, which can be used to create a background for a barcode. Creating a light background for the barcode significantly increases the contrast, which allows easier detection and analysis of the barcode. A background with high tonal value gives a higher contrast than black lines directly applied to the sheet surface. There were no clear differences in tonal values of the patterns before and after their deformation, which permits the assumption that the contrast of the barcode before and after the metal forming process will be preserved.

## 6. Experimental measurement of barcode distortion

Barcode distortion in sheet metal forming could be a result of both material deformation and changes in geometry. These two phenomena change the barcode dimensions recorded by the CCD camera sensor before (for the flat sheet metal blank) and after the bulging process. These dimensions depend on both the measurement location and camera orientation. The schematic presentation of the measurement method is shown in Figure 7.

In the bulging process, the sheet metal deformation leads to the permanent barcode distortion. The 25 mm barcode applied initially to the sheet metal surface therefore experiences a complex strain state in three directions (two of them on the surface and one in the thickness). To recognize the barcodes and to investigate the results of a scanning process, the authors of

this paper have been using the CCD-equipped camera and a specially developed scanning application written by (Pavlidis et al., 1990) in the Matlab/Simulink programming language. The application was designed to scan and present the results in real time, as shown in Figure 7. To determine the readability of the scanning method, three barcode locations with numbers 1, 2 and 3 were chosen (Figure 7c). The camera was then perpendicularly oriented to the surface to consider only a plastic deformation of the barcodes and their displacement. To estimate the barcode deformation, the equivalent strain of specimen was calculated after bulging by using a specially patterned specimen. Additionally, to take into account the camera orientation, several tilt angles were chosen (0º, 25º and 45º degrees), as shown in Figure 8.
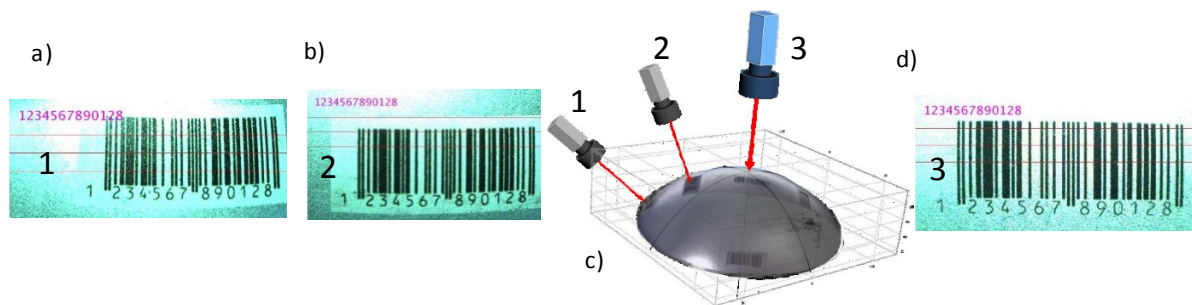


**Figure 7.** Schematic presentation of the scanning process for three barcode locations, as described (c): location 1 (a), for location 2 (b), and location 3 (d).

Source: own elaboration.

For the first group of measurements, three barcode locations (Figure 7c) perpendicular to the specimen surface were selected. The results for the scanning of selected barcodes using machine vision technology were displayed online during the measurement (the pink number above the scanning lines), as shown in Figure 7 a, b, d. The identifications were correct for all the barcodes.
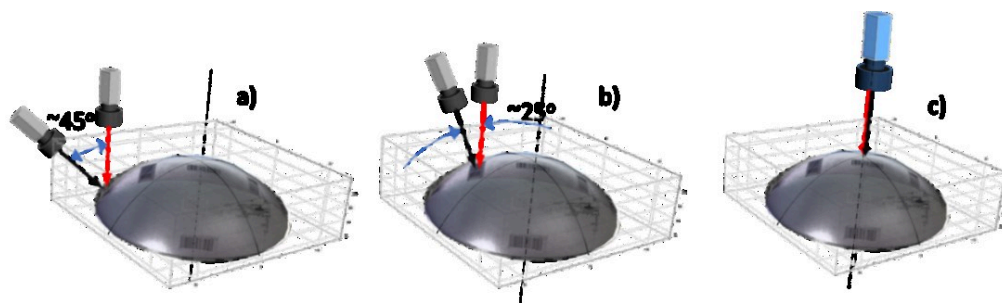


**Figure 8.** Schematic presentation of the barcode identification with different camera tilt angles: tilt angle 45º degree (a), tilt angle 25º degree (b), tilt angle 0º degree (c).

Source: own elaboration.

In the second group of measurements, the barcode was read with different tilt angles of CCD camera orientation (Figure 8a, b, c). As before, identifications were correct for all the barcodes. To quantify the process of the sheet metal deformation, a specially designed stereovision system was utilized (Figure 9a). A laser marking method was used to create a circle grid pattern on the surface of sheet metal blank for the bulging process. Next, a complex measurement based on image processing and data analysis was performed. In this case, image acquisition data was

used to capture the real shape of specimens from two different points of view (Figure 9b, c) and then to proceed to a 3D reconstruction of the object (Figure 9d).

To calculate the true strain values, a mathematical model based on the directional derivative of the material surface displacement has been utilized. A numerical solution of the presented method developed and published by (Świłło, 2001) was adapted in this research for measurements of the grid before and after deformation. True strain reached the highest value of 0.6 (Figure 9d) for a barcode placed on the top of the specimen surface. As for the next two locations of barcodes, the true strains were 0.5 and less than 0.3, respectively.
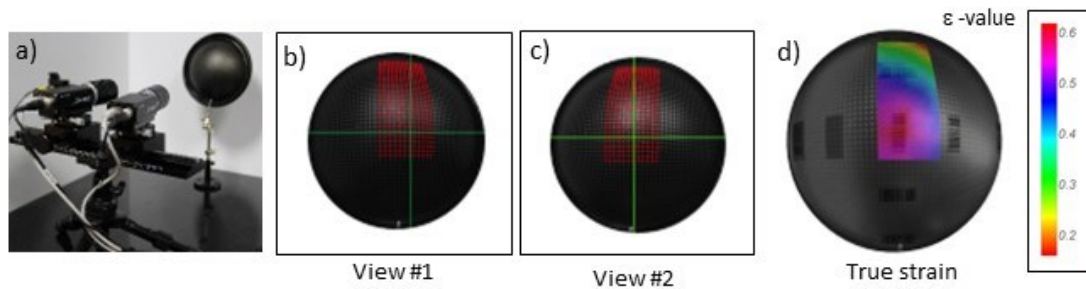


**Figure 9.** Experimental set-up with stereovision camera, deformed specimen, and video display (a), and results of surface strain measurement (b, c, d).

Source: own elaboration.

In the final investigation of the scanning process readability, the effects of barcode deformation were considered simultaneously, i.e., sheet metal surface displacement and changes in geometry (Figure 10c). Also, under these extreme conditions the results have proved that the final quality of barcode marked by the proposed method would not be a limitation for its recognition, as shown in Figure 10 a,b,d.
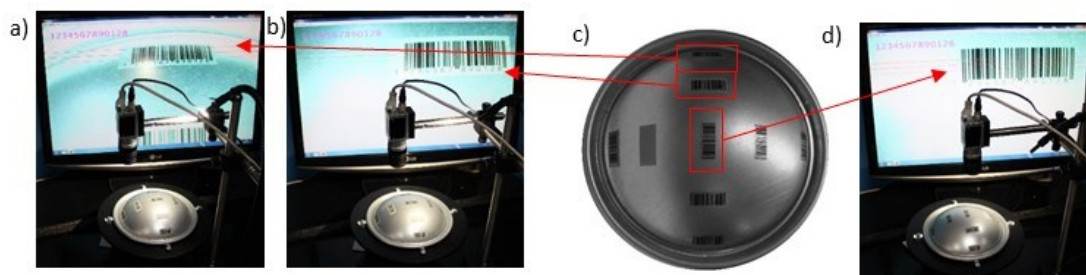


**Figure 10.** Scanning processes for the selected barcodes subjected to extreme conditions due to sheet metal surface displacement and changes in geometry (a, b, and d), for fixed camera orientation as shown (c).

Source: own elaboration.

## 7. Conclusions

This paper presents the results of potential influence of a laser marking method on sheet metal surface quality. Two aspects of surface quality were considered in relation to the sheet metal formability and barcode recognition. For these purposes, specially applied barcodes and calibration patterns were generated on the specimen surface using advanced laser technology, and the specimen was exposed to a large deformation through a hydraulic bulging process. Finally, several measurements were performed for both barcodes and calibration patterns. The results can be summarized as follows:

- The proposed method of applying appropriate laser marks at the initial phase of the product manufacturing process considerably extends traditional solutions and provides a wide range of data storage options.

- Laser beam speed $v$ significantly affects the tonal values of the marked surfaces of the DC04 sheet metal.

- By selecting the appropriate laser beam, tonal values of the marked surface that are even higher than those of the native sheet metal surface can be obtained, allowing a truly high contrast between a white background and black marks when identifying barcodes.

- Differences in these high tonal values of the marked sheet metal surface before and after the bulging process are negligible.

- A barcode reading process was successfully accomplished by using vision scanning technology for the sheet metal surface subjected to large deformation (true strain within the range of 0.3-0.6).

- Additionally, the distortion of the barcode image caused by large sheet metal deformation was also successfully verified by tilting the camera around the optical axis in a range of 0 to 45 degrees.

- Laser marking of barcodes on a sheet metal surface introduced no problems with sheet metal formability in the applied bulging process with relatively large plastic strains.

- The presented application of barcode marking technique should be regarded as a very helpful solution for the technology information and the flexible manufacturing management strategy that can lead to an increase in the quality of obtained products, in accordance with the assumptions of Industry 4.0.

## Acknowledgements

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# EVALUATING THE USEFULNESS OF COST ACCOUNTING IN SELECTED BUSINESS ENTITIES IN LIGHT OF THE COVID-19 PANDEMIC — RESULTS OF THE AUTHOR'S SURVEY RESEARCH

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**Purpose:** The purpose of this article is to analyze and evaluate the usefulness of the cost accounting system of selected enterprises in the Świętokrzyskie voivodeship for managing their costs under the conditions of the COVID-19 pandemic.

**Design/methodology/approach**: The article presents the results of the author's survey research. This research was carried out using the Computer-Assisted Web Interview survey method. Business entities from the Świętokrzyskie voivodeship with an entry in the National Court Register were invited to the survey via e-mail. These were commercial companies, mainly limited liability companies and joint-stock companies.

**Findings:** The main conclusion of the study is that the full cost accounting used in business entities is partially useful for effective cost management of the studied entities. With the COVID-19 pandemic, there was little impact on the usefulness of cost information extracted from applied costing.

**Originality/value:** The COVID-19 pandemic has destabilized all areas of economic and social life in Poland. Therefore, an important issue is the analysis and evaluation of its impact, which is still faced today by representatives of various industries and sectors of the Polish economy. The considerations presented here concern evaluating the utility of cost accounting systems in light of the COVID-19 pandemic. This information can be useful for those dealing with cost accounting issues and the effects of the coronavirus pandemic in theory, as well as business owners, controlling managers or accounting services staff.

**Keywords:** cost accounting, commercial companies, COVID-19 pandemic.

**Category of the paper:** research paper, surveys.

## 1. Introduction

The analysis of the socio-economic conditions of the Polish economy, as well as economies in other countries — in particular — in 2020-2021 must take into account the COVID-19 (coronavirus) pandemic. It has caused destabilization of all spheres of economic and social life

in Poland, especially in 2020 and the first quarter of 2021. To this day, entities representing various industries and sectors of the Polish economy still face its varied effects. Therefore, a full assessment of the impact of this pandemic must be multidimensional and address various aspects of entities' business activities.

The lockdown, introduced in Poland in 2020, prevented selected entities from conducting business in full, which resulted in a decline in the level of the earned revenue. However, it was not necessarily associated with a decrease in the level of costs incurred by these entities. This was especially true of the fixed costs of running business, which in most cases did not respond at all to the change in economic conditions caused by the pandemic. This has caused numerous entities to struggle to maintain liquidity. It can be assumed that the need to adapt the business to the specifics of the new economic reality has highlighted the information needs of effective cost management. This became one of the prerequisites for undertaking research on evaluating the usefulness of cost accounting systems used in business entities for effective management of their costs.

The purpose of this article is to analyze and evaluate the usefulness of the cost accounting system of selected enterprises in the Świętokrzyskie voivodeship for managing their costs under the conditions of the COVID-19 pandemic. The article presents the results of the author's survey of selected business entities from the Świętokrzyskie voivodeship. The analysis of the results of the survey gave rise to the conclusion that the cost accounting used in the surveyed companies is partially useful for effective cost management.

## 1.1. COVID-19 pandemic — a synthetic approach

The COVID-19 pandemic, particularly in 2020–2021, has significantly affected the socio-economic functioning of most European and global economies (Czech et al., 2020; Ligaj, Pawlos, 2021; Wnukowski, 2020). The first cases of COVID-19 caused by the SARS-CoV-2 virus were reported on 17 November 2019 in Wuhan city in central China. Initially, the number of registered cases classified the disease in epidemic terms, but on March 11, 2020, the World Health Organization (WHO) gave COVID-19 a pandemic status (Coronavirus: China's First Confirmed Covid-19 Case Traced Back to November 17 | South China Morning Post; Coronavirus, 2020). In mid-January 2020, the virus spread throughout China, and in mid-February 2020, outbreaks of infection were reported in South Korea, Iran and Italy. The first cases of infection in Poland were registered in early March 2020 (Pierwszy Przypadek Koronawirusa w Polsce - Ministerstwo Zdrowia - Portal Gov.pl, 2020). The virus spread extremely quickly, covering more continents ('Coronavirus Spreads to Antarctic Research Station', 2020; WHO: Europa Stała Się Epicentrum Pandemii Koronawirusa SARS-CoV-2 - Puls Medycyny - Pulsmedycyny.pl). Therefore, specific international measures were taken to counter the spread of these infections. Quarantines, curfews, postponement or cancellation of sports or cultural events, as well as restrictions on border traffic were among the measures introduced. Numerous countries also decided to temporarily close their borders (Coronavirus:

Poland to Close Borders to Foreigners, Quarantine Returnees, Europe News & Top Stories - The Straits Times, n.d.; Denmark Closes Border To All International Tourists For One Month). Lack of sufficient information about the SARS-CoV-2 and COVID-19, at the beginning of the pandemic caused great fear among the public and total disorganization of private and professional life. One of the solutions to curb the coronavirus were the so-called lockdowns, or bans on movement without a legitimate need, introduced by state authorities. The first such restrictions in Poland were introduced on 13 March 2020. On that day, schools, cultural institutions were closed and mass events were canceled, and where possible, work was carried out remotely. The incidence of the disease, both in Poland and around the world, was increasing rapidly, forcing those in power to introduce further restrictions. The implemented restrictions had a significant impact on the operation of business entities, which quickly had to adapt to the new business environment. The decline in their economic activity observed during the pandemic, particularly at the peak of the number of cases, while very deep, was also temporary. In light of the data presented in the literature, the food and hospitality industry, tourism, culture, education, entertainment and recreation, transportation, retail, export, investment and consumer goods manufacturing sectors have been most severely affected by the coronavirus (Stojczew, 2021). Others such as: industries that produce and sell convenience goods, such as: food, or the construction sector have not been strongly affected by the pandemic (Kowalczyk, 2020; Szczepaniak et al., 2020). But there were also those that saw significant growth in turnover during the period, such as: courier services, Internet sales and hygiene products manufacturing.

## 1.2. Economic situation of business entities in Poland during the COVID-19 pandemic

As mentioned, the COVID-19 pandemic caused a variety of effects on the functioning of individuals and business entities, organizations and institutions in all sectors and industries of the Polish economy, reflected in:

- making it completely impossible to conduct business during the lockdown period (as in the case of the hospitality or food industries),
- the need to adapt the manner and scope of business activities to the conditions of the pandemic, which was usually associated with an increase in the cost of these activities (such as educational activities),
- the development of the scale and scope of existing operations, resulting from a sharp increase in demand for the products and services offered by certain business entities (such as logistics services).

In light of the above considerations, it is cognitively interesting to analyze and assess the impact of the COVID-19 pandemic on the activities of business entities. A number of them had to respond immediately to the situation, ensuring the continuity of ongoing tasks and processes. It was necessary to implement a remote work mode, particularly in those areas of the business where it was possible as well as necessary. This generated the obligation to implement costly IT tools to enable operations in this form. Their use for some entities was a major challenge

(in economic terms as well), particularly for those that thus far had used such solutions in a limited scope or did not use them at all. The new economic reality in which these units had to operate was reflected in the level and structure of their costs. Some business entities noted a deterioration in their financial situation, which also reduced the efficiency of their operations. The pandemic has had a marked impact on financial performance in a number of sectors, according to the Statistics Poland data. According to the survey carried out by the National Bank of Poland, in the second quarter of 2020, as many as 80% of entities in the "hotels and restaurants" industry and half of companies involved in culture, entertainment and recreation recorded a loss (Sytuacja Społeczno-Gospodarcza Polski w Dobie Pandemii, 2020).

Business entities very often reacted to the new economic conditions of conducting business by reducing costs, including sharply cutting investment plans. This is a fairly obvious and widely used solution in practice, however, its effects do not always produce the expected results. The most typical solution, also applied during the pandemic period, is to reduce the number of full-time employees, and therefore, reduce the cost of remunerations, which is usually the largest cost item in a business entity. Therefore, in order to reduce layoffs, the so-called government's anti-crisis shields were developed and implemented, allowing employers to benefit from subsidies to their employees' remunerations. The possibility of temporarily reducing working hours and limiting the amount of remunerations paid was also introduced.

## 2. Methods

Fulfilling the purpose of this article required preparing and conducting a survey of a selected sample of business entities. The research in question was conducted in 2021, and thus while the COVID-19 pandemic was still ongoing in Poland. Due to the counter-epidemiological recommendations in effect at the time, regarding the need for social distance, it was decided to use the Computer-Assisted Web Interview method, i.e., computer-assisted survey via one of the Internet portals offering such services.

The purpose of the survey conducted was to *evaluate the usefulness of the cost accounting system of business entities for managing their costs under the conditions of the COVID-19 pandemic.* A proprietary survey questionnaire was developed for the purpose of the presented study, including a total of 23 questions divided into three thematic blocks, including:

- characteristics of the surveyed company,
- assessment of its financial activities under conditions of the COVID-19 pandemic,
- characteristics of cost accounting for effective cost management used in this entity.

2450 subjects from the Świętokrzyskie voivodeship were invited to survey. Due to the fact that the data of the surveyed companies was generated from the online database of the Central Economic Information Center, which publishes contact details of companies with an entry in the National Court Register, commercial companies formed the group covered in the survey. The invitation to the survey, as well as the survey itself, took place online, thus, one of the sampling criteria for the survey was that the company had an email address. The survey was anonymous.

In the end, 1,300 subjects participated in the survey, which accounted for 53% of the total surveyed population. The vast majority, as much as 70%, were represented by limited liability companies, mainly employing up to 9 employees. The largest number of surveyed entities represented the manufacturing and service industries, while the smallest represented the food and catering industries. The survey was conducted over a period of four months. During this time, there was also constant monitoring of the completed questionnaires. During the survey, reminder messages were sent to respondents who did not respond to the invitation they received, asking them to take part in the survey. After the completion of the survey period, a summary survey report was compiled based on the results obtained, the results of which will be presented in the next section of this article.

## 3.  Results

Due to the purpose of the presented considerations as well as the limited volume of the article, this section will present synthetic results of the conducted surveys relating mainly to the third part of the questionnaire. In particular, they will be concerned with the analysis and evaluation of the cost accounting used in the entities studied, for the effective management of their costs under the conditions of the COVID-19 pandemic. However, the evaluation of the financial activities of the surveyed group of companies was analyzed in a separate article (Moskwa-Bęczkowska, 2021).

According to an analysis of the literature in Poland, the most common cost accounting system is full cost accounting (Sobańska, 2009). Its basic thesis is the assumption that the costs of the products are all costs incurred in the unit in relation to their manufacture (Gabrusewicz et al., 2002). Therefore, the adjective "full" used in its name refers to the need to allocate all production costs to the products manufactured. Such a high prevalence of full cost accounting in business practice is due to the fact that it is an obligatory cost accounting system under the provisions of the balance sheet law. This is because the reporting accounting system in force in Poland prescribes accounting entities to determine the financial result, including the preparation of the profit and loss account in accordance with the principles of full cost accounting (Ustawa z Dnia 29 Września 1994 r. o Rachunkowości, 2021).

The above considerations are also confirmed by the results of the survey, which show that the vast majority of respondents — nearly 85% — use the full cost accounting system in their entities. More than 12% of the surveyed companies pointed to variable costing (not analyzed further in the article), and the remaining 3% pointed to other costing systems, such as activity-based costing and target costing (which will also not be discussed further).

The essence of the full cost accounting system and the way costs are accounted for per unit of output make this system useful, primarily for long-term decision-making, rather than for current information needs. This is because this account provides correct cost information only when the unit's capacity is fully utilized. However, in practice, it is often the case that the company does not fully utilize this capacity, resulting in costs not related to production, i.e., so-called fixed costs. These, in turn, including, e.g., production readiness costs, due to the adopted procedure of accounting for costs per products, in the analyzed cost accounting system, cause distortion of unit cost information. And in the long term, revenue from product sales should cover all of the products' own costs, including fixed costs. Therefore, this cost account should rather be used for long-term analysis and evaluation of the level and structure of costs incurred. The results of the survey, on the other hand, showed that the main purpose for which the surveyed companies use the applied full cost accounting is current cost accounting. Answering the question: *for what purposes the cost accounting system is used in their enterprise, a vast majority of respondents* indicated the mentioned current cost accounting (approx. 64%) and cost control (approx. 56%). Table 1 presents, in percentage terms, the remaining responses of the surveyed companies to the above question.

**Table 1.**
*Purposes of using cost accounting in the surveyed companies*

| Market | % |
|---|---|
| short-term cost planning (within a period of up to 1 year) | 48.89% |
| long-term cost planning (within a period exceeding 1 year) | 26.67% |
| current costs accounting | 64.44% |
| analysis of costs incurred in the past | 33.33% |
| control of costs | 55.56% |
| calculation of unit costs | 23.33% |
| calculation of costs of selected processes occurring in the enterprise | 20.00% |

Source: Own elaboration.

Analyzing the data presented in Table 1, it is worth noting that long-term cost planning, and therefore the main objective of the full costing concept, is the least important according to the surveyed entities. This answer was chosen by only 27% of respondents.

The results of the survey confirmed the thesis that the full cost accounting used in the surveyed enterprises is of little use for effective cost management of these units — see Table 2.

**Table 2.**

*Evaluating the usefulness of the cost accounting system — cost management*

| Market | % |
|---|---|
| fully useful | 45.56% |
| partially useful | 47.78% |
| not useful at all | 6.67% |

Source: Own elaboration.

As can be seen from the above data, for nearly half of the surveyed companies, the cost information generated from the cost accounting system used is partially useful for the effective management of their operations, with no connection at all to the COVID-19 pandemic. In their view, the full cost accounting system provides limited scope for obtaining detailed cost data. The economic conditions for the operation of these companies during the coronavirus pandemic therefore did not affect the desire to obtain more cost information. This was declared by nearly 55% of the surveyed companies. Their possible need for information stems from the inadequacies of the costing concept itself rather than the surrounding economic conditions caused by the coronavirus pandemic. A critical analysis of this cost accounting system has shown that it is primarily determined by a number of conditions arising from various pieces of legislation. The specifics of the full cost accounting used, on the other hand, make it impossible to obtain detailed information about the causes, structure and locations of costs, making the cost information generated by this accounting method useful primarily for reporting rather than management purposes, according to nearly 43% of respondents.

The most desirable information from the point of view of effective cost management is knowledge of the level and structure of costs incurred, which is used, i.a., for reliable calculation of unit costs. This is what is missing from the full cost accounting system, where cost information is often in aggregate form. Therefore, respondents were asked to identify necessary changes to their cost accounting system — the answers given are presented in Table 3.

**Table 3.**

*Proposal for changes in the cost accounting system of the surveyed enterprises*

| Market | % |
|---|---|
| simplification of existing procedures for recording, accounting and calculating costs | 25.00% |
| detailing the existing procedures for recording, accounting and calculating costs | 21.88% |
| development of the cost planning function | 21.88% |
| implementation of an IT system to expand scope of cost information | 25.00% |
| introduction of a new cost accounting system | 9.38% |
| there is no need to make any changes to the existing system | 18.75% |

Source: Own elaboration.

As can be seen from the data presented in Table 3, the simplification of the existing procedures for recording, accounting and calculating costs, and the implementation of an IT system to expand the scope of cost information would bring the greatest improvement in terms of the usability of the applied cost accounting system in the surveyed companies.

## 4. Summary

The analysis of the results of the surveys allows to draw a conclusion on the usefulness of the cost accounting system for managing costs under the conditions of the COVID-19 pandemic. Namely, the change in the operating conditions of the market sector as a result of the coronavirus pandemic did not have a significant impact on the utility of the cost accounting system used in the surveyed business entities. The account, according to more than half of the respondents, is either partially useful or not useful at all for effective collection and management of cost information. Rather, this judgment is based on the identification of the flaws and inadequacies in the full cost accounting concept itself. The pandemic period undoubtedly made it difficult or completely impossible to conduct business, but it did not provide a basis for identifying additional information needs from the range of costs incurred. Perhaps this is due to the peculiarities of the surveyed companies, which, despite the difficult socio-economic conditions of conducting business caused by the pandemic, have mostly maintained positive financial results. And while the full cost accounting system they use does have flows, it also makes it possible to prepare mandatory financial statements and to analyze costs in specific accounting systems.

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# A PRODUCTION COMPANY SIZE
# AND WORKPLACE SAFETY HAZARDS

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**Purpose:** The objective of the study is to examine whether a wood processing company size affects the differentiation of workplace safety hazards as well as to investigate the influence of features characterizing an occupational accident casualty on their injury severity, considering the company size.

**Methodology**: The study used non-aggregated data obtained from the Central Statistical Office, Poland. The data for analyzes were prepared through quality diagnosis, cleaning and transformation. Variables of no informative value were excluded from further investigation. Statistical tests were performed implicating the need for independent analyzes for two data subsets referring to: micro and small enterprises (employing up to 49 persons), and medium and large enterprises (employing 50 persons or more). For each of the two company groups, a logistic model was developed classifying the occupational accident casualty injury severity based on the casualty characteristics. In each case, the classification quality was assessed using a test data set.

**Findings:** It was shown that the enterprise size had an impact on the severity of accidents at work and that the proposed method of classifying enterprises by size into two categories was justified. Explanatory variables in logistic models were interpreted according to their importance and intensity of influence on the explained variable.

**Practical implications:** The obtained results can be used in the development of materials on occupational safety risks for entrepreneurs and OSH services.

**Social implications:** Each type of economic activity carries various risks. Occupational accidents pose a serious social and economic problem. Research in the field of occupational safety allows a better understanding of the nature of such accidents and makes it possible to take effective preventive actions which, however, can depend on a company size.

**Originality/value:** On the basis of the obtained results, it is possible to identify the factors influencing the severity of occupational accidents in wood processing companies according to their size. The research also showed that bivariate multiple logistic regression is an appropriate tool for analyzing occupational accident data.

**Keywords:** occupational accident casualties; production company size; tests for equality of proportions; logistic models.

**Category of the paper:** Research paper.

# 1. Introduction

Each type of economic activity carries various risks. Occupational accidents pose a serious social and economic problem. Research in the field of occupational safety allows a better understanding of the nature of such accidents and makes it possible to take effective preventive actions. The study focuses on work safety problems in Poland; selected aspects of accident phenomenon research were analyzed. Data analysis methods such as statistical tests, data balancing, and logistic regression were used for a specified manufacturing sector – wood processing.

Statistical modeling and data-mining techniques are popular methods in occupational accident-related studies (Chan et al., 2022). The most common are: artificial neural networks (e.g. Ayhan, Tokdemir, 2020), association analysis (Martínez-Rojas et al., 2022), Bayesian networks (Lu et al., 2020), cluster analysis (Nowakowska, Pajęcki, 2021), decision trees (Martínez-Rojas et al., 2020), linear regression (Nowobilski, Hoła, 2022), logistic regression (Hansen et al., 2022), support vector machines (Mangeli et al., 2019), text mining (Shi, Rothrock, 2022).

Logistic regression (LR) allows introducing both qualitative and quantitative explanatory variables into the model equation and has the capability of estimating and quantifying meaningful results in terms of odds ratios. LR analysis, in particular binary LR, has been widely used in studies related to occupational safety to classify occupational injuries and extract information to improve workplace safety. Among work safety analysis studies, the explained variable does not always refer to the degree of injury of the accident casualty – it is defined in different ways, depending on the purpose of the research. One can find the regression modeling regarding occupational safety and health (OSH) in various areas of the economy, such as agribusiness or agricultural industries (Hayati et al., 2021; Davoudi Kakhki et al., 2019; Swanton et al., 2016), electrical industries (Gholizadeh, Esmaeili, 2020), mining (Yedla et al., 2020; Onder, Mutlu, 2017), metal industry (Durmaz, Atalay, 2021; Kifle et al., 2014), construction (Halabi et al., 2022; Dong et al., 2020), petroleum manufacturing (Tsai et al., 2011), or automotive manufacturing (Reyes et al., 2015). However, its use in occupational safety analysis as regards the woodworking industry has been minimal.

Dida et al. (2019), in their study, focused on workers from small-scale industries in Southeast Ethiopia, including woodwork. They modeled occupational injury using binary (dichotomous) simple and multiple logistic regression. The following conclusions were drawn: (1) workers who took health and safety training involving their profession were less likely to be injured compared to those who did not take the training, (2) lack of supervision, any objects on the floor that can cause an accident, and low occupational risk perception increased the odds of occupational injury by several times in comparison to the respective opposite work circumstances. Bentum et al. (2021) discussed occupational safety conditions in wood and

wood products processing industry in a selected region of Ghana (in relation to informal woodworkers). The authors examined the influence of socio-demographic variables on the usage of PPE (personal protective equipment, a binary explained variable). Any educational level (as referenced to illiterate) and over 10-year service of the woodworkers positively influenced their PPE usage. Among four job types, only machine operators had strong positive attitudes to protect themselves against occupational injuries and death.

Various industry sectors are considered to be dangerous in terms of OSH, depending on work conditions in a country, a sector, or a company, and workplace safety climate, including the production company size. The most frequently indicated ones are construction and mining. In Poland, in addition to the industries mentioned above, the occupations in wood processing are rated with high accidents and injuries (Pajęcki, 2020). Wood industry workers are highly susceptible to injuries and accidents due to the hazardous and risky nature of their work connected with the performance of many dangerous operations occurring in the production process, such as cutting, planning, sawing, other mechanical processing, gluing and laminating.

The objective of the study is to examine whether a wood processing company size affects the differentiation of workplace safety hazards as well as to investigate the influence of the features characterizing an occupational accident casualty on their injury severity, considering the company size.

The paper is organized as follows. After this background section regarding the modeling of occupational accident circumstances in various industry sections, including woodworking, the methodology section details are presented. Then, data preparation for logistics modeling is described. Next, the results of the modeling process are demonstrated for the companies of two categories as regards the company size, and the hazardous accident tendencies observed in this trade are outlined. Finally, the findings of the study are discussed and summarized.

## 2. The methodology approach

Bivariate multiple logistic regression is a classifier used to identify the relationship between the explanatory variables and the explained variable (Agresti, 2013). The explained variable takes two values; one is usually called a success or an event and the other is called a failure or a non-event. The logistic classifier estimates the probability of the explained variable $Y$ taking the category of the success at certain values of the explanatory variables $X_1$, ..., $X_k$, according to the formula:

$$P(Y = Success \mid X_1 = x_1, \ldots, X_k = x_k) = \frac{\exp(B_0 + \sum_{i=1}^{k} B_i \cdot x_i)}{1 + \exp(B_0 + \sum_{i=1}^{k} B_i \cdot x_i)} \tag{1}$$

In the study, *Casualty injury severity* is the explained variable and it is considered as a risk-related OSH measure. The variable takes two values: *Serious* (success, event) and *Other* (failure, non-event).

The odds and the odds ratio are utilized in logistic regression. The odds are defined as the quotient of the probability of success and the probability of failure. The odds can be determined for two groups of observations, which differ in the value of a specific explanatory variable. The quotient of these ratios defines the odds ratio *OR*. *OR* allows the interpretation of the logistic regression structural parameters; the possibility of success in one group is compared to the success in the other group. When $X_i$ is a qualitative variable, the *OR* informs that the odds of the explained variable taking the success value are for the *k2* category of the explanatory variable $X_i$ as $\exp(B_i)$ of the odds for the *k1* reference category of that variable, with the other inputs fixed (ceteris paribus):

$$OR\big(X_{i,\ (k2\,vs\,k1)}\big) = \frac{P(Y = Success \mid X_i = k2)\,/\,P(Y = Failure \mid X_i = k2)}{P(Y = Success \mid X_i = k1)\,/\,P(Y = Failure \mid X_i = k1)} = \exp(B_i) \quad (2)$$

An odds ratio is always non-negative and it matters in the logistic model if the parameter that defines it is statistically significant. An odds ratio of 1 indicates no influence. An odds ratio greater than 1 indicates that the specific factor increases the odds of the success (a positive influence), while an odds ratio less than 1 indicates that the factor decreases the odds of the success (negative influence). The further the *OR* value is away from unity, the stronger the influence, positive or negative, of the factor on the explained variable is.

The following tools were used to assess the obtained logistics models (Hand et al., 2001; Agresti, 2013):

- Model Significance Likelihood Ratio Chi-Square test.
- The *AIC* and *SBC* measures.
- Classification quality measures:
  - Sensitivity, True Positive Rate (*TPR*; *Serious* → *Serious*): $TPR = \frac{TP}{TP+FN}$.
  - Specificity, True Negative Rate (*TNR*; *Other* → *Other*): $TNR = \frac{TN}{TN+FP}$.
  - Proportion Correctly Classified (*PCC*): $PCC = \frac{TP+TN}{TP+TN+FP+FN}$.
  - Harmonic Mean Of Sensitivity And Specificity: $HMSS = 2 \cdot \frac{TPR \cdot TNR}{TPR+TNR}$.

Sensitivity measures the proportion of correctly classified successes (serious casualty injury severity), whereas specificity measures the proportion of correctly classified failures (other casualty injury severity).

The model estimation process was carried out in several steps, as described below.

1. The raw data set was partitioned into training and test data sets, in the proportions: 70% to 30%.
2. In order to compensate for the negative impact of the unequal distribution of the explained variable on the modeling results, a balanced set (50% of successes, 50% of

failures) was created from the training data set (Hand et al., 2001), on the basis of which the logistic regression model was built.

3. Stepwise selection of the explanatory variables was applied in the logistic model estimation process.

4. Classification quality was assessed on the test data set and the unbalanced training set.

SAS Enterprise Miner was used in the calculations.

## 3. Data preparation for logistics modeling

Data for the analysis were acquired from the occupational accident database of the Central Statistical Office (CSO), Poland. The Office conducts tasks in the scope of recording and managing all occupational accidents data in the whole country. The data structure reflects the structure of the national statistical accident card (defined by the regulation of the Minister of Labor and Social Policy of January 7, 2009 (Journal of Laws of 2009, No. 14, item 80), amended in 2019 by the regulation of the Minister of Family, Labor and Social Policy of June 4, 2019 (Journal of Laws of 2019, item 1106), which contains details (features) on an employee injured in an accident.

This research is focused on the OSH issues as regards wood processing industry. Therefore, records assigned to division 16 *Manufacture of wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials* were selected out of 24 divisions of section C *Manufacturing* according to Polish Classification of Activities. Data on the occupational accidents directly related to the production process, which took place in 2008-2017 throughout Poland, were analyzed.

In the data pre-processing step, variables (the features characterizing injured employees) were selected for the logistic modeling. Records in which the values of certain variables were unknown, undefined, or not available were excluded from the analysis. In order to solve the problem of rare categories and to limit the possibility of expanding the logistics model, the aggregation of values in the set of explanatory variables was proposed, taking into account their substantive meaning.

As declared earlier, *Casualty injury severity* is the explained variable that takes two values: *Serious* and *Other*. The variable is considered as a risk-related OSH measure. According to the literature (Abdalla et al., 2017; Sinclair, Cunningham, 2014), there is a difference in terms of the severity of the effects of occupational accidents (including loss of life) between employees of smaller companies and employees of larger companies. In order to verify whether the above applies to Polish conditions, the Pearson's chi-square test of independence (Howell, 2011) was performed at the significance level of $\alpha = 0.05$. Two variables were considered:

- *Casualty injury severity*.
- *Company size*, determined on the basis of the number of employees as having two values: *wk*1 – for micro and small companies, *wk*2 – for medium and large companies.

The following hypotheses were formulated:

H0: The company size does not affect the occupational accident casualty injury severity.

H1: The company size affects the occupational accident casualty injury severity.

The observed frequencies in both subsets are included in the contingency table (Table 1). The calculated value of the chi-square statistic is 219.05, and the *p-value* < 0.0001. Therefore, the null hypothesis has to be rejected. It can be concluded, with the 95% probability, that the size of the company has an impact on the severity of the occupational accident casualty injury.

**Table 1.**

*The observed frequencies for Company size vs. Casualty injury severity*

| Casualty injury severity | Company size | | Total |
|---|---|---|---|
| | *wk*1 | *wk*2 | |
| *Other* | 2763 | 7430 | 10193 |
| *Serious* | 685 | 1174 | 1859 |
| **Total** | 3448 | 8604 | 12052 |

Source: authors' own elaboration.

Table 2 summarizes the variables considered in the logistic modeling by the company size. Values of explanatory variables and the codes of these values represent factors that can influence the explained variable. They are later utilized in the interpretation of modeling results. Two logistic models: *M-wk*1 and *M-wk*2 are built independently for data subsets from the two companies: *wk*1 and *wk*2 respectively.

**Table 2.**

*Characteristics of the research data*

| Variables in the logistic model | | *wk*1 [%] | *wk*2 [%] |
|---|---|---|---|
| **Explanatory variables** | **Factors** | *n* = 3448 | *n* = 8604 |
| ***P*01 – Casualty gender** | | | |
| Male | *P*01_1 | 92.49 | 82.44 |
| Female | *P*01_2 | 7.51 | 17.56 |
| ***P*02 – Casualty age** | | | |
| Up to 24 years old | *P*02_1 | 17.43 | 17.61 |
| 25 - 34 years old | *P*02_2 | 30.42 | 30.51 |
| 35 - 44 years old | *P*02_3 | 24.74 | 25.50 |
| 45 - 54 years old | *P*02_4 | 18.10 | 18.56 |
| Over 54 years<br>*Aggregation of original values*: (*55 - 59 years*) + (*over 59 years*) | *P*02_5 | 9.31 | 7.82 |
| ***P*05 – Casualty occupation** | | | |
| Industrial workers, craftsmen, and employees doing simple works<br>*Aggregation of original values*: (*Industrial workers and craftsmen*),<br>(*Employees doing simple works*) | *P*05_1 | 78.94 | 63.66 |
| Operators and assemblers of machines and devices | *P*05_2 | 21.06 | 36.34 |

Cont. table 2.

| | | | |
|---|---|---|---|
| **P06 – Enterprise job seniority** | | | |
| Up to 5 years | P06_1 | 69.43 | 67.18 |
| 6 - 10 years | P06_2 | 15.43 | 16.09 |
| Over 10 years<br>   *Aggregation of original values*: (*11-15), (16-20), (21-30), (Over 30 years*) | P06_3 | 15.14 | 16.74 |
| **P07 – Hours worked between starting work and the time of the accident** | | | |
| 0 - 3 | P07_1 | 46.61 | 47.00 |
| 4 - 7 | P07_2 | 48.72 | 48.38 |
| 8 and more<br>   *Aggregation of original values*: (*8-11), (12-15), (16-19), (20-23*) | P07_3 | 4.67 | 4.61 |
| **P08 – Injury type** | | | |
| Wounds and superficial injuries | P08_1 | 56.27 | 62.04 |
| Bone fractures | P08_2 | 19.66 | 16.00 |
| Displacements, dislocations, sprains and strains | P08_3 | 6.38 | 12.48 |
| Traumatic amputations (loss of body parts) | P08_4 | 14.68 | 5.32 |
| Internal injuries | P08_5 | 3.02 | 4.15 |
| **P09 – Injured body part** | | | |
| Head, neck<br>   *Aggregation of original values: (Head), (Neck with cervical spine)* | P09_1 | 5.02 | 6.68 |
| Body<br>   *Aggregation of original values*: (*Thoracic and lumbar spine), (Torso and internal organs), (Whole body and its various parts), (Other body part*) | P09_2 | 3.16 | 4.37 |
| Upper limbs | P09_3 | 73.93 | 68.03 |
| Lower limbs | P09_4 | 17.89 | 20.92 |
| **P16 – Season when the accident happened** | | | |
| Spring months<br>   *Aggregation of original values: (March) + (April) + (May)* | P16_1 | 24.86 | 25.78 |
| Summer months<br>   *Aggregation of original values: (June) + (July) + (August)* | P16_2 | 25.73 | 24.74 |
| Autumn months<br>   *Aggregation of original values: (September) + (October) + (November)* | P16_3 | 24.45 | 25.35 |
| Winter months<br>   *Aggregation of original values: (December) + (January) + (February)* | P16_4 | 24.97 | 24.13 |
| **P21 – Activity performed at accident time** | | | |
| Operating machinery | P21_1 | 57.05 | 44.97 |
| Working with tools and objects<br>   *Aggregation of original values*: (*Working with hand tools), (Handling objects*) | P21_2 | 25.49 | 30.85 |
| Transport at workplace<br>   *Aggregation of original values: (Driving means of transport / operation of moving machines and other devices), (Manual transporting)* | P21_3 | 12.24 | 14.81 |
| Being at accident scene<br>   *Aggregation of original values*: (*Moving about), (Presence*) | P21_4 | 5.22 | 9.38 |
| **P26 – Material factor as injury source** | | | |
| Buildings, structures, surfaces<br>   *Objects as above and their elements including positions*: (*At ground level), (Below ground level), (Above ground level*) | P26_1 | 5.83 | 8.18 |
| Waste | P26_2 | 1.80 | 1.84 |
| Hand tools<br>   *Aggregation of original values*: (*Non-powered hand tools), (Hand-held or hand guided mechanized tools*) | P26_3 | 11.02 | 9.75 |
| Machines and devices<br>   *Aggregation of original values*: (*Portable or mobile machines and equipment), (Stationary machines, devices and equipment), (Machines, devices and equipment for lifting, carrying and storage*) | P26_4 | 50.84 | 40.49 |
| Materials, objects, products, machine parts | P26_5 | 30.51 | 39.74 |

Cont. table 2.

| *P27* – **Main accident cause** | | | |
|---|---|---|---|
| Defect of material factor<br>*Aggregation of original values*: (*Design defects or inappropriate technical and ergonomic solutions of material factor*), (*Improper manufacturing of material factor*), (*Material defects of material factor*) | *P27_1* | 21.75 | 14.39 |
| Misuse of material factor<br>*Aggregation of original values*: (*Inappropriate exploitation of material factor*), (*Employee's non-use or inappropriate handling of material factor*) | *P27_2* | 14.36 | 14.53 |
| Inappropriate work organization<br>*Aggregation of original*: (*Inadequate overall organization of work*), (*Inappropriate organization of a workplace*), (*Employee's failure to use protective equipment*) | *P27_3* | 10.99 | 11.91 |
| Safety neglect<br>*Aggregation of original values*: (*Employee's psychophysical state, not ensuring safe work performance*), (*Employee's inappropriate arbitrary behavior*), (*Employee's misconduct*) | *P27_4* | 52.90 | 59.17 |
| **Explained variable** | **Value** | ***wk*1** [%] | ***wk*2** [%] |
| *P289* – **Casualty injury severity** | | | |
| Other<br>*Aggregation of original values*: (*Minor accident resulting in inability to work for 0-13 days*), (*Minor accident resulting in inability to work for 14-29 days*), (*Minor accident resulting in inability to work for 30-89 days*) | Failure | 80.13 | 86.36 |
| Serious<br>*Aggregation of original values*: (*Severe or fatal accident*), (*Minor accident causing inability to work for more than 90 days*) | Success | 19.87 | 13.65 |

Source: authors' own elaboration.

## 4. Logistic regression models for occupational accidents by the company size

Table 3 shows the logistic models assessment. The results of model significance test indicates that both models, *M-wk*1 and *M-wk*2, which classify casualty injury severity, are statistically significant at $\alpha = 0.05$. The complexity of the full logistic models (*FM* – all explanatory variables included) combined with the relatively small size of the balanced training data sets was reflected in the *AIC*(*FM*) and *SBC*(*FM*) values greater than the corresponding values of the *AIC*(*SM*) and *SBC*(*SM*) values for the stepwise models (*SM* – selected explanatory variables included). These results indicate that in each case, the stepwise model (*SM*) is better than the full model (*FM*). The introduction of balancing to the training data set made it possible to estimate the models in which the infrequent value of the success category (*Serious*) was well classified, while the classification of the failure category (*Other*) was not deteriorated. The model quality assessment is satisfactory for all data sets. *PCC* exceeds the value of 0.66. However, the classifications of individual values of the explained variable are important. The *TPR* (*Serious* → *Serious*) index values are equal to 0.62 and 0.67, and the *TNR* (*Other* → *Other*) index value are about 0.71 and 0.70 for the *M-wk*1 and *M-wk*2 models respectively, for both the balanced and imbalanced data sets. The good quality

of the classifiers is confirmed in particular by the *TPR* and *TNR* indices for the test data set, ranging from 0.56 to 0.73, which is further supported by the *HMSS* index values of 0.64 and 0.68 for *M-wk*1 and *M-wk*2 respectively.

**Table 3.**
*Assessment measures for the M-wk1 and M-wk2 logistic models*

| Assessment measure | M-wk1 | | | M-wk2 | | |
|---|---|---|---|---|---|---|
| | Balanced training data | Test data | Imbalanced training data | Balanced training data | Test data | Imbalanced training data |
| Lik. Ratio Chi-Square | 147.155 | | | 317.272 | | |
| DF | 7 | – | – | 15 | – | – |
| *p-value* | <0.0001 | | | <0.0001 | | |
| AIC(FM) | 1215.91 | – | – | 2005.70 | – | – |
| AIC(SM) | 1196.91 | – | – | 1991.02 | – | – |
| SBC(FM) | 1366.72 | – | – | 2173.22 | – | – |
| SBC(SM) | 1235.83 | – | – | 2077.48 | – | – |
| Number of observations | 958 | 1035 | 2413 | 1642 | 2583 | 6021 |
| Percentage | | | | | | |
| *Serious* | 50% | 19.90% | 19.85% | 50% | 13.67% | 13.64% |
| *Other* | 50% | 80.10% | 80.15% | 50% | 86.33% | 86.36% |
| *Serious → Serious* | 0.624 | 0.568 | 0.624 | 0.664 | 0.671 | 0.664 |
| *Serious → Other* | 0.376 | 0.432 | 0.376 | 0.336 | 0.329 | 0.336 |
| *Other → Serious* | 0.292 | 0.274 | 0.285 | 0.302 | 0.310 | 0.309 |
| *Other → Other* | 0.708 | 0.726 | 0.715 | 0.698 | 0.690 | 0.691 |
| PCC | 0.666 | 0.695 | 0.697 | 0.681 | 0.687 | 0.687 |
| HMSS | 0.663 | 0.637 | 0.666 | 0.680 | 0.680 | 0.677 |

Source: authors' own elaboration.

Table 4 present the results of stepwise selection applied to 11 explanatory variables considered in the logistic modeling. The model for medium and large enterprises (*M-wk*2) is more extended than that for micro and small enterprises (*M-wk*1). The following variables turned out to be statistically significant:

- for the *M-wk*1 model: *P*08 (*Injury type*), *P*21 (*Activity performed at accident time*),
- for the *M-wk*2 model: *P*02 (*Casualty age*), *P*08 (*Injury type*), *P*21 (*Activity performed at accident time*) and *P*26 (*Material factor as injury source*).

**Table 4.**
*The results of stepwise selection for the M-wk1 and M-wk2 logistic models*

| Variable | M-wk1 | | | M-wk2 | | |
|---|---|---|---|---|---|---|
| | DF | Wald Chi-square | p-value | DF | Wald Chi-square | p-value |
| P02 | – | – | – | 4 | 29.09 | <0.0001 |
| P08 | 4 | 104.063 | <0.0001 | 4 | 184.19 | <0.0001 |
| P21 | 3 | 22.345 | <0.0001 | 3 | 8.85 | 0.0314 |
| P26 | – | – | – | 4 | 21.62 | 0.0002 |

Source: authors' own elaboration.

Using odds ratios obtained from the logistic models makes it possible to determine how the possibility that an occupational accident casualty was seriously injured changed with the indicated change in the value of the explanatory variable while the other variable values are held fixed (ceteris paribus). Table 5 contains information about the odds ratios. Non significant

factors (*p-value* = 0.05) are marked by a gray background and they are omitted in the interpretation. The interpretation of the odds ratio of each significant factor, controlling for other factors, is given in relation to the reference values of individual explanatory variables. Figure 1 shows a graphical illustration of the modeling results.

According to the *M-wk*1 model, the odds of the serious occupational accident casualty injury are:

- in the case of *Injured body part*:
    - for *Bone fractures* over three times greater than for *Wounds and superficial injuries*; $OR(P08\_2$ vs. $P08\_1) = 3.376$,
    - for *Displacements, dislocations, sprains and strains* two times greater than for *Wounds and superficial injuries*; $OR(P08\_3$ vs. $P08\_1) = 2.166$,
    - for *Traumatic amputations* six times greater than for *Wounds and superficial injuries*; $OR(P08\_4$ vs. $P08\_1) = 6.190$,
    - for *Internal injuries* two and a half times greater than for *Wounds and superficial injuries*; $OR(P08\_5$ vs. $P08\_1) = 2.462$,
- in the case of *Activity performed at accident time*:
    - for *Working with tools and objects* by almost 50% smaller than for *Operating machinery*; $OR(P21\_2$ vs. $P21\_1) = 0.521$,
    - for *Transport at workplace* by nearly 60% smaller than for *Operating machinery*; $OR(P21\_3$ vs. $P21\_1) = 0.431$.

According to the *M-wk*2 model, the odds of the serious occupational accident casualty injury are:

- in the case of *Casualty age*:
    - for workers *Up to 24 years old* by over 60% smaller than for workers *Over 54 years*; $OR(P02\_1$ vs. $P02\_5) = 0.367$,
    - for *25 - 34 years old* workers by 50% smaller than for workers *Over 54 years*; $OR(P02\_2$ vs. $P02\_5) = 0.488$,
    - for *35 - 44 years old* workers by 40% smaller than for workers *Over 54 years*; $OR(P02\_3$ vs. $P02\_5) = 0.587$,
- in the case of *Injured body part*:
    - for *Bone fractures* almost five times greater than for *Wounds and superficial injuries*; $OR(P08\_2$ vs. $P08\_1) = 4.704$,
    - for *Displacements, dislocations, sprains and strains* almost three times greater than for *Wounds and superficial injuries*; $OR(P08\_3$ vs. $P08\_1) = 2.708$,
    - for *Traumatic amputations* nearly ten times greater than for *Wounds and superficial injuries*; $OR(P08\_4$ vs. $P08\_1) = 9.841$,
    - for *Internal injuries* three times greater than for *Wounds and superficial injuries*; $OR(P08\_5$ vs. $P08\_1) = 2.993$,

- in the case of *Activity performed at accident time*:
  - for *Working with tools and objects* by slightly over 30% smaller than for *Operating machinery*; *OR(P21_2 vs. P21_1) = 0.681*,
- in the case of *Material factor as injury source*:
  - for *Buildings, structures, surfaces* by 45% smaller than for *Machines and devices*; *OR(P26_1 vs. P26_4) = 0.555*,
  - for *Hand tools* by slightly under 50% smaller than for *Machines and devices*; *OR(P26_3 vs. P26_4) = 0.513*,
  - for *Materials, objects, products, machine parts* by over 40% smaller than for *Machines and devices*; *OR(P26_5 vs. P26_4) = 0.584*.

The same variables are present in both of the models: *Injury type* (*P*08) and *Activity performed at accident time* (*P*21). Considering *P*08, there is the same tendency as regards the magnitude of the injury type influence on the consequences of an accident at work. The importance of the *P*08 effect for medium-sized and large companies is greater than for micro and small companies, as shown by the corresponding odds ratios for the individual factors. In both cases, the impact of the reference category *Wounds and superficial injuries* (*P*08_1) is smaller than all other types of injury. The fact that *Traumatic amputations* (*P*08_4) have the greatest positive impact on the injury severity is intuition-consistent, but the magnitude of this impact is meaningful, several times greater than the other injury types. For the variable *P*21, the reference category *Operating machinery* (*P*21_1) identifies a greater risk for occupational safety than the other statistically significant activities; *Working with tools and objects* (present in both models *M-wk*1 and *M-wk*2) and *Transport at workplace* (only in *M-wk*1). The *Working with tools and objects* factor (*P*21_2) has a greater negative impact on the success value of the explained variable in model *M-wk*1 than in model *M-wk*2. The *M-wk*2 model includes two more variables, absent in the *M-wk*1 model: *Casualty age* (*P*02) and *Material factor as injury source* (*P*26).

**Table 5.**
*The odds ratios for the M-wk1 and M-wk2 logistic models*

| Parameter | M-wk1 | | | | M-wk2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Value | Standard error | p-value | Odds ratio | Value | Standard error | p-value | Odds ratio |
| Intercept | -0.489 | 0.115 | <0.0001 | - | 0.240 | 0.204 | 0.24 | - |
| P02_1 | - | - | - | - | -1.003 | 0.241 | <0.0001 | 0.367 |
| P02_2 | - | - | - | - | -0.717 | 0.216 | 0.0009 | 0.488 |
| P02_3 | - | - | - | - | -0.533 | 0.212 | 0.0119 | 0.587 |
| P02_4 | - | - | - | - | -0.192 | 0.220 | 0.3838 | 0.826 |
| P02_5 | - | - | - | - | Reference value | | | |
| P08_2 | 1.217 | 0.177 | <0.0001 | 3.376 | 1.548 | 0.148 | <0.0001 | 4.704 |
| P08_3 | 0.773 | 0.303 | 0.011 | 2.166 | 0.996 | 0.174 | <0.0001 | 2.708 |
| P08_4 | 1.823 | 0.199 | <0.0001 | 6.190 | 2.287 | 0.238 | <0.0001 | 9.841 |
| P08_5 | 0.901 | 0.374 | 0.016 | 2.462 | 1.096 | 0.236 | <0.0001 | 2.993 |

Cont. table 5.

| P08_1 | Reference value | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| P21_2 | -0.652 | 0.171 | 0.0001 | 0.521 | -0.385 | 0.145 | 0.008 | 0.681 |
| P21_3 | -0.841 | 0.247 | 0.0007 | 0.431 | -0.236 | 0.175 | 0.177 | 0.790 |
| P21_4 | -0.031 | 0.300 | 0.919 | 0.970 | 0.067 | 0.215 | 0.757 | 1.069 |
| P21_1 | Reference value | | | | | | | |
| P26_1 | - | - | - | - | -0.589 | 0.227 | 0.009 | 0.555 |
| P26_2 | - | - | - | - | -0.301 | 0.444 | 0.499 | 0.740 |
| P26_3 | - | - | - | - | -0.668 | 0.242 | 0.006 | 0.513 |
| P26_5 | - | - | - | - | -0.537 | 0.128 | <0.0001 | 0.584 |
| P26_4 | - | - | - | - | Reference value | | | |

Source: authors' own elaboration.
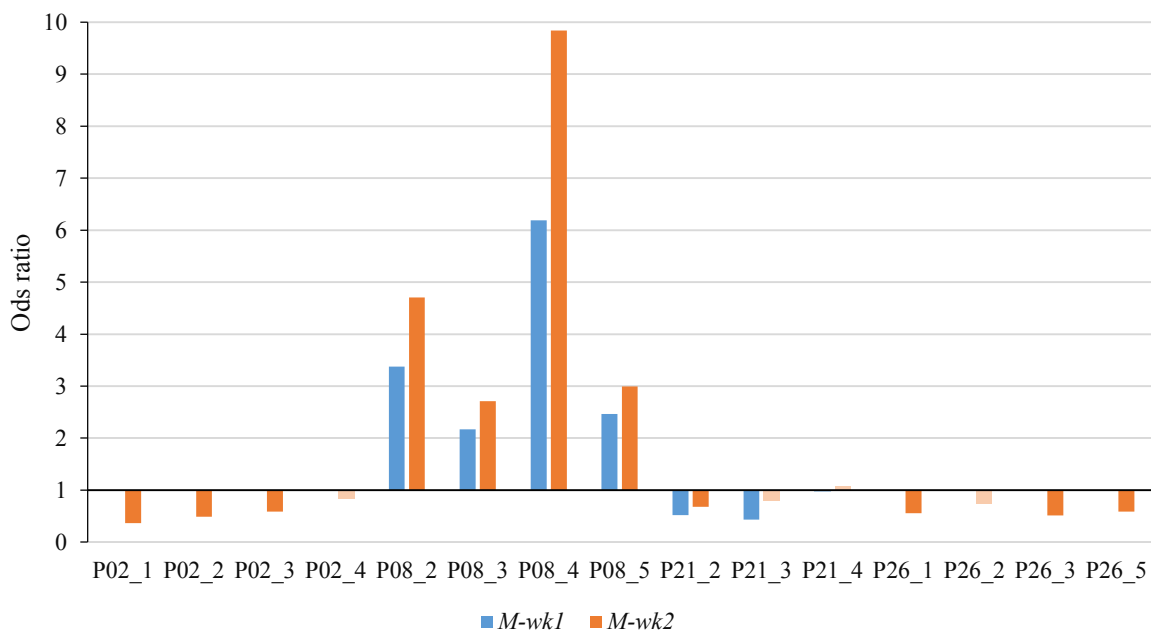


**Figure 1.** The comparison of the *M-wk*1 and *M-wk*2 logistic models results.

Source: authors' own elaboration.

## 5. Conclusions

Each type of economic activity carries various hazardous situations as regards occupational safety. Some of them generate greater danger for an employee than other. Although wood processing industry is an economy sector with a relatively high risk of accidents at work, the problem is discussed in few publications.

In this study, factors that can influence the injury severity of the occupational accident casualty in wood processing companies were investigated using logistic regression. It was shown in the work that the enterprise size had an impact on the severity of accidents at work. Therefore, logistic models were developed for enterprises classified into two groups: (1) micro and small and (2) medium and large. Using odds ratios, explanatory variables in logistic models

were interpreted according to their importance and intensity of influence on the value of the explained variable.

Among the 11 analyzed variables, many of them were not identified as important in the logistic models, in the stepwise selection procedure. In particular, there were: *Enterprise job seniority* or *Injured body part*. It is possible that their explanatory role may have been taken over by variables significant in the models.

In larger workplaces, all types of injuries as referenced to *Wounds and superficial injuries* were identified as having a greater impact on the outcome of an occupational accident than in smaller workplaces. This could indicate that medium and large enterprises experience more safety climate problems than micro and small companies.

The greatest risk regarding *Activity performed at accident time* in both types of enterprises was created by *Operating machinery*. Inadequate initial or job training, or scant machines and devices maintenance, or insufficient equipment of the machine with safety elements are the likely explanations for such findings. These circumstances can also refer to handling of potentially dangerous *Machines and devices* identified as the most risky *Material factor as injury source*, but only in larger enterprises, which may be caused by higher pressure and pace of work.

In larger companies, workers over the age of 54 were more likely to be seriously injured in occupational accidents than workers of any other age. This may be due to routine or habitual neglect of risk factors at work, but also physical or mental exhaustion, which can be accompanied by lack of or poor supervision.

The research showed that bivariate multiple logistic regression is an appropriate tool for analyzing occupational accident data. The obtained results can be used in the development of materials on occupational safety risks for entrepreneurs and OSH services.

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# FACTORS AND MECHANISMS OF CREATING AN INNOVATIVE CULTURE IN AN ORGANIZATION

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**Purpose:** The aim of the article is to study the category of innovative culture if the organization, to establish its relationship with the organizational culture as well as the factors, dimensions and mechanism of its creation.

**Design/methodology/approach**: Desk research and critical analysis methods were used in the research. The methods used are based on a review of the literature, documentary and theoretical, in order to find publications related to the categories of "innovation culture", "organizational culture". The databases studied are Semantic Scholar, Science Direct and Research Gate. The selected period is 1990-2022.

**Findings:** During the research, on the basis of the analysis of the existing concepts of creating an innovative culture, its original character in relation to the organizational culture was justified, factors, dimensions and the mechanism of creating an innovative culture in the organization were identified.

**Practical implications:** The results of the research make it possible to identify the key factors of an innovative organizational culture, to understand the principles and mechanism of its creation. The results can be useful for companies and organizations actively involved in innovative activities to develop strategic planning documents.

**Social implications:** The research results make it possible to understand the place and role of innovation in building a knowledge-based economy and to make people aware of the need to create pro-innovative attitudes of society.

**Originality/value:** The proprietary concept of an innovative organizational culture was presented, its dimensions were proposed to be classified, and a mechanism for its creation was developed. The article is addressed to the managers of enterprises, organizations and institutions dealing with innovative activities.

**Key words:** innovative culture, innovation, organizational culture.

**Category of the paper:** Research paper.

## 1. Introduction

The creation of a knowledge-based economy is based on the growth of its innovativeness as the ability to quickly and effectively introduce new solutions in the field of technology, products and services, organization and marketing into the practice of business activities of enterprises. The source of innovation is the original idea. But before this idea is put into practice and brings the expected results in the form of increased profits, strengthening the competitive position, expansion on the market, a lot of effort should be devoted to the implementation of individual stages of the innovative cycle. Creating innovative products is characterized by tendencies to shorten the life cycle, increase costs and risks. Solving this problem requires changing the very philosophy of conducting innovative activity and perceiving it in terms of the organizational culture of enterprises. Therefore, in scientific publications, organizational culture and innovative culture are more and more often the subject of research. The aim of the article is to study the category of innovative organizational culture, to establish its relationship with the organizational culture as well as the factors, dimensions and mechanism of its creation. Desk research and critical analysis methods were used in the research. The methods used are based on a review of the literature, documentary and theoretical, in order to find publications related to the categories of "innovation culture", "organizational culture". The databases studied are Semantic Scholar, Science Direct and Research Gate. The selected period is 1990-2022.

## 2. Determinants, structure and dimensions of an innovative culture

The growing importance of innovation in the development of the modern economy manifests itself in the increased interest of researchers and practitioners in scientific issues related to various aspects of conducting innovative activities. Scientific publications increasingly emphasize the need to perceive this activity as a philosophy of doing business in general. Each innovation begins with the emergence of a certain idea to introduce changes in these or other spheres of the company's economic activity in order to increase the efficiency of their operation. Since the source of every idea is a human being, the issue of the growth of innovation should be considered through the prism of the functioning of the entire enterprise, and not only focus on the processes that take place strictly within the stages of the innovative cycle. An idea transforms into an innovative product only under certain conditions, which can be briefly presented using the "know – can – want" model (Oksanych, 2021). This means that the implementation of the entire innovation cycle – from the emergence of an idea to the commercialization of an innovative product – requires appropriate knowledge, resources and employee motivation. Creating these conditions must be systemic and concern all functional spheres of the organization. This determined the emergence of the category of innovative culture. It is very often analyzed in the context of organizational culture.

Organizational culture or "Corporate Culture" interpreted as a set of values and norms that has been accepted and complied on by members. Culture creates a sense belonging for organization members. Organizational culture also applicable as a framework which set guidelines for member behavior, thus lead to a particular decision for members and directs their actions to achieve organizational goals (Tama, 2019).

Organizational culture can be defined as "a pattern of basic assumptions that a group has invented, discovered, or developed when confronted with environmental problems and internal coordination problems that functioned well enough to be considered proven and valid by the group, and that are communicated through the process. socialization to new members of the group as a proper way of perception, interpretation and action in the face of the above problems of external adaptation and internal integration" (Schein, 2004).

A. Poskien interprets organizational culture as "a complex set of ideologies, commitments, traditions and values that are common to the entire organization and that influence the way the organization manages its overall performance, becoming a potential source of advantage, progress and innovation" (Poskien, 2006).

A similar definition is presented by W. French, who describes the organizational structure as "values, beliefs, assumptions, myths, norms and goals that are commonly accepted in organizations" (French, 1990).

Many researchers pay attention to the close links between organizational culture and innovation activities (Aboramadan et al., 2020; Azeem et al., 2021; Chen et al., 2018; Farley, Hoenig, Ismail, 2008, Harel, Schwartz, Kaufmann, 2021; Hartmann, 2006; Guerlek, Tuna, 2018; Leal-Rodriguez et al., 2018; Palmen, 2012; Szczepanska, Dacko-Pikiewicz, 2015; Zieliński, 2011; Zołnierski, 2017).

According to the report of the National Center for Research and Development, the components of organizational culture are:

- patterns of thinking, i.e. values and norms allowing employees to adopt common, uniform criteria for assessing phenomena,
- patterns of behaviour defining ways of responding to various types of stimuli,
- symbols, including: physical (clothes, badges), linguistic (professional jargon, communication style, used anecdotes), behavioural (rituals, ceremonies), personal (authorities, mentors) (Żołnierski, 2017).

The review of the presented definitions of organizational culture and its connections with innovative activities lead to the conclusion that the company's innovation depends on a "set" of standards, rules, principles commonly accepted by employees, etc. It follows that narrowing down the scope of using organizational culture elements to the area of innovative activity determine the concept of innovative culture as an organizational part of culture. According to the source (Prokopowicz, Pawlak-Michułka, Rudnicki, 2018), "the culture of innovation is the values, beliefs and methods of action shared in an organization or society that favor the creation and implementation of new ideas and solutions".

It seems obvious that in its innovative activity an organization relies on formal and informal rules, norms, principles and models of conduct which are appropriate for it. In this context, "an innovation culture is the values, beliefs and ways of action shared in an organization or society that foster the creation and implementation of new ideas and solutions" (Prokopowicz, Pawlak-Michułka, Rudnicki, 2018).

However, this approach only works in the short term. In the long term, it is the innovative culture that determines the general culture of the organization, because the development based on innovation requires the application of its elements (the aforementioned rules, norms, etc.) on the scale of all functional spheres of the organization, which allow to create and effectively use its innovative potential. In the long term, an organization that bases its development on innovation will spread the elements of an innovative culture that prove effective in innovative activities into other functional spheres. In other words, in the long run, the innovative culture will be primary in relation to the organizational culture. According to Davies M, Buisine S. "culture of innovation" is a particular configuration that makes innovative thinking natural in the organization and encourages innovative activities at the level of all employees" (Davies, Buisine, 2018). According to L. Morris, "the innovation culture (…) is likewise an expression of people, their past, and their current beliefs, ideas, and behaviours. They make innovation happen, and they do so consistently over time" (Morris, 2007).

Innovative culture – it is a certain philosophy of its functioning, based on the use of mutually related formal ('hard' and informal 'soft' rules, norms, algorithms, principles, models of behaviour and conduct that relate to all aspects of its functioning and aimed at creating such attitudes) , beliefs and intentions of employees, which to the maximum extent ensure constant development based on innovation.

Among the factors for the development of an innovative culture, most sources indicate the pro-innovative attitude of the management (Macin, 2018; Czerska, Rudka, 2014; Ramos-Garza, Ramoz-Garza, 2019; Villaluz, Hechanova, 2018). A manager must be a leader, initiator of pro-innovative changes and provide support for initiatives aimed at the growth of an innovative culture. The quality of management is a very important factor in creating an innovative culture. The quality of human capital and the nature of communication within the organization are no less important.

In the scientific literature, the issue of human capital is presented quite broadly. One definition of this category is that the human capital is "the human factor in the organization; the combined intelligence, skills and expertise that gives the organization its distinctive character. The human elements of the organization are those that are capable of learning, changing, innovating and providing the creative thrust which if properly motivated can ensure the long-run survival of the organization" (Bontis et al., 1999). Human capital, on the one hand, is an object of management, and its functioning is subordinated to certain rules, principles, norms, etc., which are set "from above", on the other – human capital not only verifies them, reacting in one way or another to their impact, but also the source of rules, principles, norms and other elements of an innovative culture. The explanation of how effectively these elements

work is based on communication – both vertical and horizontal. It is in the communication process that the effectiveness of capital use and the effectiveness of the applied elements of innovative culture are verified. Experts point out that communication is one of the key problems in the use of human capital (Ployhart et al., 2014).

The innovative culture is multidimensional, therefore its structure can be analyzed in various planes.

According to C.B. Dobni, an innovative culture consists of:

- innovative intentions: propensity to innovate, acceptance of innovative orientation,
- -innovation infrastructure – learning, creativity and employee involvement,
- the impact of innovation – market orientation, value orientation,
- conditions for implementing innovations – implementation context (Dobni, 2008).

Experts of The Institute for Research and Innovation in Social Services distinguish three areas (internal factors) of the innovation culture, which are referred to as ABC:

A. Attitudes are tangible and refer to individual and organisational attitudes to innovation and improvement.

B. Bechaviours are intangible and refer to an individual's and an organisation's behaviours that can encourage or block innovation and improvement.

C. Capabilities are tangible and refer to an individual's and organisation's capacity for innovation and improvement through knowledge (knowledge, understanding and access to information and training on innovation and improvement). (Creating..., 2012).

According to M. Davies i S. Buisine, the innovation culture in organizations can be presented by ETOILe model, which contains:

- Environment/Links to the external environment/ Easy and speed collaboration/ Multiplicity and diversity contact points.
- -Team/Presence and recognition innovative teams/Promotion-oriented regulatory focus/ ---Excellence in complementary discovery skills.
- Organization / Shared attitudes in the organization / Product and consumer involvement / Processes that promote the use and recognition of discovery skills / Acceptance of error / Social representation of innovation.
- Individuals / Presence and recognition of innovative individuals / Emotional engagement / recognition of discovery skills.
- Leaders: Innovative leaders and managers / Mastery of discovery skills (Davies, Buisine, 2018).

Denison Consulting has developed a fairly detailed model of an innovative culture as a component of an organizational culture, which consists of the following elements:

- adaptability – creating change, customer focus, organizational learning,
- mission – strategic direction and intent, goals and objectives, vision,
- consistency – core values, agreement, coordination and integration,
- involvement – empowerment, team orientation, capability.

These elements are analyzed in the "external – internal" and "stable – flexible" coordinates (Introduction..., 2006).

Based on these assumptions, the state and development trends of the company's innovative culture should be assessed and analyzed on the basis of a three-dimensional model (Figure 1).

According to the proposed model, all elements of the innovative culture should be considered in terms of their division into:

- explicit (formal) and hidden (informal),
- stable & controlled and flexible & discreet,
- centralized and decentralized.

The division into overt and hidden makes it possible to determine the source of the elements of innovative culture and the spheres they relate to.
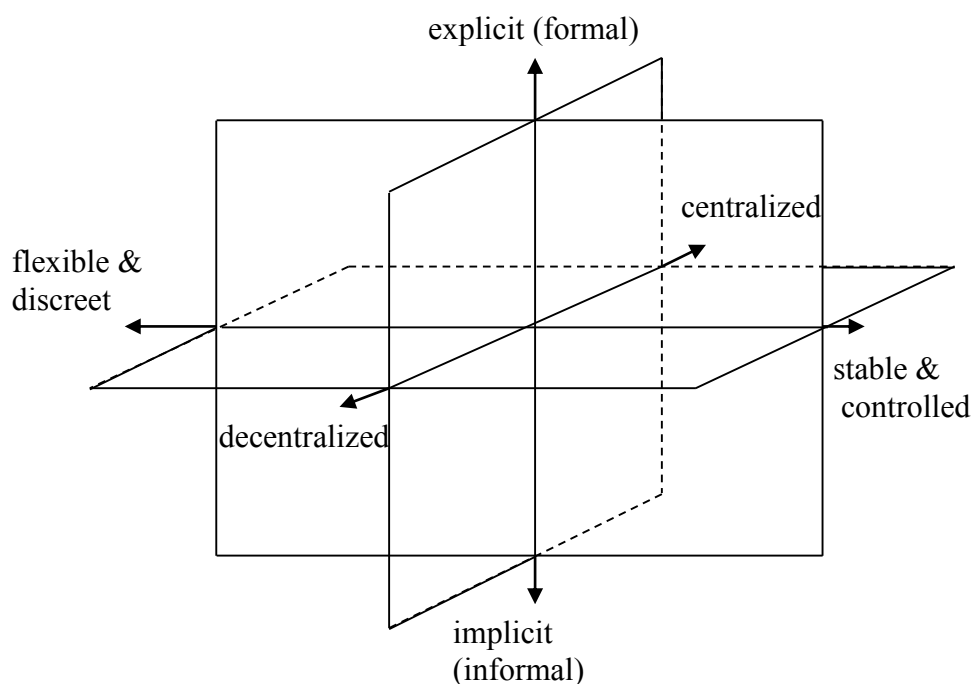


**Figure 1.** Model of innovative Culture Dimensions.

Source: Own study based on (Introduction..., 2006).

The division into fixed (rigid) and flexible allows taking into account the nature of the organization's response to the implementation of these elements.

The division into centralized and decentralized determines, on the one hand – the sphere of application of this or that element, on the other – the level of independence of organizational units in terms of their use.

## 3.  The mechanism of creating an innovative culture in an organization

An innovative culture cannot be implemented like a specific management model. Culture is deeply rooted in the company's history, values and beliefs shared by employees, and so complex that it is difficult to change (Denison, 1996).

Creating an innovative culture in no case has to be associated with the implementation of a certain project or program. It is a continuous, consistent process of creating a model of human resources functioning based on the perception of such formal and informal rules, attitudes, principles and algorithms that would, to the greatest extent, ensure the pro-innovative development of the organization. The basis of this process is understanding, acceptance and commitment of all groups of employees to their creation and perception.

"The driving force" of the mechanism of creating an innovative culture is the appropriate attitude of the management and their assertiveness in striving to implement activities in accordance with the vision of the pro-innovative future of the organization.

The vision of how an organization must function is a necessary but insufficient factor in the functioning of the mechanism of creating an innovative culture. Top-down implementation of the management board's decision must be approved by teams of structural units and departments of the organization. Therefore, it is important to involve employees (primarily middle-level managers and front-line managers as well as opinion leaders) in the process of creating elements of an innovative culture, and this requires that most employees overcome the distance from perceiving and understanding the problems of the organization's development to the willingness to engage in solving them, according to known algorithm "perception – knowledge acquisition – assessment – perception – belief – acceptance – commitment" (Cameron, Quinn, 2011).

The key elements of an innovative culture – rules, attitudes, principles, algorithms, protocols, behaviour models, norms and traditions – are created over a long time horizon, which allows to verify their effectiveness through the mechanism of multiple iterations until their optimal composition and parameters are established. Final verification is done by the market. High innovative culture means ensuring high innovativeness of the enterprise, which means its strong competitive position. This thesis works well also at the macro level – the KEI (Knowledge Economy Index), SII (Summary Innovation Index) and GDP per capita indicators are characterized by a high level of correlation.

The diagram of the functioning of the mechanism of creating and developing an innovative culture in a company is presented in Figure 2.

The starting point for the mechanism of creating an innovative culture is the awareness by the management of the organization of the need for innovation, its acceptance and readiness to engage in innovative activities. On the one hand, this awareness results from the assessment of the external operating conditions and resources of the organization, and on the other – from the knowledge, qualifications, skills and talent of top managers. Top managers must have certain features: creativity, teamwork, tolerance to alternative points of view, ability to learn, flexibility, assertiveness, empathy. Of course, it is difficult to count on the fact that each of the

heads of the organization has all these features at a sufficiently high level. Therefore, the level of innovative culture is largely determined by the pace of development of these traits by higher-level managers, which is based on the ability to objectively assess their own advantages and disadvantages and the will to personal development (Cameron et al., 2006).

The environment has a great influence on persuading the management of the organization to create a vision of its future. The more innovative the external environment is, the more the management board of the organization will be convinced of the non-alternative nature of pro-innovative development and the greater the effort will be made to create appropriate attitudes of employees and their involvement in innovative activities. However, the process is based on the development and implementation of what is defined as elements of an innovation culture. These elements include formal (explicit) and informal (hidden) rules, principles, algorithms, protocols, norms, models of behaviour and conduct.
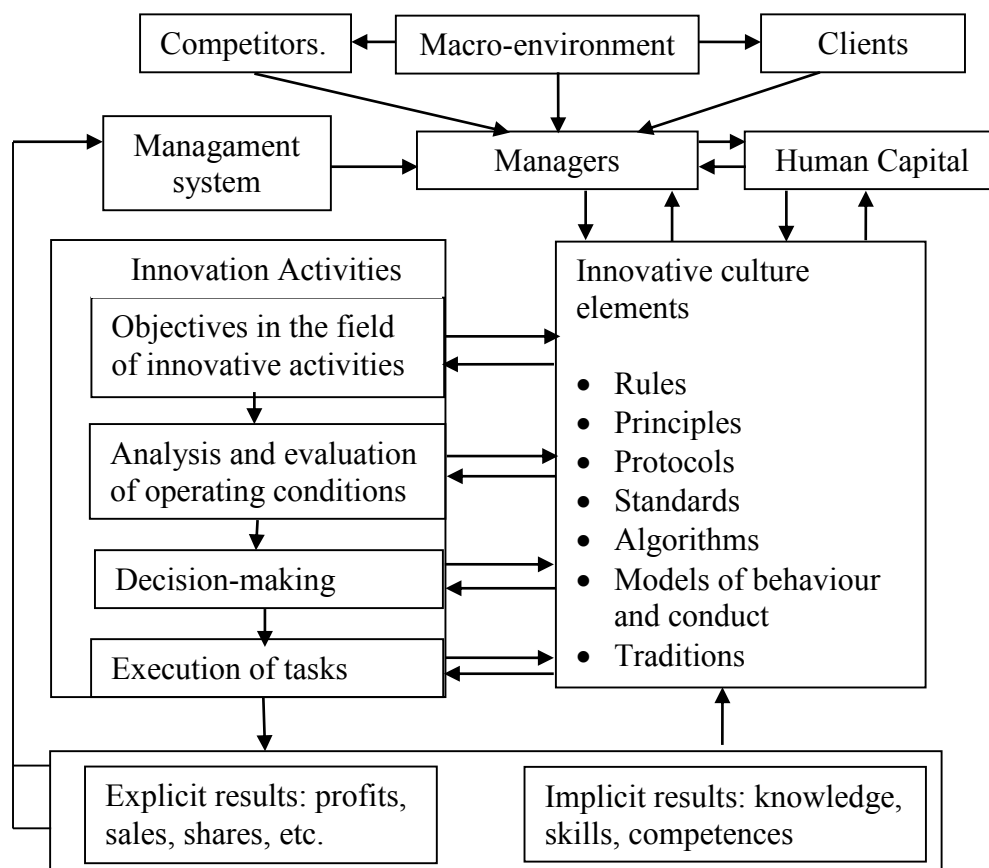


**Figure 2.** The diagram of the functioning of the mechanism of creating and developing an innovative culture in the company.

Source: Own study.

The process of creating an innovative culture is iterative and continuous, which results from the specific nature of the introduced changes. This specificity results from the following assumptions.

1. Apart from the formal (explicit) elements, the innovative culture also consists of informal (implicit) elements. Changes in them cannot be made "from the top", because the informal elements themselves are created "from the bottom", usually through informal communication between employees. Therefore, carrying out these changes is based on changing beliefs, attitudes and points of view. This requires a lot of effort on the part of the organization's managers in terms of explaining the necessity of changes, the expected effects, presenting the necessary information, and conducting formal and informal meetings with employees. This process also takes a long time.

2. The transformation of the informal (implicit) elements of an innovative culture is gradual and slow as it requires acceptance by the staff. It cannot be managed directly, but is the result of a change in employees' attitudes (above all, the attitudes of "opinion leaders").

3. The effectiveness of innovative activities largely depends on the effectiveness of creating and using human capital. Since the changes introduced in the cross-section of individual elements of innovative culture have a large impact on this process, the consequences of wrong decisions in the change process can be serious. Therefore, managing the process of creating an innovative culture must be very flexible and have an evolutionary character.

Each activity as part of innovative activity – from the formulation of goals to the practical implementation of projects (task implementation) – is based on the application of the above-mentioned elements of the innovative culture of the organization. Therefore, the results of innovative activity verify the effectiveness of the applied "set" of these elements, thus allowing the assessment of the model of innovative culture existing in the organization as a whole. The effects of activities in the implementation of individual innovative projects from the point of view of creating an innovative culture should be assessed not so much through the prism of direct (explicit) results of their implementation - cash flows, profits, competitive position, etc. – but by the effectiveness of the formal and informal principles, rules, algorithms, the protocols on which the innovation activity is based, and the communication systems. These effects of innovative activity are "implicit", informal, but they are the ones that allow to define the problem areas and barriers in the development of an organization's innovative culture, to determine which of the applied elements of the innovative culture are effective and which should be changed. Problematic areas and elements of innovative culture must be thoroughly analyzed, which allows to identify areas and scope of changes. "Understanding culture… can therefore be useful for two reasons. First, knowledge of the culture makes it possible to assess the extent to which members of the organization are willing to accept changes; secondly, it helps to identify the cause of the problems that hinder the development of the organization" (Szczepańska-Woszczyna, Dacko-Pikiewicz, 2015).

Striving to increase the level of innovative culture, the management of the organization and the team of employees directly dealing with this issue should find answers to the next question, according to a Kipling method „5W1H" (Table 1).

Changes in the each elements of an innovative culture make it possible to increase its level only with their acceptation by the employees of the organization and their involvement in their implementation. It should be remembered that some elements of innovative culture have "bottom-up" roots, ie. they are created by teams of employees. Therefore, it seems logical that the process of making changes to these or other elements of the innovative culture, or the implementation of a new element of it, should follow the scheme presented in Figure 3.

**Table 1.**
*Key questions in the process of change in framework of creating an innovative culture*

|   | Questions | Issues |
|---|-----------|--------|
| 1 | Who? | Determining managers responsible for appropriate areas of innovation culture. |
| 2 | What needs to be changed? | Which of the elements of an innovative culture needs to be changed. |
| 3 | Where should the changes made | Identification of the area and scope of changes. |
| 4 | When? | Estimating deadlines and time horizons of changes. |
| 5 | Why should this be changed? | Building cause-effect relationships between the "defective" element of innovative culture and the results of innovative activity, justifying the need for changes. |
| 6 | How it should be changed? | Determining the activities necessary to achieve the goals and the sequence of their implementation. |

Source: Own study.
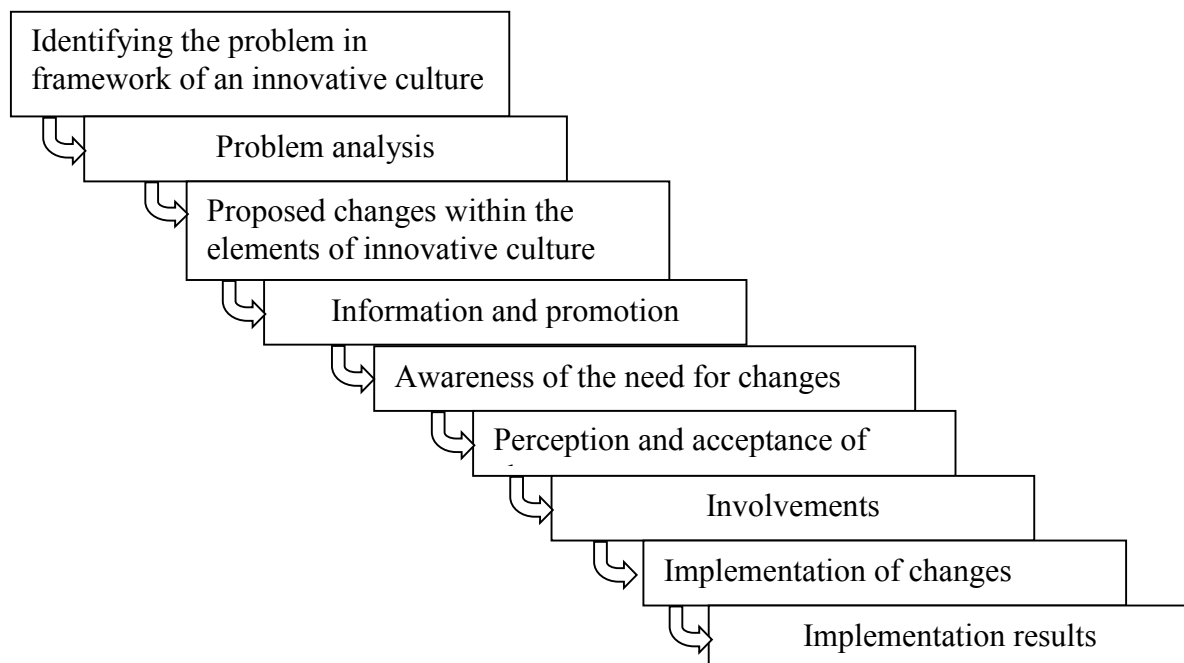


**Figure 3.** Diagram of the process of making changes to the elements of innovative culture.
Source: Own study.

The presented diagram applies not only to formalized activities (eg, the introduction of a new algorithm for financing innovative projects), but also activities in the field of informal ("implicit") elements of an innovative culture (eg, the principle of informal acceptance by the new manager's team of employees).

Feedback is essential as errors and shortcomings in each step can have a multiplier effect and hide the true state of the solution to the problem.

The effectiveness of the mechanism of creating an innovative organizational culture largely depends on the principles on which it is based. Their perception is crucial for the configuration of its structure and the relationship between its components.

Assuming that an innovative culture is based on the application of certain behavioural models, the following principles should be considered:

- balance of interests – ensuring a compromise of interests of various groups of employees, allowing for adequate motivation,
- flexibility – quick reaction to the change of the external and internal environment,
- systemic – taking into account the cause and effect relationships between all components of an innovative culture,
- tolerance – the ability to express each point of view, ensuring the most objective assessment of it,
- communication – development of formal and informal relations within the organization,
- involvement – what counts is the involvement of each employee in innovative activities,
- access to information – every employee must have access to information that concerns him to a certain extent,
- knowledge supplementation – each employee must constantly supplement his knowledge, and the organization must ensure access to its sources,
- continuity and consistency – creating an innovative culture is a permanent and continuous process,
- initiatives – supporting any idea to improve the efficiency of the organization's functioning.

## 4. Strategic aspects of creating an innovative culture

The increase in the level of innovative organizational culture is determined by the existing strategy of overall development and its component – the innovation strategy of the company This process is shown in Figure 4. However, attention should take into account the relationship between the choice of these strategies and the parameters (elements) of the innovative culture. On the one hand, the guidelines of the overall organizational development strategy and innovation strategy determine the "profile" of an innovative culture. For example, depending on the assumptions of the innovation strategy, the organization establishes a specific system of acquiring and disseminating knowledge or sets the rules of internal communication in. On the other hand, the innovative culture verifies the effectiveness of the innovation strategy and, through it, the effectiveness of the overall development strategy of the organization. For example, the effectiveness of the actions taken depends on the decision-making algorithm that is part of the innovative culture.
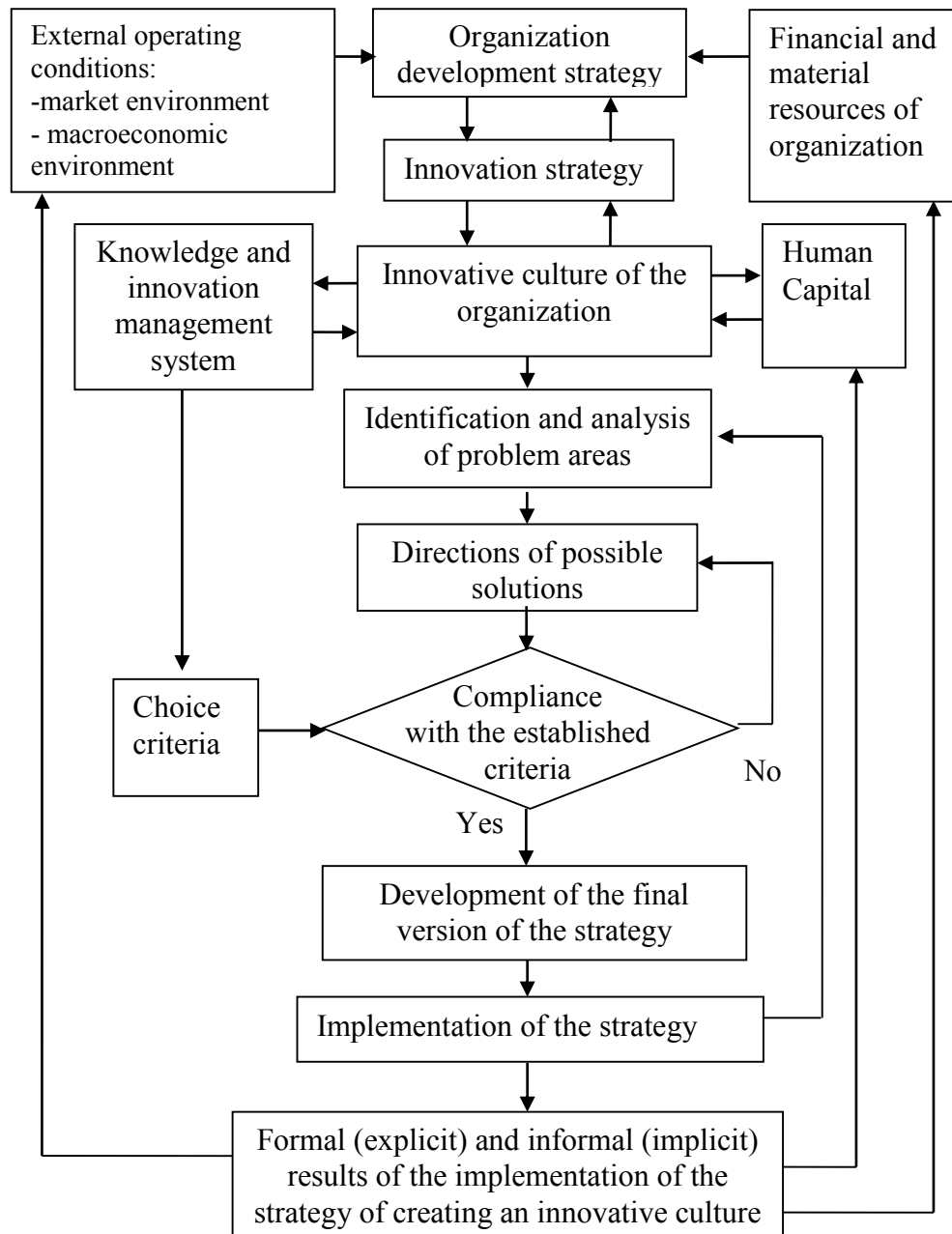
**Figure 4.** A diagram of a strategy for creating an innovative culture in the organization.
Source: Own study.

An important stage in developing a strategy for creating an innovative culture is the identification and analysis of its problem areas. In practice, this means an assessment of the cause-effect relationships between the elements of innovative culture and the results of innovative activities, determining the "weight" of individual elements, their state of development trends. At this stage, it is important to choose the methods of assessing the elements of the innovative culture and the reference base (e.g., the average level in the branch of the economy, the level of the leader or the level of prior measurement in the organization itself).

The assessment of the elements of an organization's innovation culture should be closely related to the parameters of the external environment, especially the market environment. These parameters characterize the state and development trends of the market, the behaviour of competitors, consumers and suppliers, and allow for the creation of specific requirements for individual areas of the organization's innovative culture as they serve as a basis for comparison in the process of establishing strategy goals and ways to achieve them.

The conducted analysis and performed assessments allow to determine the directions, spheres and time horizons of possible solutions. At this stage, it is important to keep the list of these solutions as long as possible. Those which, in the present conditions, will be considered the most effective and compliant with the applied selection criteria, become the basis of the strategy of creating an innovative culture. On the other hand, the remaining solutions should not be rejected, as they are the result of the efforts of employees and managers, and therefore elements of the intellectual capital of the organization and may be useful in other conditions.

In the process of developing and implementing the strategy of creating an innovative culture, the key role is played by the managers of the organization. Their task is to develop a general concept of an innovative culture, a vision of its optimal model. This vision translates directly into the scope, methods, strategy and tactics of innovative activity. The effects of this activity from the point of view of creating an innovative culture should be assessed not so much through the prism of the results of the implementation of individual innovative projects – cash flows, profits, competitive position etc., but by the effectiveness of the formal and informal principles, rules, algorithms and protocols on which it is based. innovative activities, and communication systems.

The assessment of the effects of innovative activity from this point of view allows to identify the problem areas and barriers to the development of an organization's innovative culture, to determine which of the applied elements of the innovative culture are effective and which should be changed.

In the process of implementing the strategy of creating an innovative culture, it is necessary to conduct an ongoing analysis of problem areas in order to correct the priorities, scope and directions of activities.

Formal (open) and informal (implicit) results of the implementation of the strategy of creating an innovative organizational culture have an impact on changes within:

- intellectual capital (new knowledge and experiences appear),
- financial and material resources of the organization (the level of income, profits changes, the quantitative and qualitative development of production systems, fixed assets, etc. is achieved),
- knowledge and innovation management system.

## 5.  Summary

The mechanism of creating an innovative culture is based on the organization's management realizing the need for innovation, its acceptance and readiness to engage in innovative activities.

Each activity as part of innovative activity – from the formulation of goals to the practical implementation of projects (task implementation) – must be based on the application of individual elements of the innovative culture of the organization. Therefore, the results of innovative activity verify the effectiveness of the applied "set" of these elements, thus allowing the assessment of the model of innovative culture existing in the organization as a whole.

The effects of activities in the implementation of individual innovative projects from the point of view of creating an innovative culture should be assessed not so much through the prism of direct (explicit) results of their implementation – cash flows, profits, competitive position, etc. – but by the effectiveness of the formal and informal principles, rules, algorithms, the protocols on which the innovation activity is based, and the communication systems.

The effectiveness of the mechanism of creating an innovative organizational culture largely depends on the principles on which it is based. These are the principles of the balance of interests, flexibility, systemicity, tolerance, communication, commitment, access to information, supplementing knowledge, continuity and consistency, initiative.

Creating an innovative organizational culture requires the development of an appropriate strategy that is closely related to the overall development strategy of the organization and the innovation strategy. On the one hand, they determine the "profile" of an innovative culture, on the other – it is the innovative culture that verifies the effectiveness of the innovation strategy and, through it, the overall development strategy of the organization.

The presented result of research leads to the conclusion that creating a knowledge-based economy requires the development of a national innovation system that takes into account the behavioral aspects of the economy innovativeness, as the effectiveness of innovation policy will increasingly depend on pro-innovative attitudes of the society. Hence – the necessity to conduct research on the cause-and-effect relations between the creation of pro-innovative attitudes within the education and higher education system and the increase of the economy innovativeness. It seems that the practical needs of the knowledge-based economy will determine the timeliness of research on the impact of innovative culture on the creation of management systems at the enterprise level, the development of algorithms for the assessment of innovative culture and models for its creation.

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# TRUST AND CONTROL MANIFESTATIONS
# IN EMPLOYEE-DRIVEN INNOVATIONS

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**Purpose:** The goal is to deepen understanding of trust and control in employee-driven innovations (EDI) and is met by empirical research basing on key informants' narration.

**Design/methodology/approach**: Nineteen interviews with key informants were conducted between March and June 2021 in three companies from different sectors (telecommunication, pharmaceutical and financial).

**Findings:** This publication contributes to the existing literature on EDI and trust-control in multiple ways. First, it reveals lack of direct reference to trust in employees' discourse on EDI. Second, it highlights manifestations of trust and control along with fit into Das and Teng (2001) framework. Third, it reveals differences among researched companies in terms of breakdown of trust and control types, which poses further questions about factors impacting these differences. Fourth, it shows that *social control* manifestations are not recognized.

**Research limitations/implications**: Research limitation stems from the method, which does not allow to make generalizations. Manifestations of *social control* in Das and Teng (2001) model were not recognized in the research, which opens a future research avenue. Future research could investigate *impersonal trust* in the context of EDI.

**Practical implications:** The research proves important role of *general managerial support*, identified in the literature on innovations and trust.

**Originality/value**: The article proposes categorization of trust and control manifestations and fit into types of trust and control in Das and Teng (2001) model, which originally presents relations between trust, control and risk types in collaboration between alliance partners.

**Keywords:** trust, control, employee-driven innovation, bottom-up innovation, manifestations.

**Category of the paper:** Research paper.

## 1. Introduction

Part of the general debate on trust and control as governance modes is focused on organizational functioning in terms of risk exposure with reference to Das and Teng (2001) framework. Their model of trust and control types configurations contributes to better understanding of risk governance in organizations.

Innovation is perceived as risky area in organization, as – according J.A. Schumpeter – it constitutes: *(…) novelty that creates economical value*[i]. Proper valuation of economical value of a novel solution is problematic, especially in case of *radical innovations*: *(…) where either the technologies or markets are unfamiliar* (Tidd, Bessant, 2020, p. 346). Therefore innovation – depending on their scale and level of newness – exposes organization towards certain risk. Employee-driven innovation (referred to as EDI), because of broad employee participation and strong link to learning processes in everyday job (Høyrup, 2012), may raise frequency of risky behaviours or outcomes in the organization.

Taking into account fields of innovation and risk, a question of meaning and role of trust or/and control in managing innovations may be posed. Unfortunately, in the recent years, trust and control debate rarely touched the field of innovations and in the literature review only several publications were found (Gebert et al., 2003; Cox, Mowatt, 2004; Gebert et al., 2004; Lindermann et al., 2009; Delbufalo, 2017; Glińska-Neweś et al., 2017; Oliveira et al., 2020; Lou et al., 2022). EDI field proposes great research potential, as only single EDI researchers explored trust or control, but they treated each phenomenon separately and explored it from managerial perspective, i.e.:

- role of trust in promoting EDI by management (Hansen et al., 2017),
- control by management in the EDI process (Li, 2016; Flocco et al., 2022).

Figure 1 presents research gap model including the area of EDI and trust-control debate.
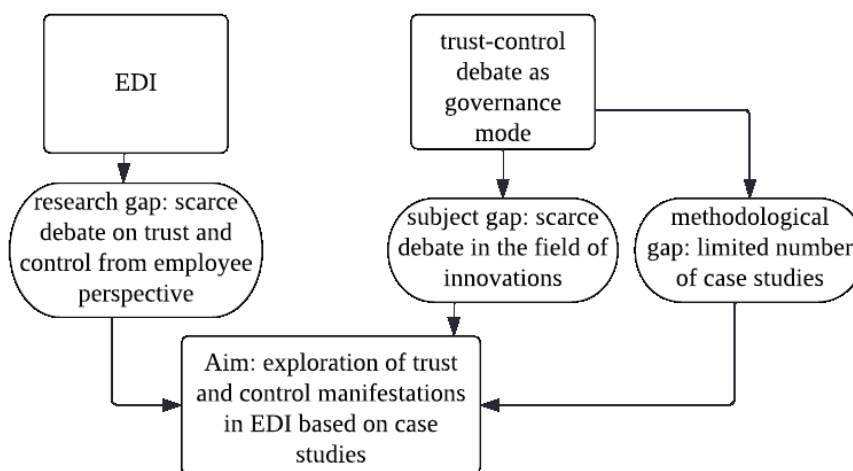


**Figure 1.** Research gap model identified on the basis of literature review on EDI and trust-control relation.

This article contributes to filling the gap of understanding subtle issues of trust and control in EDI by exploring their empirical manifestations. It introduces a new field in the ongoing trust-control debate with reference to case studies, which are underrepresented in the trust-control debate.

Combination of EDI and trust and control issues from employee perspective poses the following research questions:

RQ1: How do participants express trust and/or control in the context of EDI in an indirect way?

RQ2: Which areas of EDI do trust or control refer to?

RQ3: Do and which manifestations fit into Das and Teng (2001) conceptual framework?

In order to find answers to these research questions, qualitative methods were used, as they enable researchers to get more insight into real issues behind the abstract phenomena. Direct interviews were conducted in three organizations with key informants.

This paper is structured as follows: the conceptual framework is divided into 4 parts: (1) trust and control in the organizational debate, (2) relations between trust and innovation, (3) relations between control and innovation and (4) relations of trust and control in the context of EDI. The methods part presents research tool development, data sampling and analysis. In the results part trust and control manifestations are categorised along with proposal of fit into Das and Teng (2001) framework. The discussion part summarizes research contribution along with future research directions and research limitations.

## 2. Conceptual framework

### 2.1. Trust and control in the general organizational debate

Any relationship within organization requires minimum level of trust (Langfield-Smith, Smith, 2003; Costa, Bijlsma-Frankema, 2007). Trust is about having confidence (Gebert et al., 2003), positive expectations (Das, Teng, 2001) or beliefs towards partner's goodwill and reliability (Das, Teng, 1998; Bijlsma-Frankema, Costa, 2005; Yang et al., 2011). The broadly accepted definition of trust exposes vulnerability to which parties have to be willing (Gebert et al., 2004, Malhotra, Lumineau, 2011; Kostis, Näsholm, 2020). On the other hand, trust is also treated as a form of governance in organization which enables i.e. coordination and interactions (Langfield-Smith, Smith, 2003; Costa, Bijlsma-Frankema, 2007; Yang et al., 2011, Cao, Lumineau, 2015). Trust plays diverse roles in organization: reduces risk of opportunistic behaviours (Langfield-Smith, Smith, 2003; Kostis, Näsholm, 2020), enables cooperation (Das, Teng, 1998) and information exchange (Bijlsma-Frankema, Costa, 2005). Although different trust typologies exist, two main types of trust are most often mentioned in the literature (Das, Teng, 2001; Langfield-Smith, Smith, 2003; Costa, Bijlsma-Frankema, 2007; Malhotra, Lumineau, 2011): (1) competence trust (trust in other party's capabilities to perform as agreed) and (2) goodwill trust (trust in other party's intentions concerning common interests).

Control in organizations can be defined as a process which enables organizational goals achievement thanks to regulated behavior of its members (Das, Teng, 1998, 2001; Costa, Bijlsma-Frankema, 2007). Two modes of control can be found in the literature: (1) formal control – i.e. contracts, procedures, monitoring, control systems and (2) informal – i.e. social norms, values, organizational culture (Costa, Bijlsma-Frankema, 2007). Figure 2 shows division into specific modes of control.
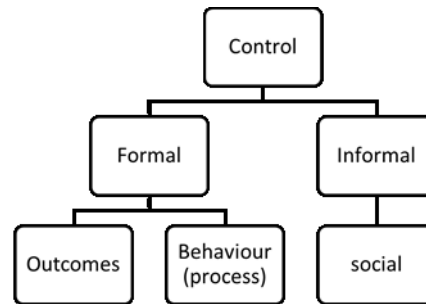


**Figure 2.** Modes of control, based on: "Trust, control, and risk in strategic alliances: An integrated framework" by Das, T. K., and Teng, B.S. (2001).

The interplay between trust and control has been studied as a mechanism enabling better governance of relations. According to Das and Teng (2001), when the perceived level of risk between partners is too high, trust and control – in different combinations - serve as governance mechanisms to reduce the perceived risk. Trust and control express differences as well as similarities, so they contribute to better management in organization. Both trust and control can strengthen confidence (Das, Teng, 1998); they require alignment of expectations and interaction (Bijlsma-Frankema, Costa, 2005) and control can exist only when a certain level of trust is ensured (Costa, Bijlsma-Frankema, 2007). Depending on the research area, three perspectives of trust-control relations can be identified (Das, Teng, 1998, 2001; Langfield-Smith, Smith, 2003; Bijlsma-Frankema, Costa, 2005; Costa, Bijlsma-Frankema, 2007; Malhotra, Lumineau, 2011; Yang et al., 2011; Cao, Lumineau, 2015): (1) both substitute, (2) both complement or (3) both co-exist (independently or simultaneously). Although vast number of research has been devoted to trust and control as general constructs, some scholars have focused on competence and goodwill trust (Das, Teng, 2001; Malhotra, Lumineau, 2011). When control is considered, research is focused on formal control, especially - contractual mode (for review of research on contractual mode see Cao, Lumineau, 2015).

## 2.2. Trust-innovation relation

In the literature on innovations, trust has been explored to great extent in context of cooperation between organizations, i.e.: SMEs (Lindermann et al., 2009; Oliveira et al., 2020) or supplier-manufacturer (Cox, Mowatt, 2004; Delbufalo, 2017; Lou et al., 2022). According to Cox and Mowatt (2004), mainstream research on transacting relationships in innovations networks is in favour of trust as a prerequisite of such cooperation, but their own is in opposition

to this view. Exploration of consumer-driven innovation in the UK food industry showed that transparent information systems between logistic contractors and retailer impact the negotiation process similarly to trust – therefore trust is not required at the beginning of the relationship, as it is induced in the process of negotiations. In their research of open innovations in SMEs cooperation in the Web 2.0-based environment, Lindermann et al. (2009) confirmed trust as one of three prerequisites for willingness of employees' participation. Oliveira et al. (2020, p. 895) referred to *trust capital* as *the trust embedded in a company's internal and external relations* (Inkinen et al., 2017, p. 1165) and provided support for the hypothesis that trust capital is key element of innovations and influences them directly in the case of SMEs including internal employees and external partners. Delbufalo (2017) proved that supplier's trust impacts on manufacturer's innovation capability only in an indirect way, via two mediating components: (1) effective knowledge sharing and (2) asset specificity (specific investments in i.e. site, human resources or physical components). Lou et al. (2022) delved deeper into the subject of supplier selection for New Product Development (NPD) and made recommendations for governance mechanisms leading to radical and incremental innovations. They emphasized role of goodwill trust in radical innovations' creation, but only to a certain extent. Over excessive level of goodwill trust could lead to NPD incremental innovations; in case of incremental innovations, trust would be accompanying stronger output and behavior control.

Exploring literature on trust in intraorganizational environment, Glińska-Neweś et al. (2017) highlighted that high levels of trust enable more creativity and innovation. Although their model of *positive relationships at work (PRW)* – proposed as prerequisite to organizational innovations - did not directly refer to trust, is was built on components crucial to innovation by employees regardless of their position [ii]: positive interpersonal relations, open internal communication and informal meetings. Exchange of information is appointed as a trust-building mechanism (Lidermann et al., 2009) and trust enables effective communication (Prichard et al., 2014). Krot and Lewicka (2020) mentioned that *impersonal trust* [iii] (institutional trust) may be a prerequisite of other types of trust in organization and addressed the gap of dimensions of impersonal trust their relations to dimensions of innovative culture. Concerning the role of trust in relation to innovations, it is worth to mention that Gebert et al. (2003, p. 45) showed an unobvious side of trust - as more empowerment and entrepreneurship are promoted to drive organizational innovativeness, trust provides balance to possible *dysfunctional innovation-related initiatives*.

## 2.3. Control-innovation relation

Research on control and innovations was conducted on various levels and in diversified areas. Cox and Mowatt (2004) focused on the control exerted by the means of information systems which gather consumers' data and enable retailers for coordination of innovation process focused on New Product Development, with the inclusion of supply chain. Kostis et al. (2018) were interested in the relation between civic culture and innovations in the economical

context (measurement of rate of growth of GDP). Their research revealed significant effect of control on innovations (along with work ethics and honesty), but this research was designed on national, not organizational level.

Gebert et al. (2003, p. 42; 2004, p. 100) considered innovativeness in the following way *(...) at the aggregate level of organization, as a function of the innovation related initiatives of employees implemented per unit of time in the organization. The implementation rate is, amongst other things, a function of the situation control of employees*. In this context specific type of control is discussed – *situation control* – that mirrors employees' beliefs about probability of a situation to change. Gebert et al. (2003, 2004) stated that *situation control* and innovativeness take a shape of an U inverted curve, and at the inflection point of the curve more situation control turns into slowdown in innovativeness. Unfortunately, the inflection point is not known before the situation occurs, so afterwards actions have to be taken to manage undesirable situations. Gebert et al. (2004) indicate to trust as one of components of counterweight measures (along with orientation and consensus).

In their research on control governance and supplier selection to develop innovations, Lou et al. (2022) distinguished two types of control: (1) ex ante control, in form of two modes of supplier selection (efficiency-oriented and innovation-oriented) and (2) ex post control: outcome, behavior and trust. They concluded that, depending on the configurations of control, organization may achieve either radical or incremental innovations. Findings indicate that in case of innovation-oriented supplier selection and trust promotion of radical innovations is raised, whereas efficiency-oriented selection and control result in incremental innovations (see Figure 3).
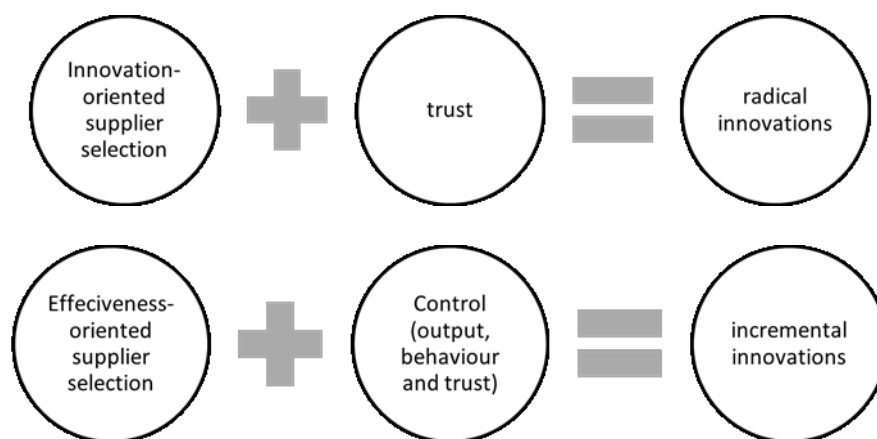


**Figure 3.** Configurations of supplier selection mode (ex ante control) and ex post control and expected outcomes, based on: Lou, Z., and Ye, A., and Mao, J., and Zhang, C. (2022). Supplier selection, control mechanisms, and firm innovation: Configuration analysis based on fsQCA.

### 2.4.  Trust and control in the context of EDI

Innovation is a process of change in organization and as any change, it is based on interactions; good interorganizational collaboration supports innovations (Hentonnen et al., 2020). During the time of change, when organizational members have not embraced new routines yet, trust acts as organizing principle (Prichard et al., 2014).

Managers play a special role as reference point for employees and managers' trust in general is crucial in organizational reality. Ahmad et al. (2022) indicated that higher trust from managers in their salespeople moderates relation between salesforce control systems and *service-sales ambidexterity* - sales and service activities aimed at achieving goals, often outside the routinized ways. Huang et al. (2021) confirmed that *trust in superiors* is one of variables which – together with *procedural justice* and *self-efficacy* – contribute to budget participation capabilities which directly impact product innovation performance. In Krot and Lewicka (2020) relationship model between impersonal trust and innovation culture, managerial support has been related to both dimensions of impersonal trust: feeling of security and organizational assurance.

Own research on EDI (Padzik-Wołos, 2020) has highlighted support on the managerial level of organization as one of the key aspects supporting innovations in companies. It can be hypothesized that in the employee-subordinate relation in the vulnerable area of innovations trust is particularly appreciated. Other piece of own research based on individual interviews with key informants (in due course, not completed yet), gives more insight into this field - for EDI to function properly, not only managerial mindset, but also set of processes and organized activities are needed. The whole innovation process is based on certain "checkpoints", where analyses are required (i.e. feasibility, viability, return on investment) – in this way, control mechanisms are implemented at managerial level. On the other hand, employees execute their own form of control, addressing demands for constant feedback on their initiatives to their superiors. This assumptions on co-existence of trust and control in the EDI process are in line with findings from Prichard et al. (2014) research of technical innovation in call centers in healthcare, which additionally has shown that some trust-building mechanisms serve as means of ensuring managerial control.

As for relations between the three concepts: trust, control and innovation, they may not be directly linked. Zahedi et al. (2022) proved indirect effect of trust – via knowledge sharing - on organizational innovation and impact of perceived behavioral control on demand-based knowledge sharing which is directly related to organizational innovation.

## 3. Methods

Findings in this paper have been identified on the basis of own research on EDI conducted between March and June 2021 in three organizations in form of semi-structured interviews with key informants.

### 3.1. Development of the research tool

According to the Cambridge Dictionary, *manifestation* is *a sign of something existing or happening*[iv]. In the iceberg model of organizational culture, manifestations are *artifacts* and *behaviours* – they are *(...) signs of cultural reality, but not the structural devices for this reality* (Sackmann, 1991, p. 297). Behaviours are visible manifestations, but they are conditioned by other factors, as i.e. tacit beliefs; discovering those invisible factors creates important part of organizational culture research (Sackmann, 1991). As Sackmann (1991) points out, manifestations may differ across organizations – although they look similar, they may have different meaning and role in a given organization.

Taking the above considerations into account along with the purpose of own research, which is to better understand issues of trust and control in the EDI process, research tool in a form of semi-structured interview was developed on the basis of literature review[v].

The interview did not contain questions referring directly to trust or control. Its primary goal was to seek answer to main research questions: (1) how do EDI transform into organizational routines and (2) what factors hinder or support this transformation. Questions were formulated in more general way, with reference to supportive or hindering elements in the EDI implementation process. Broader scope of questions created possibilities to obtain more insights into manifestations of trust and control. Resignation from questions referring directly to *trust* and *control* allowed to minimise possible interviewees' biases regarding both terms and to show their manifestations from employee perspective.

### 3.2. The sampling and data collection

The purposeful selection of companies assumed that two criteria have to be met simultaneously: (1) continuously practiced EDI as understood by Høyrup (2012) and (2) implementation of EDI into organizational routines. Companies were found on LinkedIn on the basis of keyword search ("innovations") in companies' posts or in employees' job descriptions. Companies were recruited via personal LinkedIn or e-mail contact, by sending: (1) personalized invitation to contact and – in case of acceptance - (2) cover letter and summarized description of the project. Overall, 19 interviews have been carried out in three companies representing different sectors: telecommunication, finance and pharmacy - every company belonging to the segment of big companies, employing over 2000 employees.

Before the interview each participant received one-page reminder with definition of EDI and organizational routine (OR) and request to think about 2-3 examples of EDI which became OR. Due to remote work in 2021, interviews were conducted via communication platforms: Teams, Zoom or Skype – according to each company's technical and safety policies. Interviews lasted from 45 minutes to 1,5 hour (single case), 60 minutes on average.

The unit of analysis was single EDI example which turned into organizational routine. Participants were key informants, as they *(...) are able to provide more information and a deeper insight into what is going on around them* (Marshall, 1996, p. 92). Key informants were appointed by companies, as advised by the researcher, from different levels of involvement in EDI processes, including: idea initiators, initiative leaders, innovation coordinators, EDI programs administrators and users (those, who have not initiated innovations, but used them after implementation, as organizational routines). Interviewees came from diversified departments in the companies, respectively to company profile.

Interviews were audio recorded in two ways: (1) on voice recorder and (2) on communication platform, if possible (mainly Zoom and Teams). Audio recordings were transcribed, anonymized and analyzed in MAXQDA.

### 3.3. Data analysis

The analysis process is shown on Figure 4 and described below. In the first step, interview transcripts were coded in an open way, on the basis on expressions used by interviewees. In the second phase, all the fragments were extracted with direct link to *control* phenomenon (including control synonyms, like: monitoring, validation, verification a.s.o – see Table 1) and issues suggesting indirect relation to control. Direct control mechanisms have been well described in the literature (Das, Teng, 1998; Bijlsma-Frankema, Costa, 2005), therefore the focus on uncovering manifestations not expressed directly as *control* (RQ1: How do participants express trust or control in an indirect way?). After this selection, the content was analysed with reference to RQ 2: Which areas of EDI do trust or control refer to? As a result, categorization of control appeared. Similar proceeding – fragments extraction and categorization – were conducted with reference to trust. In the final stage, the categories for control and trust were fitted into Das and Teng (2001) framework.
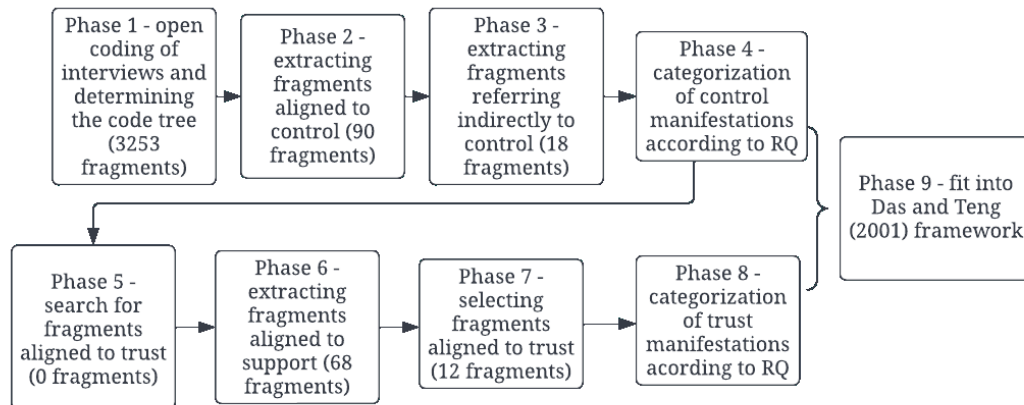
**Figure 4.** Analysis process.

Own analysis based on quotations from interviews, as in a case study they *(...) represent one way of presenting the data from open-ended interviews. The quoted phrases and sentences help present the participants' perspectives and thinking* (Yin, 2011, pp. 62-63). According to Corden and Sainsbury (2006, p. 11): *Reporting findings usually depends on textual representation of excerpts from transcripts of the conversation or narrative account alongside the researcher's own interpretation and commentary on those excerpts.* As scientific aim of the research is to deepen understanding of trust and control issues in the context of EDI, *Verbatim quotations could, it was believed, offer readers greater depth of understanding* (Corden, Sainsbury, 2006, p. 13). As proposed by Eldh et al., (2020), quotations were treated in own research as explanation of own analytical process, with reference to scientific goal. Long (2018) used this approach in his analysis aimed to describe how managers apply control and demonstrate trust in order to motivate subordinate cooperation. Finding appropriate links was key activity in analysis process *Interview texts were examined in Phase 3 to identify systematic links between activities to determine how managers integrate their efforts to promote control and trust. Links were identified and recorded when managers described how they attempted to build trust while they were also focused on applying a particular form of control and vice-versa* (Long, 2018, p. 73).

Table 1 shows breakdown of fragments with subcodes in the documents with and without the code. Some excerpts contained general remarks on control whereas others described specific mechanisms of control. Those mechanisms are in line with findings of literature review on control in organizations. *Audit, monitoring* or *reporting* are frequently mentioned, but *validation* may be less common - it appeared as specific condition of the pharmaceutical company. After content analysis excerpts have been coded with subcodes linked to specific mechanisms of control or as *control mechanisms not referred to directly as control*.

**Table 1.**

*Breakdown of fragments coded with subcodes related to main code "control"*

| Subcodes of the *control* code | Classification rules | Percentage | Percentage (valids) |
|---|---|---|---|
| control mechanisms not referred to directly as control | the term *control* not mentioned directly | 32,14 | 69,23 |
| monitoring/reporting | either *monitoring* or *report(ing)* appeared | 14,29 | 30,77 |
| audit | the exact phrase appeared | 10,71 | 23,08 |
| control by employees[vi] | the term *control* was not mentioned directly | 7,14 | 15,38 |
| validation | the exact phrase appeared | 3,57 | 7,69 |
| Training | the exact phrase appeared | 3,57 | 7,69 |
| quality | the exact phrase appeared | 3,57 | 7,69 |
| document(s) with code(s) | | 46,43 | 100,00 |
| document(s) without code(s) | | 53,57 | - |
| documents analysed | | 100,00 | - |

Source: own analysis in MAXQDA.

## 4. Results

### 4.1. Control manifestations in the context of EDI

Table 2 provides fragments of interviews coded as *control mechanisms not referred to directly as control*. In the course of content analysis, four questions were posed: (1) what was the main activity expressed by the interviewer (2) which control mechanisms did interviewer refer to (3) how could this control mechanism be categorized and (4) which types of control in Das and Teng (2001) framework would this category fit to? All the coded fragments were analysed according to this scheme and Table 2 presents results of this analysis.

**Table 2.**

*Analysis results based on quotations with fit to Das and Teng (2001) framework*

| Fragment | Key activity | Control mechanism | Proposed category of control | Fit to control in Das and Teng (2001) |
|---|---|---|---|---|
| *Interviewee20 (Int20): So it's not like you just don't watch over it either.* *Researcher (R)- Yhm,* | watch | verification of operation | Effects' control | output control |
| *Int20- Here, too, you are asked if this is really what the implementation was about, or if this is what we expected.* | ask about the effects | feedback | Effects' control | |
| *Int20- (...) there is this care to make it better for us.* *R - Yhm.* *Int20 - And that we, however, implement those plans that are and are simply satisfied with what we have to do, and not do it, so to speak with, I do not know ... by coercion.* | execute plans | verification of execution with plans | data control | output control |

Cont. table 2.

| | operate not in your own way | service standards of operation | behavior control | behavior control |
|---|---|---|---|---|
| *Int29- no one here can operate in their own way, but we have work tools.*<br>*R- Yhm, yes.*<br>*Int29 - Which we have to draw from and use and it's great that the company shows us the paths here and we train on it and keep updating our knowledge.* | use work tools | standards of operation | behavior control | |
| *Int29 - I am also a supporter that when someone tells me: "Because I did it", I say: "Then show that you did it"* | show/prove personally | personal verification | behavior control | behavior control |
| *Int28 - First of all, to shorten client's conversation, where we also look at these indicators strongly from business perspective.* | look on business indicators | verification of execution with plans | data control | output control |
| *Int23 - I've heard some have a meeting every morning where the manager gives out tasks to be done.*<br>*R - Such a severance pay.* | give away tasks to be done personally | manager's position (hierarchy) | control related to power | output control |
| *Int23 - Yes, I mean this is how I perceive it that, again, this strong hierarchy is visible here, that the manager, the director must see the employee, that he is working.*<br>*R - Yes.*<br>*Int23 - That he is at hand, that you can drop into his room and assign him a new task.* | see the employee working personally<br>assign tasks | manager's position (hierarchy) | control related to power | behavior control |
| *Int11- we appoint the business owner ... well, of course, it doesn't happen automatically, it requires a bit of guardianship* | appoint a business owner | position of the person entitled | control related to power | behavior control |
| *Int11 - you have to keep an eye on the business owner, so that he/she replies* | watch | verification of operation | Behavior control | behavior control |
| *Int5 - We also have to, and I usually prepare own internal instructions for my subordinate team, for employees.*<br>*R - Yes?*<br>*Int5 - And they all have to be trained in this, a list has to be signed, it is very important for us, so that exists. For every machine, for every installation that is currently working in the drug department.*<br>*R - Yhm.*<br>*Int5 - And we have to keep an eye on this, because it is checked there during audits.* | sign a list after training<br>watch | personal commitment<br>verification of operation | self-control of behavior<br>Behavior control | behavior control |
| *Int4 - Because our research always follows, our product is tested in comparison to the reference product.*<br>*R - Yes.*<br>*Int4 - A market product (...).* | compare with market product | verification with the market | Effects' control | output control |
| *Int3 - as we set up our schedule, it was also closely watched* | watch | verification of performance on time | Effects' control | output control |
| *Int 1 - other plants in our group, whether [entity A] or [entity B] or [entity C] are able to view stocks in my magazine - dedicated ones, those that we have agreed that they can see, because I can define it even for one specific element. So, when they need it, they call me "[Int1 name] - send it, because we need it"* | have an overview at the stock level | verification of stock level | Data control | output control |

Cont. table 2.

| | manage time | position of the person entitled | control related to power | behavior control |
|---|---|---|---|---|
| *Int1 - I manage this time, so I already have over 3500 elements introduced, there are still some 1500 to be introduced and I have everything done* | | | | |
| *Int22 - we are then able to do more tasks, we are also able to serve the customer faster. So it works to the advantage, only for us, because then we are also able to do more tasks. (...) And for this we are held accountable, exactly.* | manage more tasks | tasks' accounting | Effects' control | Output control |
| *Int22 - all the submitted ideas must also comply with procedures, with arrangements that applied in the company, right? (...) Well, we cannot implement an idea that, for example, was inconsistent with the procedure (...) So it is checked on the basis of procedures.* | Compliance with procedures | Job standards | behavior control | behavior control |
| *Int22 - Yes, we have daily ones [goals – Author's remark] that need to be done. Thanks to the fact that we focus on these things in order to improve them, facilitate service, we are able to do more of these things, and then the goal is greater. The daily ones that we carry out.* | manage more tasks | tasks' accounting | Effects' control | Output control |
| *Int25 – (...) if we did not have general culture of meetings to have status of results, of current affairs…* | Status meetings | update of current situation | Effects' control | Output control |

Source: own analysis of interviews in MAXQDA.

Figure 5 shows aggregated categories of control manifestations not referred directly as *control*. *Verification* is the dominating type, referred to: activities, plans, time schedule, market or stock. The category *position* embraces mechanisms stemming from hierarchy (in case of superiors) or tasks performed by an interviewee in the EDI process. *Standards* of job are mentioned in telecommunication company as methods of customer service and in financial company – as reference points for improvement ideas. *Task accounting* appears in financial company, in the context of regular team meetings and servicing customers in a faster way.
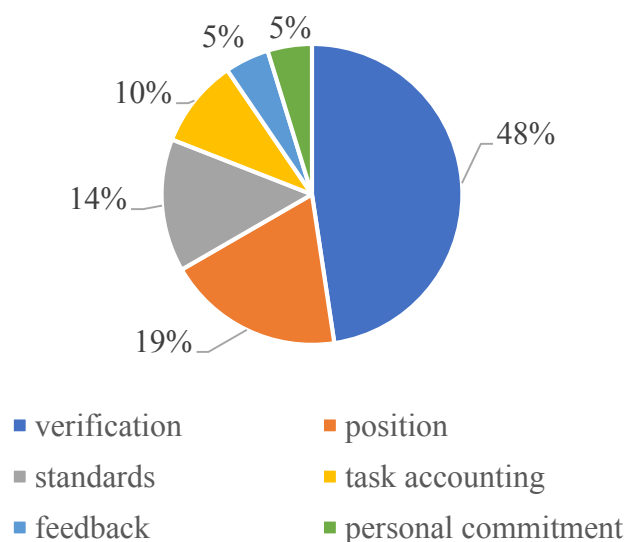


**Figure 5.** Breakdown of categories of control, source: own on the basis of interview analysis in MaxQDA.

Breakdown of manifestations identified in Das and Teng (2001) matrix is presented as Figure 6. The beforementioned issue of researching differences between those combinations and their dependence on variables, such as company or departmental specific, could be raised here.
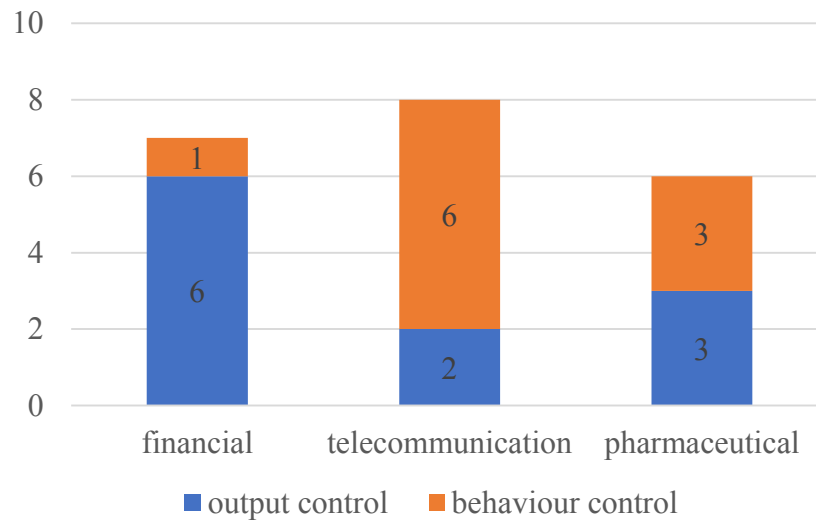


**Figure 6.** Breakdown of types of control categorized to fit Das and Teng (2001) framework, source: own on the basis of interview analysis in MaxQDA

Concluding Table 2 and Figure 6, one should notice lack of *social control* – informal rules, norms or organizational culture - present in Das and Teng (2001) framework. This type of control has not been identified in own research.

### 4.2.   Trust manifestations in the context of EDI

The research instrument did not contain a direct question about trust, but a general one on elements which supported implementation of EDI. More detailed issues were tackled in this question, referring to support on organizational and interpersonal level. After analysis of the code tree in MAXQDA and search for keyword *trust* (*zaufanie* in original Polish transcriptions), trust elements were found in fragments coded with the general code "support" – with reference to support factors for EDI in analysed organizations.

In the next step, content analysis was done with following the scheme: (1) identification of supporting elements/activities expressed by the interviewer (2) reference to supported areas in organization (3) fit into Das and Teng (2001) framework of *competence* and *goodwill trust*. Every fragment was analysed following this logic and Table 3 presents results of this analysis.

**Table 3.**

*Results of analysis of trust manifestations with fit to Das and Teng (2001) framework*

| Fragment | Supporting elements/activities | Supported areas/activities | Fit to type of trust (Das&Teng, 2001) |
|---|---|---|---|
| Int18: *If there is no support from senior managers, management and this space for work on improvements, apart from the standard goals that we have, then it will not be possible either, because after working hours no one will implement ideas for improvement. (…) it must be cooperation, but I think mostly the space and support from above, right? So we can do it and we have space for it.* | general managerial support | space and time for working on improvements | goodwill trust |
| Int28: *certainly involvement of various areas and willingness to cooperate, right? Because cooperation is key element here. If this is a good idea and everyone sees the business case, it is easier to implement it, because there is willingness to get involved, willingness to implement it. And it kind of helps. Of course, also, as if, budget and resource support. Well that is all that helps.* | engagement of different fields and willingness to cooperate | cooperation | goodwill trust |
| Int27: *In this process I would probably say that the organization should give some free rein, right? (...) To give the necessary resources to implement such a project or such an innovation, and then give a free hand and only check from time to time, right? Motivate by checking whether you are going in the right direction, whether you are achieving any effects, and not only spending money and meeting each other, and not achieve anything in the time horizon that you have assumed…* | resources and some freedom | overall control and motivation along with some freedom | competence trust |
| Int26: *We worked with people, these experts from different areas, to work out these principles. How will we act, so that it is the most efficient and that we do not have to go to the top or go somewhere for approvals, so that we can make decisions at operational level.* | experts in the organization | better efficiency in the decision-making process | competence trust |
| Int26: *We just got permission to make decisions at lower level for these initiatives, we got permission, "Get it on your level," right?(...) If something comes out, something more expensive there, then contact us or something, so that we also have control over it. But try to control it among yourselves.* | allowance for decisions at lower levels (organizational level) | better efficiency in the decision-making process | competence trust |
| *Organizationally, it's very good, right? Actually, I entered this environment where it was already working and well organized. The financing was appropriate, the management's attitude was right - yes, the management - yes, the boss is often this program as well - he ran his separate spin-off, it additionally motivated and there was acceptance that, especially at the beginning, more time was spent on getting to know area.* | board support | motivation of employees | competence trust/goodwill trust |
| Int6: *I know that where I am today and what I know I owe to my company and my superiors.* <br> *- Because they just ... allowed me to devote some part of my work time to this, on such research, building my competences, and financing.* <br> *- Sometimes I was not able to arrange this financing myself, so they came with me.* | general managerial support | space and conditions for research work and competence development | competence trust |

Cont. table 3.

| | | | |
|---|---|---|---|
| Int4: *it was like a breakthrough, because the supervisor had to say "ok then, I won't do anything if it doesn't work out.*<br>*R - Yhm, so it must have been a bit like-*<br>*- System consent (...) allowing, making an initiative involving many people, involving some time, with the prospect of failure.* | manager | allowance for failures | goodwill trust |
| Int4: *(...) this internal environment, you could say it was favorable for me, both in terms of decision-making, financial etc.* | internal environment | decision making | competence trust |
| Int3: *Certainly the support of managers, directors, yes, i.e. managers.*<br>*R - Yhm.*<br>*- Certainly such a good climate around this case, yes.* | general managerial support | better climate | goodwill trust |
| Int22: *We have such good contact between the leaders and colleagues that we are not afraid, for example, to submit an idea, and someone will think "what are you talking about?" and everything. There is no negative overtone and there is also support from the leaders* | good contact among co-workers and leaders | leveraging number of initiatives | goodwill trust |

Source: own analysis in MAXQDA.

Majority of supporting elements or activities is connected with general managerial support in terms of better efficiency and output of the innovation process. This is manifested in: (1) access to resources, (2) allowance for making decisions at lower levels of organizational structure or (3) time allocation to work on improvements. Another category is linked with organizational culture, demonstrated in allowance for failures in innovation process or – as one Interviewee 3 put it *a good climate around the case*.

Although this research's results cannot be generalized, additional overview was carried out with point of interest on breakdown of trust types in each company. Every trust manifestation was counted, as every interviewee could mention various trust manifestations. As illustrated on Figure 7, every company had different combination of *goodwill trust* and *competence trust*. The interesting issue to research would be dependence of these combinations on certain variables – i.e. market, company or departmental specific.
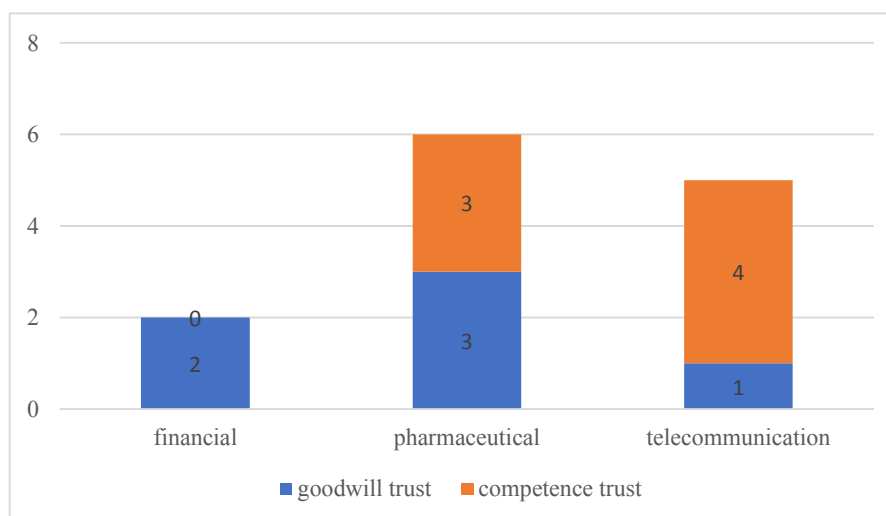


**Figure 7.** Breakdown of manifestations of trust categorized in Das and Teng (2001) framework with reference to company type, source: own on the basis of interview analysis in MaxQDA.

## 5. Discussion

The article's goal was to deepen understanding of subtle issues of trust and control in EDI context. The goal has been met by empirical research basing on content analysis of key informants' narration. This method allowed to get more insights on trust and control, when they were not spoken of directly, which was possible due to partly free conversation flow.

The research contributes to the area of EDI and trust and control in four ways.

First, it shows that trust as a concept may not be expressed directly, therefore the need for more attention towards trust manifestations within organization. This direct absence of trust as a concept in relation to innovations is in line with findings of Glińska-Neweś et al. (2017). Their model of Positive Relationship at Work (PRW) as a prerequisite of organizational innovations embraces manifestations of trust, like open communication or informal meetings[vii]. Content analysis shows asymmetry in addressing trust and control issues in the sense that interviewees do not refer directly to trust, but mostly to control.

Second, the article proposes categorization of trust and control manifestations and fit into types of trust and control in Das and Teng (2001) model, which originally presents relations between trust, control and risk types in collaboration between alliance partners. Although EDI is an intraorganizational phenomenon, it exposes participants to high risk, therefore the proposed link to this model.

Third, the breakdown of trust and control types in researched companies shows differences among them. This poses questions whether and how those differences could be explained. Future research could investigate those differences on bigger scale, with the use of quantitative methods. On the one hand, specific sector could be taken into account, on the other hand – more companies from the proposed three sectors could be researched.

Fourth, manifestations of *social control* in Das and Teng (2001) model have not been recognized in the research, which opens a promising future research avenue.

Moreover, the research proves important role of *general managerial support*, which has been identified in the literature on innovations and trust (Huang et al., 2021; Ahmad et al., 2022). Future research could investigate Krot and Lewicka (2020) term of *impersonal trust* in the context of EDI to find out which elements of impersonal trust are identified by organizational members.

The study is bounded by its limitations. First limitation stems from the method itself, which does not allow to make generalizations on the basis of interviews – especially in terms of comparisons between companies as for their combinations of control and trust type. Lack of reference to specific types of trust and control – as proposed by Das and Teng (2001) – might be considered as study restriction. This article bases on analysis of interviews with employees and does not include other types of materials, like intraorganizational documents or information available publicly.

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**Footnotes**

[i] As the original Schumpeter's publication from 1934 was impossible to obtain, I referred to Høyrup (2010). For detailed information on Schumpeter's approach towards innovations, see Hospers (2005).

[ii] This perspective is in line with the EDI concept, where innovation initiators and implementors do not have to be appointed by organization as innovation creators.

[iii] For scope of this term and its dimensions, see Krot and Lewicka (2020).

[iv] MANIFESTATION | meaning, definition in Cambridge English Dictionary.

[v] According to Horton et al. (2004, p. 340), semi-structured interviews are helpful: *(…) in order to allow the interviewees a degree of freedom to explain their thoughts and to highlight areas of particular interest and expertise that they felt they had, as well as to enable certain responses to be questioned in greater depth, and in particular to bring out and resolve apparent contradictions.*

[vi] This subcode differs from others, as it suggests opposite direction of control – the "bottom-up" (exerted by employees towards their superiors), not "top-down". Because of this differentiation it is not subject of further analysis in this article.

[vii] The role of meetings as support factors in the innovation process has been visible in own empirical research on EDI – especially in case of the financial company.

# INTERNATIONALIZATION OF POLISH HIGHER EDUCATION IN THE CONTEXT OF DEMOGRAPHIC CHALLENGES. SELECTED ASPECTS

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**Purpose:** This article addresses selected aspects of internationalization of higher education (HE) in Poland in the context of demographic changes. The purpose of it is to analyze the dynamics of the number of foreign students studying at Polish Higher Education Institutions (HEIs) and their structure by type of HEI, field of study and origin.

**Design/methodology/approach**: A review of the literature on the subject and desk research with reference to data from the Statistics Poland were used. The analysis, covered the years 2004-2020, was based on selected methods of descriptive statistics.

**Findings:** Between 2004 and 2020, the number of foreign students increased almost 10-fold. The average growth rate in the analyzed time series was 15.2% for the group of HEIs and 21.5% for non-public HEIs. The choices of foreign students most often group fields of study in the areas of social sciences, economy and medicine. There has been an increase in interest in studies in technology and services, while there has been a marked decline in fields of study related to the humanities and education.

**Research limitations/implications**: The demographic perspective adds a new dimension to the issues of growth and development of HEIs, that is why this issue involves further in-depth analysis.

**Practical implications:** Despite the apparent positive change with regard to the number of student-foreigners studying at Polish HEIs, this statistic, compared to other European countries, is still unsatisfactory. In the face of projected further unfavorable demographic trends, countries with positive natural increase and younger age structures, become an opportunity to compensate for the loss of Polish students. Efforts by the entire HE sector are needed to seize these opportunities. It is necessary to further correlate sectoral policies — HE with population, foreign and social policies. HEIs should improve processes related to caring for the broader relationship with foreign students.

**Originality/value:** The paper is addressed to all interested in HE policy. The study should be seen as a contribution to the existing discussion in the issue of growth and development of HEIs.

**Keywords:** higher education, higher education institutions, internationalization, demography.

**Category of the paper:** research paper.

## 1. Introduction. Transformation in the higher education sector

It is estimated that higher education in Poland is one of the fastest developing areas of social life. After 1990, it underwent significant quantitative as well as institutional transformations, which primarily include the establishment of non-public higher education institutions (HEIs) and the creation of opportunities for part-time education. The last decade of the 20th century and the first five years of the 21st century were characterized by a very high momentum in the establishment of HEIs, and consequently an increasing number of students. After 2005, this momentum has clearly weakened (figure 1), which has to do with unfavorable demographic trends — a declining population of the age nominally assigned to the higher education level (figure 2) and the exhausting needs of working people to improve their professional skills by gaining higher education.
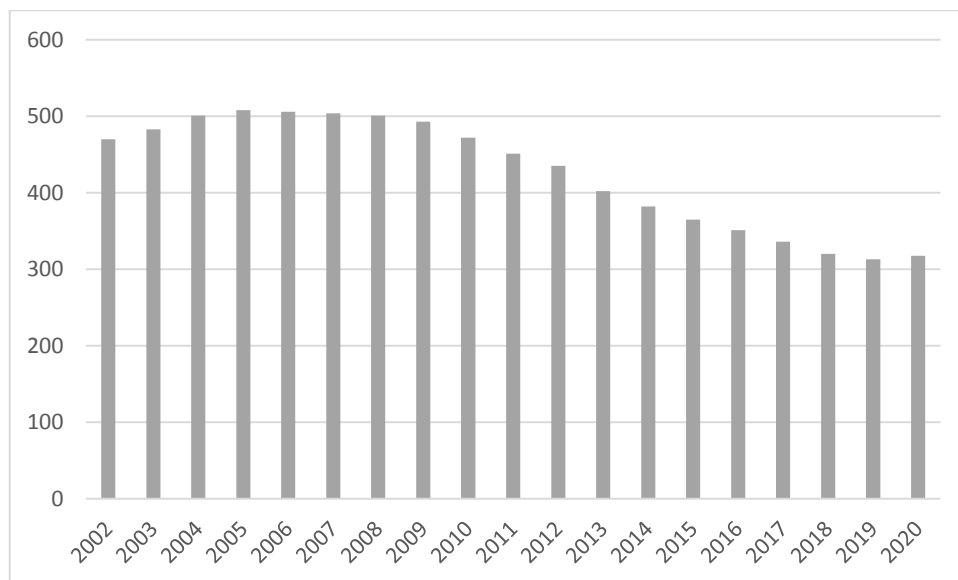


**Figure 1.** Number of students per 10,000 population in Poland in 2002–2020.

Source: own elaboration based on BDL.
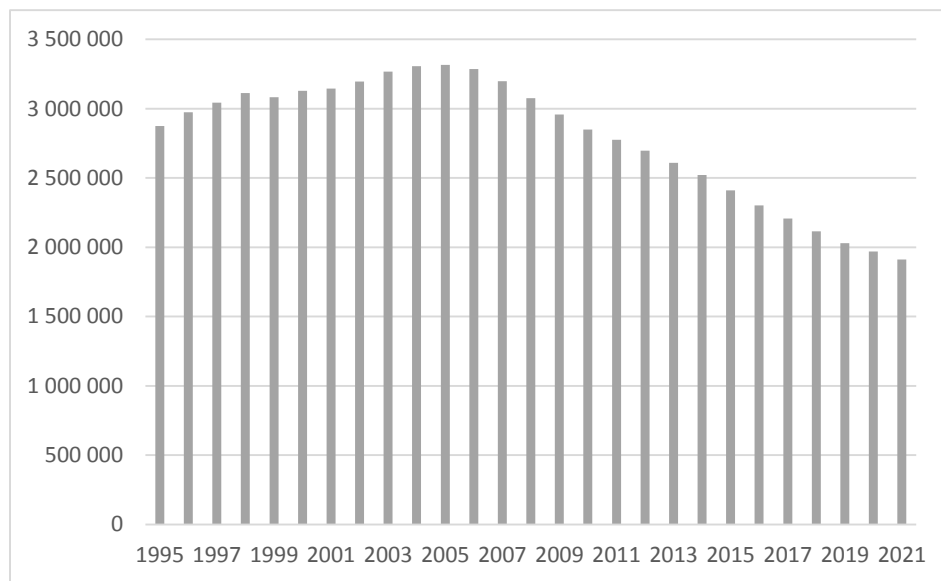
**Figure 2**. Population of people aged 20–24 between 1995 and 2021.

Source: own elaboration based on BDL.

After a period of dynamic growth and development, the present is a period of constant questioning about the direction of transformation in the Polish higher education system, both in terms of the educational model and the processes of HEI management[1] — which is reflected, i.a., in changes in legal basis and institutional governance. This is primarily related to the demographic conditions already mentioned (which was more visible in non-public sector), insufficient state expenditure on science and higher education funding[2] and the challenges to the education process posed by the labor market under conditions of globalization, the knowledge economy and the information society.

The scale and strength of the impact of the demographic decline on higher education is often referred to as a demographic tsunami (e.g.: Antonowicz, Gorlewski, 2011). On the other hand, period of HEIs development in the last decade of 20th century, due to favorable demographic trends, is often referred to as "the Polish educational miracle" (Anielska 2022, p. 14).

Since 1989, Poland has seen a continuous decline in the total fertility rate (below the level guaranteeing simple generational replacement), resulting in unfavorable changes in the structure of the biological and economic age groups of Polish society. Since 2006, there has been a declining population of people aged 20–24 (figure 2), and according to the Statistics Poland demographic forecast, this number will decrease further by nearly 58,000 in 2035 compared to 2021 (GUS, BDL).

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[1] The discourse around the concept – the Humboldtian model of higher education vs. the entrepreneurial university model of B. Clark.

[2] The share of public expenditure on higher education in GDP in Poland in 2005 was at the level of 0.99%, in 2010: 0.71%, in 2015: 0.72%, and in 2018: 1.0%.

Opportunities to minimize the negative impact of the demographic decline in Polish higher education are seen in the influx of students from abroad (i.a.: Domański 2017, p. 67; Kubiciel-Lodzińska 2014, p. 135). The demographic perspective adds a new dimension to the issues of growth and development of HEIs due to the observed general increase in global migration movements and related processes. The changing patterns of social behavior are also not without significance — successive generations are characterized by increasing openness to new phenomena and ease of networking and functioning in global networks of social links.

This article addresses selected aspects of internationalization of higher education in Poland in the context of demographic changes. The purpose of it is to analyze the dynamics of the number of foreign students studying at Polish HEIs and their structure by type of HEI, field of study and origin. The analysis covered the years 2004-2020 — a time series that allows observation of long-term trends. In the article a review of the literature on the subject (including available reports) and desk research (with reference to data from the Statistics Poland) were used. The analysis was based on selected methods of descriptive statistics.

## 2. Institutional aspects of internationalization of higher education in Poland

Internationalization of higher education according to B. Siwińska (2016, p. 39) — an expert in this field — is the purpose, function and mode of operation of institutions in this sector characteristic of operating in a globalized world. Processes that have been natural to businesses for a number of years now are slowly becoming a component of the growth and development of HEIs. They are also an increasingly important element of public policies in higher education and science in the broadest sense. Individual countries are developing strategies and programs to attract international students. What is apparent in this "market" is the strong concentration of the effects of these activities — 40% of foreign students are hosted by a total of four countries: Australia (a country with one of the highest rates of internationalization of studies), Canada, the United Kingdom and the United States (Fundacja Edukacyjna Perspektywy, 2021, p. 8).

One form of internationalization is the internationalization of educational programs — teaching in foreign languages (by native and foreign lecturers) and educating foreign students. The benefits of these processes are multifaceted and unquestionable (table 1).

**Table 1.**
*Benefits of internationalization of higher education programs*

| For the country hosting foreign students | For the HEI hosting foreign students |
|---|---|
| - filling shortages and enrichment of resources (supply) in the internal labor market<br>- penetration of cultural patterns and increase in social competence of residents<br>- increase in the level of innovation (penetration of knowledge, technology)<br>- financial benefits (consumer spending of foreign students)<br>- dissemination of a positive image of the country in the foreigner's country | - image benefits<br>- financial benefits (a source of revenue[3] and a "bonus" in the basic grant algorithm for the so-called internationalization component[4])<br>- positive impact on the quality of education (stimulation of foreign language learning, internal competition, the need to improve internal processes)<br>- development of social skills (in students, academic staff, administrative staff)<br>- participation in international research project |

Source: own elaboration.

The chief government administration body responsible for implementing policies related to the education of foreigners at Polish HEIs is the Minister of Higher Education and Science. The stimulation of internationalization processes in education was and is evident in various development strategies and programs (*explicit* and *implicit*), i.a.: "Strategy for Responsible Development until 2020 (with an outlook until 2030)", "Polish Foreign Policy Strategy 2017–2021", "Long-term Development Cooperation Program 2016–2020" and "Government Program for Cooperation with Poles and Polish Community Living Abroad in 2015–2020", "Human Capital Development Strategy 2030" (which aims to increase the percentage of foreigners studying in Poland in 2030 to 12.2%[5]).

Currently, the key entity supporting the processes in question is the Polish National Agency for Academic Exchange (Narodowa Agencja Wymiany Akademickiej, NAWA), established in 2017, which replaced the Bureau for Academic Recognition and International Exchange (established in 1999). The need to establish NAWA arose from the lack of an institution that would implement a comprehensive long-term state policy in support of individual academic mobility aimed at increasing academic and research potential, as well as support the development of HEIs in internationalizing their educational offerings and promoting Polish higher education abroad (Najwyższa Izba Kontroli, 2020, p. 18). As we read in the agency's action plan for 2021–2027, its activities are aimed at (Narodowa Agencja Wymiany Akademickiej, 2021a, p. 4):

- strengthening international cooperation of scientists from Polish HEIs and scientific institutions,
- strengthening international cooperation of Polish HEIs and scientific institutions,
- increasing the number of outstanding foreign students at Polish HEIs,

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[3] In some countries, hosting foreign students is even becoming a separate industry (Bień, 2018, p. 1).

[4] The component was introduced in the 2016 grant algorithm, and is calculated based on, i.a.: the number of foreign students, the number of foreign doctoral students, the number of foreign students receiving scholarships from the Polish National Agency for Academic Exchange.

[5] Area: Human Capital, Objective 1: Increase the level of competence and qualifications of citizens, including digital competences.

- disseminating information about the Polish system of higher education and science,
- expanding the international community of people familiar with the Polish language and culture.

In the context of the directions formulated in this way, NAWA is part of the system of support for the development of Polish HEIs and scientific units, interacting with government administration, as well as with the National Science Center, the National Center for Research and Development, the Foundation for Polish Science, the Łukasiewicz Research Network, the Foundation for the Development of the Education System and other entities working for the development of science and higher education (Narodowa Agencja Wymiany Akademickiej, 2021b, p. 6).

The drive to intensify internationalization processes is also evident in the strategic documents of Polish HEIs — strategies, the preparation and implementation of which have been the responsibility of HEI rectors since 2011. Among the strategic goals and actions of Polish HEIs we find: increasing the participation of foreigners in education and research processes, increasing the number of foreign-language education programs or introduction of "double degree" programs. HEIs seek international certifications and prestigious accreditations (for example, in the case of business schools: EQUIS European Quality Improvement System, AACSB (Association to Advance Collegiate Schools of Business) or AMBA (Association of MBAs). It also happens that strategies/programs in this area are developed at the level of organizational units of HEIs (e.g. "Strategy for internationalization of the Faculty of Political Science at Marie Curie-Sklodowska University in 2016–2021").

An example of an initiative born out of the academic community's sense of the need for joint action on the internationalization of Polish HEIs is the Association of Polish Universities for Internationalization, founded in 2017. The Association's activities are aimed at (Stowarzyszenie na Rzecz Internacjonalizacji Polskich Uczelni, https://apui.edu.pl/pl/statut/):

- conducting activities aimed at internationalization of HEIs,
- inspiring and assisting HEIs in the process of development of international exchange of students and academics,
- promotion of Polish HEIs outside Poland,
- participation in building a European and global knowledge-based society,
- integration of the academic community and cooperation in building academic mobility strategies by HEIs,
- acting for the development of higher education,
- conducting activities for the education of the student as a citizen with a broad international and intercultural experience.

## 3. Dynamics of change in the number of foreign students

Observation of the share of foreign students in the total number of students (Figure 3) indicates an increasing interest in Poland as a place to study and, at the same time, is a result of ongoing public activities and the activation of Polish HEIs in this area.
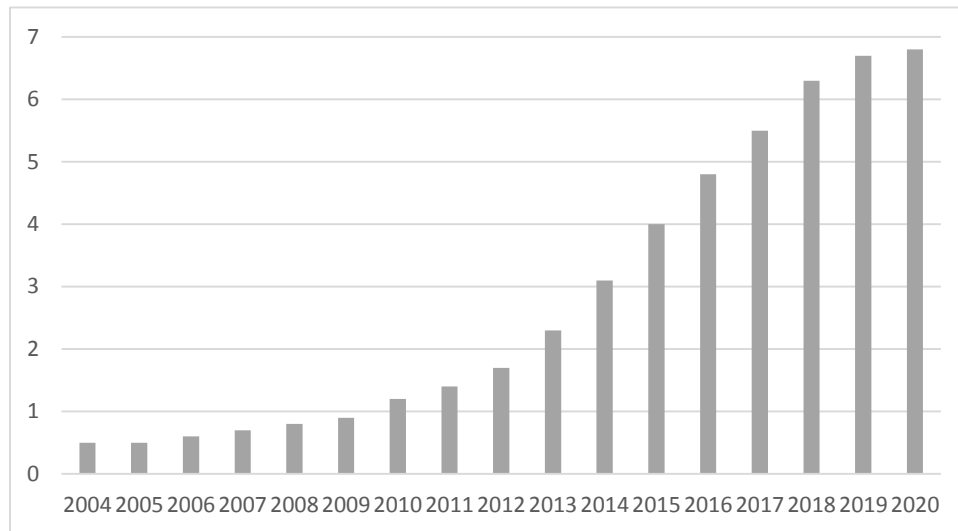


**Figure 3.** Percentage of foreign students studying at Polish HEIs in 2004–2020 (%).

Source: own elaboration based on BDL.

Between 2004 and 2020, the number of foreign students increased almost 10-fold (figure 4). At the same time, globally it has slightly more than doubled (from 2.8 million to 6.1 million). Among the reasons why student-foreigners are increasingly willing to choose education in Poland are (in their opinion): high quality of education, diverse educational offerings, willingness to learn a new culture, international recognition of Polish diplomas, and good career prospects after studies (Stasiak, p. 9).
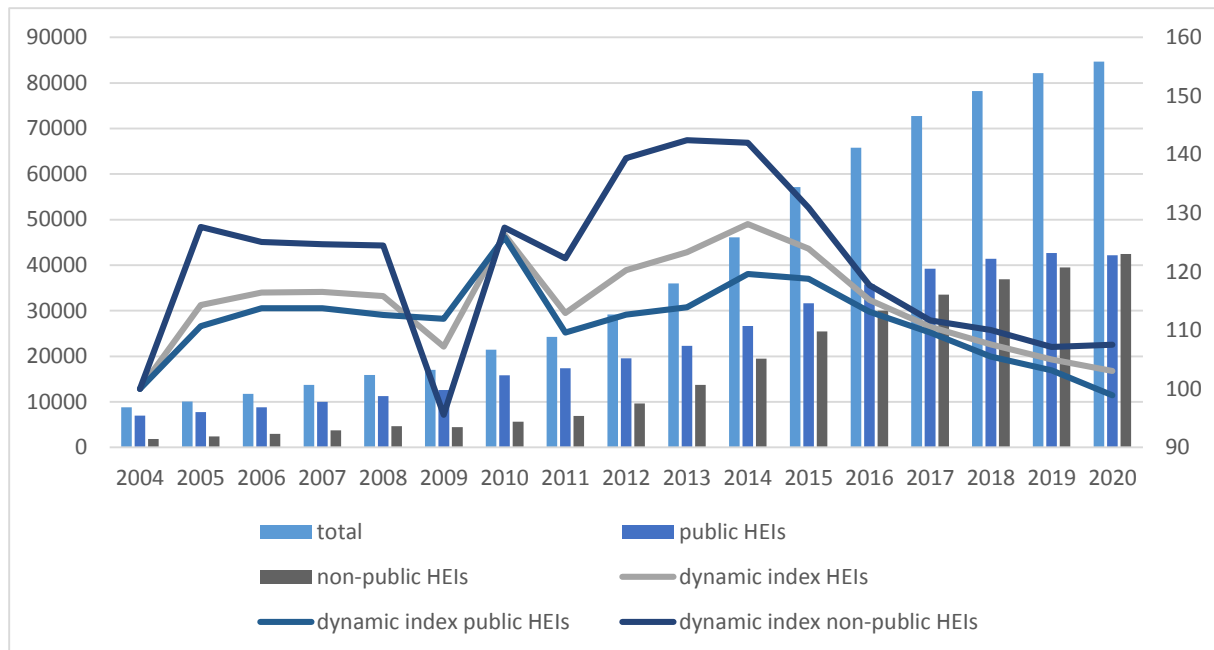
* Chain dynamics index.

**Figure 4.** Number (left axis) and dynamics of change* (right axis) of foreign students in Poland by public and non-public HEIs in 2004–2020.

Source: own calculations and elaborations based on: Główny Urząd Statystyczny, 2005, p. 56; Główny Urząd Statystyczny, 2006, p. 176; Główny Urząd Statystyczny, 2007, p. 172; Główny Urząd Statystyczny, 2008, p. 168; Główny Urząd Statystyczny, 2009, p. 223; Główny Urząd Statystyczny, 2010, p. 233; Główny Urząd Statystyczny, 2011, p. 239; Główny Urząd Statystyczny, 2012, p. 241; Główny Urząd Statystyczny, 2013, p. 121; Główny Urząd Statystyczny, 2014, p. 123; Główny Urząd Statystyczny, 2015, p. 117; Główny Urząd Statystyczny, 2016, p. 123; Główny Urząd Statystyczny, 2017, p. 119; Główny Urząd Statystyczny, 2018, p. 148; Główny Urząd Statystyczny, 2019, p. 131; Główny Urząd Statystyczny, 2020, p. 98; Główny Urząd Statystyczny, 2021, p. 46.

Interestingly and noteworthy — by far the better results are observed in the group of non-public HEIs . In 2004, only slightly more than 20% of all foreigners studying in Poland were educated at non-public HEIs, and 16 years later the statistic amounted to more than 50%. In 2020, among the 50 HEIs with the largest number of foreign students, 25 were public HEIs (in this group, the largest number of foreigners studied at Jagiellonian University and Warsaw University, and the largest percentages were at Nicolaus Copernicus University and University of Opole) and the same number of non-public HEIs (in this group, the largest number of foreigners studied at the Vistula University in Warsaw and the largest percentage was at the University of Information Technology and Management in Rzeszów). The average growth rate[6] in the analyzed time series was 15.2% for the group of HEIs and 21.5% for non-public HEIs.

Despite the apparent positive change with regard to the number (percentage) of student-foreigners studying at Polish HEIs, this statistic, compared to other European countries, is still unsatisfactory. Poland is still one of the least internationalized countries in the European Union and the OECD. According to OECD data, among the leading European countries in 2019 are: the UK, Austria, the Czech Republic and Hungary (OECD, 2022).

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[6] Average rate of change for chain indexes in 2004–2020.

## 4. Directions of education of student-foreigners

The factors that prospective students consider when choosing a foreign HEI are primarily its program offerings, tuition fees, scholarship assistance[7], the complexity of the admissions procedure, and the possibility of pursuing further education or obtaining a job during and after graduation. Students' motivations for studying at a foreign HEI vary depending on their country of origin, field of study and educational cycle. Different types of HEIs and fields of study are characterized by varying "susceptibility" to internationalization processes — from very high in the sciences and medical sciences to relatively low in the legal sciences.

The structure of student-foreigners by groups of fields of study in selected years from the adopted time series is presented below (figures 5[8] and 6[9]). The choices of foreign students most often group fields of study in the areas of social sciences, economy and medicine. There has been an increase in interest in studies in technology and services, while there has been a marked decline in fields of study related to the humanities and education. In 2020, the largest number of foreigners studied management, medicine and computer science (respectively: 15.9%, 9.0%, 7.6% of total foreigners at Polish HEIs).
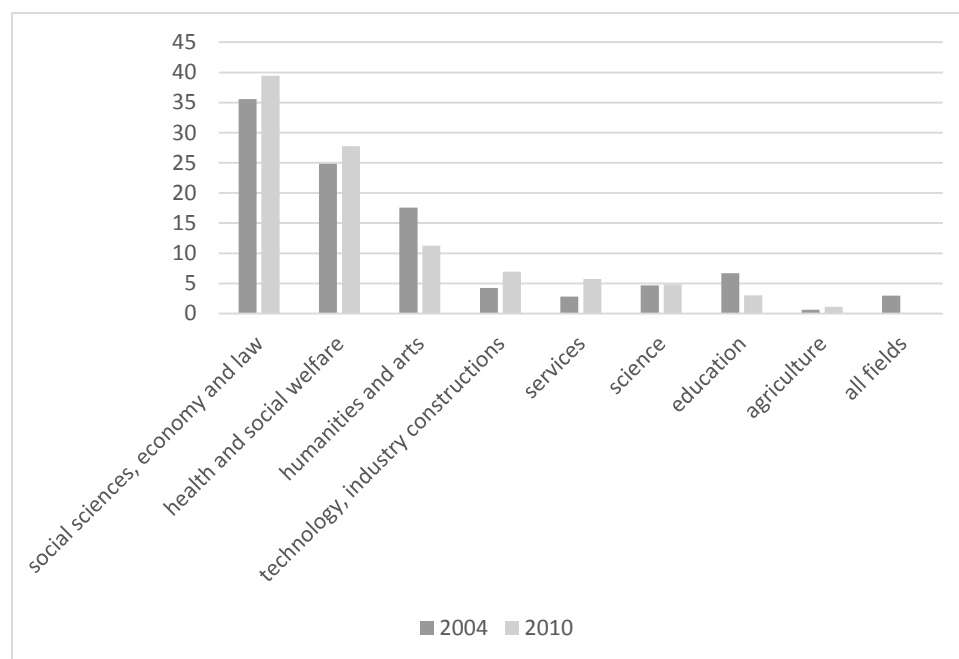


**Figure 5.** Structure of student-foreigners by groups of fields of study in 2004 and 2010 (%).

Source: own calculations and elaborations based on: Główny Urząd Statystyczny, 2005, pp. 56-57; Główny Urząd Statystyczny, 2011, pp. 240-241.

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[7] In Poland foreign students can apply for, i.a., a resettlement allowance for the first year of study and an allowance for the preparation of a thesis.

[8] In 2010, no data were available for the "all specialties" group.

[9] In 2013, the international classification of fields of study (ISCED 2013) changed, therefore data for 2020 is presented in a separate figure.
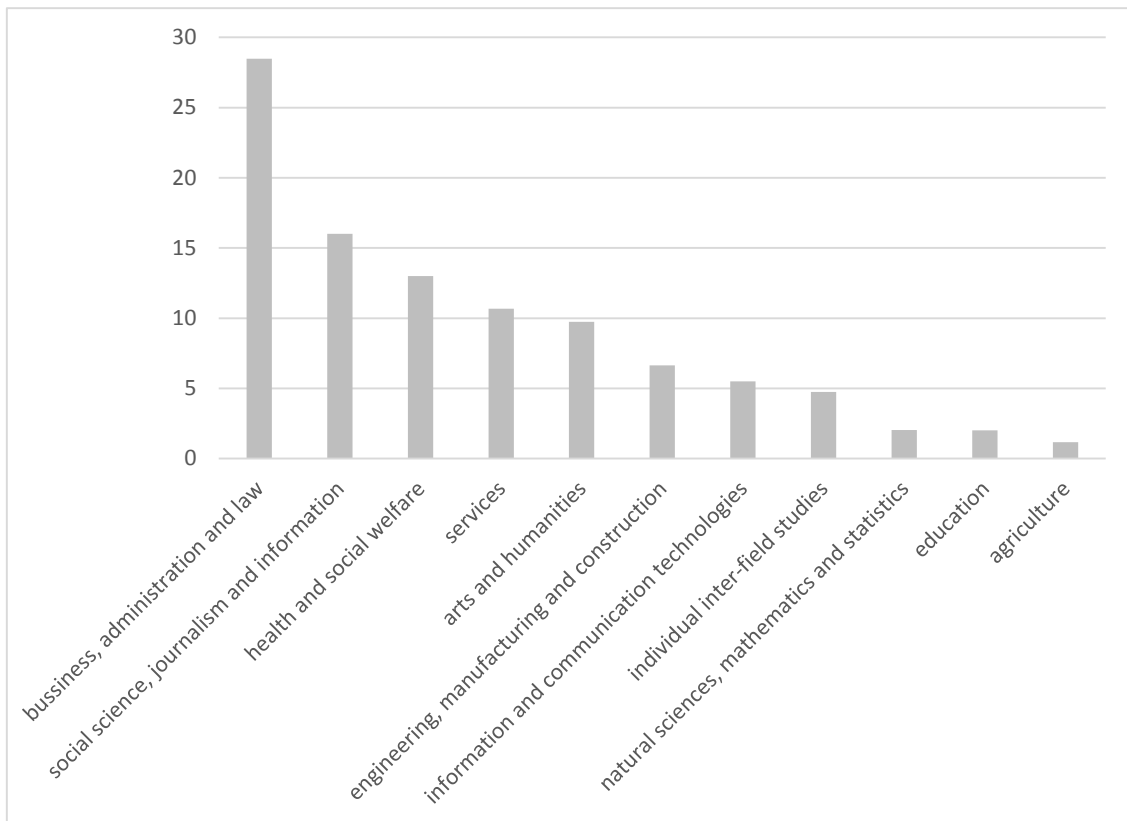
**Figure 6.** Structure of student-foreigners by groups of fields of study in 2020 (%).

Source: own calculations and elaborations based on: Główny Urząd Statystyczny, 2021, pp. 47-48.

A phenomenon worth noting is the clear interest of certain nationalities in certain fields of study. For example, medicine in Poland is most likely to be chosen by Swedes, students coming from the United States, Norway and Germany.

Related to the choice of the field of study by a prospective foreign student is the decision regarding the type of HEI. Table 2. presents the structure of student-foreigners by type of HEI in selected years from the analyzed time series[10]. In this case, however, the analysis, due to institutional transformations in higher education (changes in the academic status of certain HEIs, consolidation processes or changes in their profiles), is hampered. In addition, the assignment of HEIs to a particular type is based on its declaration in the reporting year and the current classification of the Ministry of Higher Education and Science. Therefore, it should be assumed that the results presented are illustrative.

The largest increase in the percentage of students is observed in the examined time series for the group of so-called other HEIs (22.05 pp), economic HEIs (9.46 pp) and technical HEIs (3.76 pp). Universities and medical universities, on the other hand, have seen the largest decline (respectively: 18.83 pp and 10.80 pp).

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[10] Due to the change in 2019 in the classification of HEIs in Statistics Poland data, for comparable data, 2018 was chosen for analysis instead of 2020.

**Table 2.**

*Structure\* of student-foreigners by type of HEI\*\* in: 2004, 2010, 2018 (%)*

| Type of HEIs | 2004 | 2010 | 2018 |
|---|---|---|---|
| universities | 41.10 | 29.95 | 22.28 |
| academies of economics (higher schools of economics) | 15.71 | 15.68 | 25.17 |
| technical universities (higher schools of technology) | 8.31 | 9.11 | 12.07 |
| medical universities | 20.61 | 23.75 | 9.81 |
| agricultural academies (higher schools of agriculture) | 2.96 | 2.28 | 2.16 |
| higher teacher education schools (higher schools of pedagogy) | 1.09 | 0.78 | 1.84 |
| fine arts academies (higher schools of art) | 2.25 | 1.78 | 1.25 |
| maritime universities | 0.25 | 0.58 | 0.51 |
| physical academies | 0.63 | 0.51 | 0.45 |
| theological academies (higher schools of theology) | 1.99 | 0.66 | 0.28 |
| other higher education institutions | 5.08 | 14.91 | 24.16 |

\*Due to the rounding adopted, the structures do not add up to 100.

\*\* In parentheses is the name of the type of HEI used by the Statistics Poland for the data presented in 2018.

Source: own calculations and elaborations based on: Główny Urząd Statystyczny, 2005, p. 56; Główny Urząd Statystyczny, 2011, p. 240; Główny Urząd Statystyczny, 2019, p. 131.

These results correspond with the results of the analysis of the number of students studying at public and non-public HEIs. While in 2004, almost 80% of foreign students studied at public HEIs (including universities, medical universities), in 2020, it was at non-public HEIs that the most foreign students studied (50.17%), whose domains include economics and management-related fields of study.

## 5. Origins of student-foreigners

Polish HEIs most often host young people from Europe (table 3), mainly Ukraine and Belarus. This phenomenon is observed throughout the time series. Prospective markets are students from Africa and Asia[11] (increase of 2.78 and 1.26 pp in structure, respectively).

In 2020, Polish HEIs educated students coming from 189 countries, with a high concentration visible (almost 75%) of foreign students come from 9 countries (Ukraine, Belarus, India, Turkey, Norway, Germany, China, Kazakhstan, and Russia). This phenomenon is even more pronounced in the case of BA/BSc studies. In this case, 75% of student-foreigners come from 4 countries: Ukraine, Belarus, India, and Turkey (Study in Poland, 2021, p. 4.).

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[11] According to OECD data, Asians account for the largest number of international students (Ośrodek Przetwarzania Informacji – Państwowy Instytut Badawczy, 2021, p. 2).

**Table 3.**
*Structure\* of student-foreigners according to the continent of origin in: 2004, 2010, 2020 (%)*

| Continent | 2004 | 2010\*\* | 2020 |
|---|---|---|---|
| Europe | 68.83 | 72.73 | 73.14 |
| Asia | 16.94 | 16.21 | 18.20 |
| North and Central America | 9.53 | 7.10 | 1.38 |
| South America | 0.64 | 0.44 | 0.53 |
| Africa | 3.92 | 3.38 | 6.70 |
| Australia and Oceania | 0.13 | 0.12 | 0.04 |

\* Due to the rounding adopted, the structures do not add up to 100.

\*\* In 2010 0.03% students-foreigners were discribed as „without citizenship".

Source: own calculations and elaborations based on: Główny Urząd Statystyczny, 2005, p. 56; Główny Urząd Statystyczny, 2011, p. 240; Główny Urząd Statystyczny, 2019, p. 131.

A disturbing phenomenon is the significant decline in the number of students-foreigners of Polish origin[12], i.e., people who, regardless of their country of birth and knowledge of the Polish language, declare Polish origin, interest in Polish culture and Poland as the country of their origin. In 2004, the percentage of such students in the total number of foreigners studying in Poland was 42.9%. In 2010 and 2020, these statistics were respectively: 19.17% and 8.8%.

# 6. Conclusions

The internationalization of higher education has important positive effects on the educational system, but also on global and intra-state social processes. In a world of global processes, the "university without walls" has become a reality, and internationalization has become the standard of higher education. A fundamental dimension of the internationalization of higher education is the education of foreign students. However, one should not forget about other equally important dimensions, i.e., the mobility of Polish students and research and teaching staff or cooperation in the research field with foreign partners (which are not considered in this article).

Undoubtedly, the visible increase in the number of foreign students at Polish HEIs is an expression of systemic measures within the framework of public policy in higher education in general, as well as specific activities of Polish HEIs, which have included this area in their development strategies. Internationalization brings unquestionable benefits in terms of increasing the quality of education and the potential of HEIs (educational, research, organizational). However, it should be realized that these processes of should be carefully planned and controlled, as they may also cause adverse effect and negative consequences (e.g. in case of non-fulfillment of foreign language requirements by students or lowering the examination requirements for them).

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[12] Observed as early as 2001.

In the face of projected further unfavorable demographic trends, countries with positive natural increase and younger age structures, become an opportunity to somewhat compensate for the loss of Polish students. Further efforts by the entire higher education sector are needed to seize these opportunities. Within the framework of the broader state action, it is necessary to further correlate sectoral policies — higher education with population (especially migration), foreign and social policies.

HEIs should improve organizational processes related to caring for the broader relationship with foreign students (from promotion, recruitment, teaching process, administrative service to assistance related to job search after graduation). It is also worth underlining that establishing an organizational unit dedicated to serving foreign students is of course necessary, but not sufficient. This is because the awareness and effort of whole HEI community is needed to make the processes of internationalization a strategic and real direction of development.

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# SOCIALLY RESPONSIBLE HUMAN RESOURCE MANAGEMENT TOWARDS MIGRANT WORKERS WITH THE FOCUS ON THE EMPLOYEES' INTERESTS

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**Purpose**: The following two main research questions were addressed in this article:
1) Which employees' interests are the most important for Ukrainian migrant workers?
2) To what extent companies ensure the interests of Ukrainian migrant workers?
Since migration is often associated with precarious employment, the problems of the relationship between the form of employment and the interests of migrants were examined as well.

**Design/methodology/approach**: For the purpose of this paper, such methods as literature survey of publications indexed mainly in Scopus database and empirical research in the form of a survey were used. The survey was carried out in 2020 in Poland and the respondents were Ukrainian workers. The research was conducted using the PAPI technique and based on a with the use of a representative sample.

**Findings**: Empirical research shows that the most important interests of migrants (of 22 analyzed interests) are salaries adequate to duties, ensuring good occupational safety and health, and clear evaluation criteria. At the same time, the second and third of the indicated interests are mostly ensured by employers, regardless of the form of employment in which the respondents work. This leads to certain practical and theoretical implications.

**Practical implications:** The Ukrainian population is gradually growing in Poland which results from the armed conflict and the difficult economic situation in Ukraine. Therefore, the presented research is utmost valid.

**Originality/value:** The concept of socially responsible HRM (SRHRM) emerged as an element of CSR focused on the inside of the company (its employees treated as the most important stakeholders). Surveys devoted to the implementation of the concept of CSR are carried out mainly among employees who are citizens of the country where the enterprise surveyed is headquartered. The issue of migration is discussed rather from the perspective of such academic disciplines as economics and sociology than the discipline of human resource management. This study aims to fill the gap in research on SRHRM through examining the HRM practices in the context of migrant workers with a focus on employee interests.

# 1. Introduction

The concept of social responsibility is changing, evolving, and continues to be the subject of public debate. With its original approach, it indicated the obligations that entrepreneurs have towards society. Bowen (1953), considered to be the father of this concept, defined corporate social responsibility as "the obligation to pursue policies, make decisions, and implement actions that are consistent with social expectations". Furthermore, Carroll (1979) introduced four types of corporate responsibility: economic, legal, ethical, and philanthropic, indicating that they are at different levels and that the enterprise should approach them in the right order.

Nowadays, due to the development of the sustainability concept, CSR is considered a management strategy, according to which enterprises voluntarily take into account social interests, environmental aspects, or relations with various stakeholder groups in their operations (Ehnert et al., 2014). Stakeholder theory states that stakeholders are groups or individuals who can influence or be influenced by an organization's objectives. It is well known that employees are one of the most important stakeholders of an organization. Employees play a key role in the success or failure of an enterprise (Freeman, 1984; Tahlil Azim, 2016; Tewari, Nambudiri, 2012).

In a study by Voegtlin and Greenwood (2016), the researchers found that the most recent attention to employee-focused CSR and various ethical aspects of HRM is paralleled by an increasing focus on the aspects of research and practice in the context of linking corporate social responsibility and human resource management. The authors made reference to papers published by Cooke and He (2010) and Morgenson et al. (2013). The concept of socially responsible HRM (SRHRM) emerged as an element of CSR focused on the inside of the company (its employees treated as the most important stakeholders).

Surveys devoted to the implementation of the concept of corporate social responsibility are carried out mainly among employees who are citizens of the country where the enterprise surveyed is headquartered (Celma et al., 2018; López-Fernández et al., 2018). Within international HRM, the focus is on cultural diversity management (e.g. (Hite, Mc Donald, 2006; Subeliani, Tsogas, 2005; Maxwell et al., 2003)) and typologies of international HRM strategies including the choice between regional and global practices (e.g (Edwards, Jalette, Tregaskis, 2012; Chiang, Lemański, Birtch, 2017)) and expatriates adjustment (Selmer, 2004). The issue of migration is discussed rather from the perspective of such academic disciplines as economics and sociology than the discipline of human resource management. Migration is often associated

with precarious employment (Deshingkar, 2019; McDowell et al., 2009; Muoka, Lhussier, 2019; Nedelcu, Soysüren, 2020; Ornek et al., 2020; Piwowar-Sulej, Bąk-Grabowska, 2020; Polkowska, 2019).

At this point, it is worth emphasizing that labor migration is usually considered an important type of migration flow. However, with advances that make it easier, faster, and cheaper to move around the globe, it is becoming more and more important (Hatton, Williamson, 2005). The major migration flows occur from developing towards industrialized countries (International Organization for Migration, 2008).

The main assumption in this study is that migrant workers are, similar to other groups of employees, internal company stakeholders. This study aims to fill the gap in research on SRHRM through examining the HRM practices in the context of migrant workers with a focus on employee interests. For the purpose of this paper, such methods as literature survey of publications indexed mainly in Scopus database and empirical research in the form of a survey were used. The survey was carried out in 2020 in Poland and the respondents were Ukrainian workers. The following two main research questions were addressed in the course of the analyses:

1) Which employees' interests are the most important for migrant workers?
2) To what extent companies ensure the interests of migrant workers?

As indicated above, migration is often associated with precarious employment. Therefore the problems of the relationship between the form of employment and the interests of migrants were examined as well.

The NBP reports published between 2015 and 2017 showed that around 507,000 Ukrainian citizens arrived to Poland to look for jobs. There were 303,000 Ukrainian labour migrants who lived in Poland in the first half of 2017, with 285,600 people employed as short-term employees and 17,400 of those who worked based on the long-term contracts (National Bank of Poland, 2016). The Ukrainian population is gradually growing in Poland. This results from the armed conflict and the difficult economic situation in Ukraine.

Employees from Ukraine bridge the gap which employers are unable to fill with employees from Poland. The Polish labor market is characterized by a low unemployment rate. Furthermore, the economic emigration of Poles is also observed. Finally, a factor that will increasingly restrict employers' access to the labor force in the coming years is the progressing demographic changes. It is believed that it is worth employing Ukrainians because of their strong financial motivation to work, linguistic and cultural proximity, the flexibility of forms of employment, and simplified rules of employment (Brasco Recruitment, 2019).

The research process was conducted according to the research design that included such stages as the formulation of the research problem, the definition of the study aim, choice of research methods, development of research tools, conducting empirical studies, analysis of the collected data and information, and preparation of conclusions.

The study is organized as follows. The second section presents the literature background. It discusses in particular the assumptions of SRHRM and previous research on migrant workers treated as company's stakeholders. The third section presents the research methodology. Then the authors describe the obtained results. In the Discussion section, the research findings in the context of studies conducted by other authors are analyzed. The last section presents key conclusions, limitations, and future research directions.

## 2. Material and methods

The research process was conducted according to the research design that included such stages as the formulation of the research problem, the definition of the study aim, choice of research methods, development of research tools, conducting empirical studies, analysis of the collected data and information, and preparation of conclusions. Therefore,

- the study was aimed to interpret and critically assess the previous scientific output devoted to the analysed issues,
- the results of own empirical research conducted in 2020 with employees from Ukraine employed in Poland.

Taking into account the importance that should be given nowadays to employee interests and respecting them in enterprises, and the transformations taking place in the enterprises, the empirical research focused on the identification of the interests of Ukrainian employees working in Poland and the approach to the realization of their interests.

The studies available in the literature were used to create a list of employee interests for the purposes of the research conducted by the authors of the present study. Reference was made to the statements that the essential expectations of employees include adequate remuneration, training and development opportunities, promotion opportunities, good occupational safety and health, welfare, and quality of work life (Babalola Oluwayemi et al., 2018; Gableta, Bodak, 2014; Hai-dong, Yu-jun, 2006; Zhong et al., 2017). Therefore, the author's questionnaire for the recognition of interests of employees who are migrants from Ukraine was developed using, among others, the suggestions indicated by the above-mentioned authors, taking into account the changes in the economic reality. In developing the author's research survey, with the results presented in this paper, the questionnaire created by Cierniak-Emerych prepared for the research project on employee interests The Perspective of Employees and Employers, implemented in 2019 was also used.

The research was conducted using the PAPI technique. Pen-and-Paper Personal Interview (PAPI) is the most conventional research method among the quantitative techniques used. It consists of a face-to-face interview with the respondent by an interviewer who reads the question and records the respondent's answers on a paper questionnaire. This type of survey is considered to be one of the most effective methods as the respondent in a face-to-face situation feels more obliged to give a reliable answer.

The research covered a representative sample of Ukrainian migrants legally working in companies located in the area of Lower Silesia. As confirmed by the statistics of the Central Statistical Office and the Social Insurance Institution, Lower Silesia is considered a geographically significant area of labor immigration from Ukraine (more than 80% of foreigners in Lower Silesia are of Ukrainian origin (Relikowski, 2019)). A total of 391 respondents were surveyed. The sample was predominantly male (62.9%). More than 57% of the respondents declared an age of below 40 years. It was found that 54% of the respondents worked in Poland for 2 to 10 years. Furthermore, 40.4% declared that they performed work based on an employment contract for an indefinite period, and 21.2% worked based on a fixed-term employment contract. On the other hand, 17.9% indicated that they provided work based on a contract of mandate. It is worth mentioning that 64.7% of the respondents did not use employment agencies. Among the respondents, 38.4% were employed in manufacturing, 37.1% in services, and 24.6% in commerce. At the same time, 91.6% of respondents said they were employed in non-managerial positions.

The chi-square test was used. Due to the statistical character of the chi-square test, hypothesis $H_1$ is an alternative hypothesis, while hypothesis $H_0$ is a hypothesis of the absence of the relationships between the characteristics studied. The decision to accept or reject the hypothesis of the relationship between the characteristics will be made based on the criterion of comparing *p-value (pv)* with the assumed significance level $\alpha$. The *p-value* means the smallest value of the significance level $\alpha$ at which the hypothesis $H_0$ is rejected, meaning the acceptance of the hypothesis $H_1$. The significance level $\alpha$ is the probability of making an error of the first kind, that is, rejecting the hypothesis $H_0$ when actually it is true. If *pv$\leq \alpha$,* the hypothesis $H_0$ is rejected. In other cases, there are no grounds for rejecting the hypothesis (Ferguson, Takane, 2003).

## 3. Literature background. CSR – SRHRM – migrants as enterprise's internal stakeholders

Ehnert, Harry and Zink (2014) argued that the Brundtland Commission, which highlighted first of all environmental goals, attracted substantial interest in the concepts of corporate responsibility, such as corporate social responsibility (CSR), and corporate social performance (CSP). According to the former concept (CSR), the organization's responsibilities can be divided into legal, economic, ethical, and philanthropic. On the other hand, the CSP concept extends CSR as it emphasizes that the organization can influence the social sphere and it assesses performance by measuring social goals in the organization" (Kramar, 2014, p. 3).

On 28 October 2010, the International Organization for Standardization (ISO), after more than 5 years of work by experts from 99 countries, published the ISO 26000 standard. This standard is intended to organize the knowledge of corporate social responsibility (CSR). ISO 26000 does not have a form of certification. Instead, it is a practical guide to the principles of responsible business, containing guidelines for organizations of all types (not only enterprises), regardless of their size or location. The ISO 26000 standard highlights the following areas of corporate social responsibility: (1) organizational governance, (2) human rights, (3) labor practices, (4) environment, (5) fair operating practices, (6) consumer issues, and (7) community involvement (Idowu et al., 2019).

Based on the above considerations, it should be concluded that being socially responsible means investing in human resources, environmental protection, relations with the company's environment, and informing about these activities, which contributes to the growth of the company's competitiveness and providing conditions for sustainable social and economic development (Piwowar-Sulej, 2021).

Albdour and Altarawneh (2012) and Glavas (2016) confirmed that CSR practices employed in the enterprise have a significant positive impact on employee engagement. As (Grego-Planer, 2019) stated, researchers are increasingly focusing on individual-level CSR by assuming that employee behavior is a crucial factor in transforming CSR into beneficial organizational outcomes. The researchers used the social exchange theory: if organizations introduce CSR, employees feel that they are important and they are proud of working for the enterprise, which contributes to solving global social problems. However, the employees should be first of all treated in a socially-responsible way.

Zaugg, Blum and Thom defined SRHRM using a set of elements of the HR function. According to these authors, this type of sustainable HRM includes „the long-term socially and economically efficient recruitment, development, retainment, and disemployment of employees" (Zaugg et al., 2001, p. II). The indicated HRM elements should be shaped taking into account the principles of transparency, non-discrimination, objectivity, and justice (Diaz-Carrion et al., 2018). Furthermore, Shen and Zhu (2011) distinguished between three

fundamentals of a SRHRM system: legal compliance related to labor law (ensuring equity, health and safety), employee-oriented HRM (fulfilling employees' needs), and HRM activities which help firms to engage in general CSR initiatives.

It should be stressed that Matthews and Muller-Camen's (2019) organizational perspective of SRHRM can be considered as of inside-out nature. According to this perspective, the organization defines economic and social goals (with the latter serving the former). It is aimed to minimize business risk and maximize shareholder value.

Fulfilling the employees' needs, which is one of the principles of SRHRM, requires treating employees as stakeholders who have a voice, and introducing employee participation. The literature points to the significant relationship between employee participation, or their participation in decision-making in the enterprise and job satisfaction, a sense of fulfillment, and meeting their interests related to work in a particular enterprise (Segalla, 2001). At the same time, it is emphasized that participation considered in the context of CSR can contribute to building a psychological bond between employers and their employees (Chen, Hung-Baesecke, 2014; Hansen et al., 2011; Im et al., 2016). Employees ignored in the decision-making process, not participating in the life of the organization, not included in the introduced organizational changes, and treated only as individuals performing the assignments, will fail to contribute significantly to the development of the organization and the realization of its goals. However, this does not mean that employees always want to participate in decision-making. Against this background, to be a socially responsible employer, it is first and foremost necessary to recognize employee interests.

The authors of the current study have searched for scientific and co-reference articles related to the discussed issues in the Scopus database. As part of the search strategy, phrases that were considered relevant from the point of view of the problems addressed in the paper were entered in the field "Article title, Abstract, Keywords". The search was then narrowed down to business, management, and accounting disciplines.

Analysis of the results showed that there are many publications devoted to "stakeholders" (36149). A similarly popular issue is "migrants" as such (3220). However, the most important phrase, i.e. "socially responsible HRM and migrants", yielded no results.

An in-depth analysis of the publications indexed as the most popular ones was also carried out. None of them directly addressed the issues raised in this paper. For example, papers on migrants' interests in enterprises have addressed problems related to:

- assessing progress in the research and practice of migrant entrepreneurship (Ram et al., 2017),
- the analysis of the use of illegal immigrant labor in small businesses (Jones et al., 2006),
- the review of experiences and findings from the assessment of migration impact around the world (Kourtit, Nijkamp, 2011),
- trends and changes that have taken place in recent years in the area of widely understood work (Zhang et al., 2010).

Furthermore, publications on human resources management discuss HRM practices in various countries (China: (Zhang et al., 2010); Dubai: (Connell, Burgess, 2013); Australia: (Cameron, Harrison, 2013); Japan: (Morita, Doja, 2018)), analyze the level and causes of employee absenteeism (Hopkins et al., 2016; Srour et al., 2017), and discuss the problems of migrants' qualifications (Bahn, 2014, 2015; Cameron, Harrison, 2013; Crowley-Henry, Al Ariss, 2018; Forde, MacKenzie, 2009; Mahadevan, Kilian-Yasin, 2017; Wright and Constantin, 2020). The papers have predominantly explored the employers' perspective. If research includes workers' preferences, it focuses on the reasons for migration in the context of professional careers (Joy et al., 2020).

Papers on "migrant and expectations" address issues (directly and indirectly) related to, among others:

- the effect of expectations of migrants on their migration decisions (Hoppe, Fujishiro, 2015; Jasinskaja-Lahti, Yijälä, 2011; Milasi, 2020; Shrestha, 2020),
- different expectations of migrants (Hennekam et al., 2020) including, for example, those concerning salaries in the case of illegal migration (Hoxhaj, 2015),
- cultural differences (Lu, Samaratunge, 2016; Park et al., 2017).

The literature review conducted in this study revealed that the corporate responsibility towards migrants and the recognition of their interests to adapt HRM policies and practices is an area that has not been analyzed to date. It represents a research gap identified based on the literature analysis.

## 4. Results

In seeking to answer the research questions, Fig. 1 shows the distribution of respondents' answers to the question of how important each job interest is to them. As can be seen from the information contained in Figure 1, the most important thing for the respondents surveyed is to be paid salaries adequate for the duties (Figure 1). This is evidenced by the total percentage of affirmative responses of 86.4%. Furthermore, as respondents provided answers on a scale from 1 to 5, with 1 meaning that the element was unimportant at all and 5 meaning that it was very important, it is worth emphasizing that the obtained mean score was 4.42, with the standard deviation of 0.85. This means that the values of the assessment of the importance of the analyzed element deviate from the arithmetic mean only by +/- 0.852 (Table 1). This means that theoretically, the values of the variable do not deviate from the mean significantly. The importance of this element is also demonstrated by the mode value, i.e. the most frequently indicated answer. This is because a mode value of 5 was reported.

Among the most important respondents' interests related to their work was the need to ensure good occupational safety and health (Fig. 1). This is evidenced both by the value of the obtained mean, which was 4.12, and the total percentage of affirmative answers (80.0%) (Table 1). Compared to the previously analyzed element, standard deviation is slightly higher, which leads to the conclusion that the values of a specific variable deviate slightly more from the mean. In third place was the need to provide employees with clear criteria for the evaluation of task performance. A total of 78.0% of the respondents considered this element as very or rather important, which was also reflected in the mean, which in this case was 4.06. The given values towards a particular variable deviate at most by +/- 0.996, which means that although the mean score was 4.06, it theoretically can deviate up to from 3.06 to 5.06 (Fig. 1, Table 1).

The least number of people considered the occurrence of participation in management (empowerment) as an important element among their interests related to work: 56.5% of respondents answered "not important at all" or "rather unimportant". The mean score was only 2.40, which is the lowest score among all analysed elements. The standard deviation slightly exceeds 1, so it can be considered that the values of the variable do not deviate too much from the mean. Poor scores were also recorded for participation in management (co-deciding), with 49.6% of responses that stated unimportance of this element. The mean is higher than the previously analysed aspect by only 0.24 pps while the standard deviation at 1.222. Only slightly more respondents considered trade union assistance as an important issue: a total of 42.0% of respondents described this element as not important at all or rather unimportant. The mean score for this element was 2.85, while the values deviate from this mean by 1.361 (Fig. 1, Table 1).
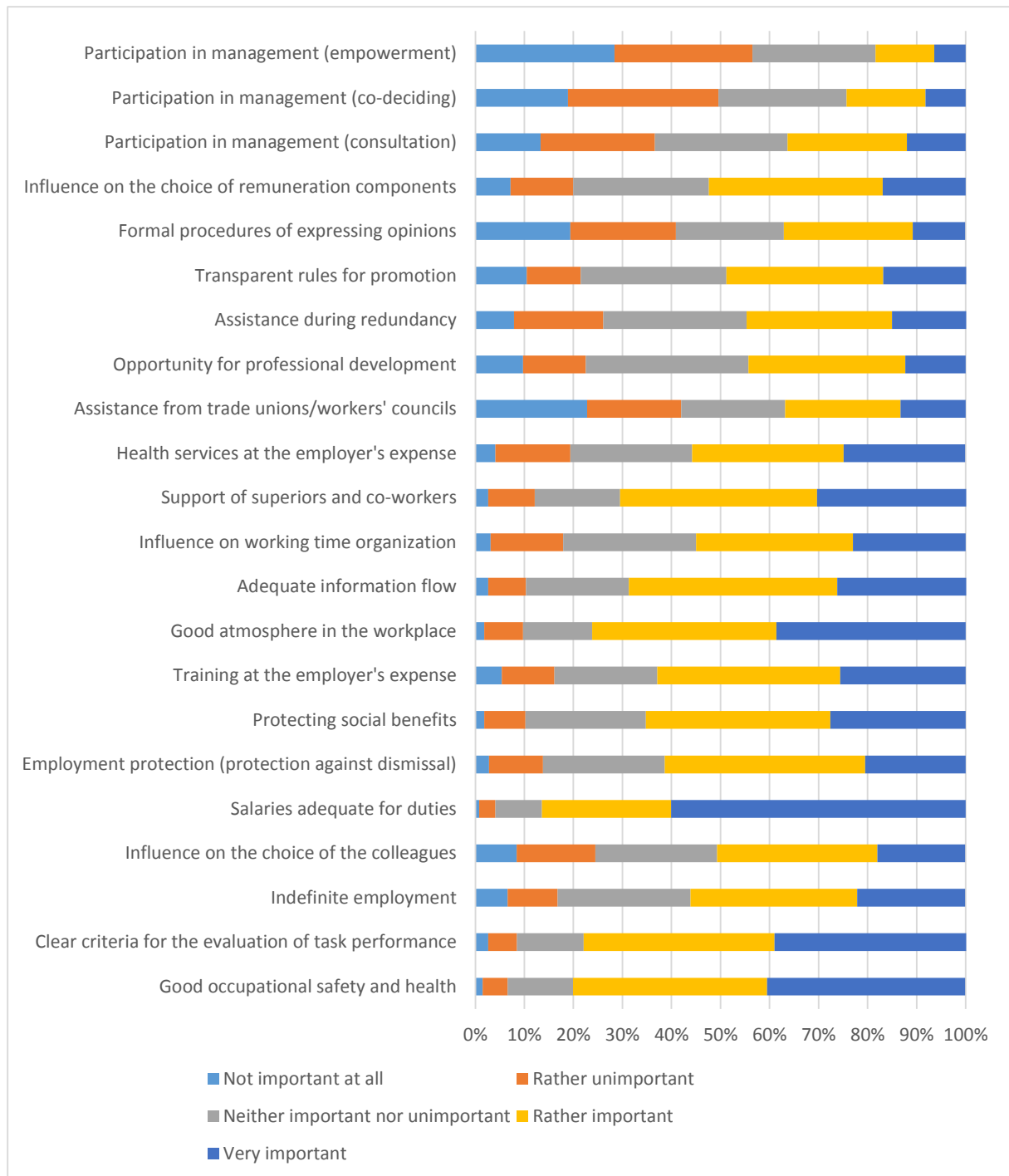
**Figure 1.** Hierarchy of interests of respondents

**Table 1.**

*Statistical measurement (statistical parameters from the sample) of employee interests*

|  | Mean | Median | Mode | Standard deviation | Skewness |
|---|---|---|---|---|---|
| Good occupational safety and health | 4.12 | 4.0 | 5 | 0.931 | -1.090 |
| Clear criteria for the evaluation of task performance | 4.06 | 4.0 | 5 | 0.996 | -1.111 |
| Indefinite employment | 3.54 | 4.0 | 4 | 1.138 | -0.552 |
| Influence on the choice of the colleagues | 3.36 | 4.0 | 4 | 1.191 | -0.376 |
| Salaries adequate for duties | 4.42 | 5.0 | 5 | 0.852 | -1.539 |
| Employment protection (protection against dismissal) | 3.65 | 4.0 | 4 | 1.014 | -0.553 |
| Protecting social benefits | 3.81 | 4.0 | 4 | 0.993 | -0.571 |
| Training at the employer's expense | 3.67 | 4.0 | 4 | 1.128 | -0.681 |
| Good atmosphere in the workplace | 4.03 | 4.0 | 5 | 1.003 | -0.970 |
| Adequate information flow | 3.82 | 4.0 | 4 | 0.991 | -0.753 |
| Influence on working time organization | 3.57 | 4.0 | 4 | 1.091 | -0.348 |
| Support of superiors and co-workers | 3.86 | 4.0 | 4 | 1.035 | -0.800 |
| Health services at the employer's expense | 3.57 | 4.0 | 4 | 1.139 | -0.400 |
| Assistance from trade unions/workers' councils | 2.85 | 3.0 | 4 | 1.361 | 0.39 |
| Opportunity for professional development | 3.24 | 3.0 | 3 | 1.128 | -0.381 |
| Assistance during redundancy | 3.26 | 3.0 | 4 | 1.156 | -0.236 |
| Transparent rules for promotion | 3.34 | 3.0 | 4 | 1.189 | -0.447 |
| Formal procedures of expressing opinions | 2.87 | 3.0 | 4 | 1.294 | -0.008 |
| Influence on the choice of remuneration components | 3.42 | 4.0 | 4 | 1.127 | -0.474 |
| Participation in management (consultation) | 2.98 | 3.0 | 3 | 1.222 | -0.13 |
| Participation in management (co-deciding) | 2.64 | 3.0 | 2 | 1.194 | 0.344 |
| Participation in management (empowerment) | 2.40 | 2.0 | 1 | 1.198 | 0.514 |

Participation in the form of consultation appeared to be the most desirable element in terms of participation in management. However, the percentage of statements confirming the necessity of ensuring this participation did not exceed 40.0%, which rather puts this element at the end of the list of elements important to the employees surveyed.

Bearing the above in mind, the respondents were also asked to indicate the interests which, in their opinion, the employers pursue (respect). The results of the survey summarized in Fig. 2 show that more than 81% of respondents stated that the employer provides them with good occupational safety and health and 77% stated that the employer provides them with clear criteria for task performance. Therefore it can be assumed that employers pursue two interests from among those identified as most important by Ukrainian employees. However, the situation is different in terms of the interest defined as salaries adequate for duties. Only 66% of the respondents declare that this interest, as mentioned above, considered as the second most important in the hierarchy of interests of Ukrainian employees, is respected by the employers.
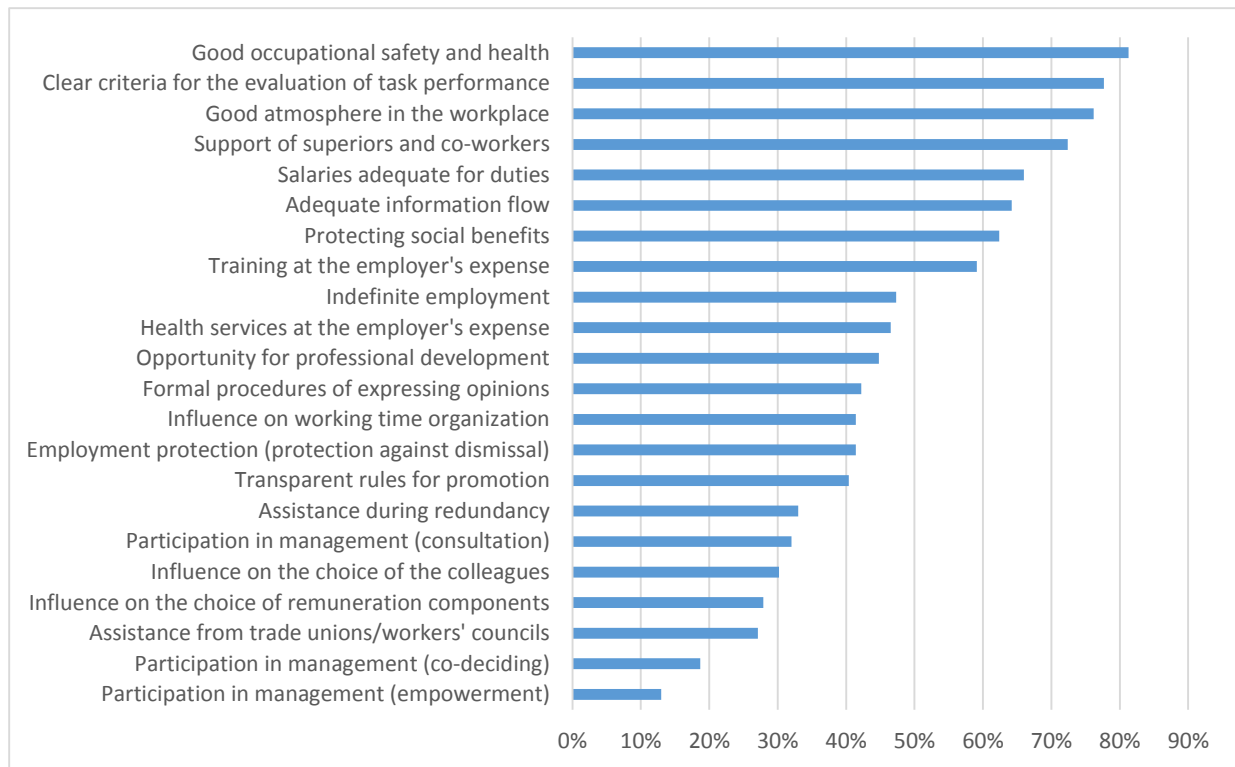
**Figure 2.** Employee interests respected by employers: employees' opinions.

The results of empirical research also indicate that in the opinion of employees, the interests related to employee participation are respected to the least extent. Meeting the interest defined as participation in management (empowerment) was indicated by 13% of respondents, participation in management (co-deciding) by 18.7% of respondents, and assistance of trade unions by 27.1%. It should be recalled that employee interests related to participation were ranked by the respondents as lowest in the hierarchy of their interests.

The research also sought answers to questions about the relationship between employee interests respected in the enterprise and the form in which the employees are employed. The verification of this position seems to be particularly important due to the assumptions formulated in the related literature that the lack of choice of the form of employment coexists with lower quality of jobs, working conditions, and a lower level of meeting employee interests.

In the research results presented here, attention was focused on determining the indicated relationships regarding three of the employee interests, which in their opinion are respected to the greatest extent in the enterprise, i.e. meeting the interest which the respondents assessed the highest. As stated above, these are:

- good occupational safety and health,
- clear criteria for task performance,
- good atmosphere in the workplace.

In terms of respecting employee interest of good occupational safety and health in hypothesis H1, it was assumed that meeting the respondents' interest depends on the form of employment. To verify the hypothesis, the chi-square test of independence was performed and a $pv = 0.069$ was obtained. Assuming the significance level of $\alpha = 0.05$, the inequality

of $pv > \alpha$ occurs, which means that there are no grounds to reject the hypothesis H0. Therefore, with a significance level of $\alpha = 0.05$, it can be concluded that meeting the interest of good occupational safety and health does not depend on the form of employment.

Furthermore, the same procedure as described above was carried out with regard to respecting the interest of clear criteria for task performance. The value of $pv = 0.198$ was obtained, which means that meeting the interest of clear criteria for task performance does not depend on the form of employment.

With regard to respecting the interest of a good atmosphere in the workplace, a value of $pv = 0.012$ was obtained. Therefore, it can be concluded that meeting the interest of a good atmosphere in the workplace depends on the form of employment.


## 5. Discussion


The empirical survey carried out in the study showed that the three most important interests expected to be met in the enterprise are salaries adequate for the duties, good occupational safety and health, and clear criteria for task performance. The least number of people considered the use of participation in management as an important interest. This shows that the most important thing for migrants is to ensure their basic needs in Maslow's classification and the findings are consistent with the reasons why migrants decide to work abroad (Ukhova, 2018).

Considering adequate salaries as the most important interest for workers seems obvious. On the one hand, many studies have shown that among the expectations related to work, employees indicate first and foremost a satisfactory remuneration. Adequately paid work is important to the quality of life because it provides a source of income and identity (Stiglitz et al., 2010). The workplace provides opportunities for personal development and socializing. At the same time, looking at this issue from the perspective of migration, research also confirms that the reasons for migration from Ukraine, especially after 2014, included political situation and fear of armed actions, and also those of economic nature. For example, according to the Gorshenin Institute, more than 40% of economically active Ukrainians aged 18 to 29 were willing to leave Ukraine for more rewarding jobs and career opportunities (Ukhova, 2018).

Similarly, considering the interest in good occupational safety and health as very important seems to be fully justified. Many studies emphasize that a person can work in any conditions, but the work can be performed effectively while maintaining good health only if working conditions do not threaten health and life. The problem of providing safe and healthy working conditions is also considered to be one of the key areas and manifestations of socially responsible behavior in the enterprise and, more broadly, the concept of CSR (Montero et al., 2009).

Against this background, it has been recently reported in the literature that in the destination countries, migrant workers are employed in low-skilled jobs and thus are often considered to be more exposed to unfavorable working conditions than native workers (Anderson, 2010; Benach et al., 2011; Tham, Fudge, 2019; van den Broek, Groutsis, 2017). It is also argued that greater difficulty in having previously acquired education and occupational safety training recognized in the host country and poor language skills may contribute to higher employment rates of immigrants in the most hazardous occupations in terms of working conditions (Rechel et al., 2013). Some studies have shown that migrant workers reported mostly greater exposure to poor material elements of working conditions (Ronda Pérez et al., 2012; Takala et al., 2014). At the same time, the literature points to the view that there is very limited overall evidence that migrant workers are more exposed to risks caused by material working conditions and poor psychosocial working conditions than natives in Europe and Canada. It is also emphasized, however, that the prevalence of bullying and perceived discrimination is consistently higher among migrant workers than among native workers. Migrant workers are more likely to suffer work-related injuries than natives. However, there is very limited evidence that working conditions are a potential variable in the relationship between immigration status and health outcomes (Sterud et al., 2018).

Given the above, it is particularly important that in our survey, respondents indicated that the interest in safe and healthy working conditions is respected by employers. Respect for this interest was placed at the top of the hierarchy of respondents' interests respected by employers. In a way, safe and healthy working conditions and respecting them are also connected to providing a good atmosphere in the workplace by employers, which was also assessed positively by the respondents, similarly to meeting the interest of clear criteria for task performance. At this point, it is worth noting that the research results show that neither the implementation of clear criteria for task performance nor good occupational safety and health depend on the form of employment. The latter is particularly important as the literature shows that migrant workers are less likely to be employed in indefinite employment than native workers (Sousa et al., 2010). At the same time, it is stated that reporting of poorer health related to, among other things, poorer health and safety in the workplace may involve the absence of an employment contract, e.g. for an indefinite period (Sousa et al., 2010). It is also worth noting that there are views in the literature that while migrant workers are generally at increased risk of occupational illness and injury, innovations in occupational health and safety have begun to mitigate some of these risks and reduce the disparity between migrant and native workers (De Jesus-Rivas et al., 2016). It can be assumed that clear ways of defining the scope of tasks and a good atmosphere in the workplace also contribute to this situation, which certainly requires socially responsible actions towards employees.

In discussing the results of our empirical research, some concerns may be raised by a small lack of interest of migrant workers in employee participation. At the same time, this participation is also considered to be an interest least respected by employers.

These concerns of the authors of this study are related to the fact that participation is commonly an important area of corporate social responsibility. Employee participation in decision-making processes (employee participation) is particularly important from the CSR perspective. The literature indicates that employee participation is likely to make CSR part of the organization through actions derived from organizational culture or values, rather than as a result of external pressure on employees (Chen, Hung-Baesecke, 2014). Furthermore, the effectiveness of CSR activities depends on the employee response to CSR, including their participation in these activities (Collier, Esteban, 2007).

Employers who wish to employ migrants should first take care of the above-mentioned interests to keep migrant workers motivated, i.e. salaries, health and safety, and clear criteria for task performance. The latter involves, among other things, the elimination of language barriers. The language barrier may be a reason for the low importance attached to participation. Understandably, an employee may not want to participate in decision-making processes regarding issues they do not understand.

The presented survey results also provide guidance to labor market institutions (e.g. employment agencies, training providers, employer supervision, and inspection bodies) and international organizations (e.g. Eurofound) dealing with the assessment of the quality of life and work. Training firms should provide training services for both employers and migrant workers. In reference to the interest of salaries, it is worth mentioning the need for a bank account. Knowledge in the field of financial institutions and in the field of health care in a given country (especially in terms of occupational medicine, which is closely related to OHS) are among the many areas in which there is a need for migrants' education. Control authorities should accurately monitor the working conditions of migrants. The present study may serve to develop international programs on the problems of work-life balance, including those promoting social dialogue.

# 6. Conclusions

This article presents SRHRM from a different standpoint than before. It stresses that migrant workers should be treated similarly to native workers as key internal stakeholders in the enterprise. The basis for the perception of employees as stakeholders is recognizing their needs and interests and then taking actions to satisfy them.

As shown in the paper, there is a lack of comprehensive research in the scientific literature on SRHRM in relation to migrant workers. The research presented in this paper fills the identified gap.

The research was conducted based on a representative sample and showed that migrant workers are mainly concerned with the satisfaction of basic needs related to remuneration and working conditions. A clear definition of the criteria for task performance is also an important interest. These are the three most important of the 22 interests. Of the interests studied, employee participation is the least important. At the same time, the research showed that employers are far more likely to meet the interest of good occupational safety and health and clear criteria for task performance than salaries adequate for duties. None of the most respected employees' interests depend on the form of employment.

This study has some limitations which can be overcome in further research. Firstly, the research was conducted in Poland. In future research projects, it is worth making international comparisons concerning the interests of the most represented nationalities of migrants as well as the interests of Ukrainians working in other countries.

Secondly, this research presents respondents' opinions. Their responses may have been influenced by factors such as fear of losing their job due to the lack of trust in the interviewer and experience in previous jobs (including their home country). Therefore, it is worth conducting in-depth interviews in the next research to provide more insights into the population studied.

Thirdly, although the research was based on a comprehensive list of interests, containing as many as 22 items, the terms used are general in nature. Future research can be focused on the identification of the components of individual interests. For example, occupational safety and health can be explored in terms of material and psychosocial factors.

Fourthly, the situation of migrants from Ukraine in Poland has changed a lot after February 24, 2022. Many refugees from Ukraine came to Poland because of the war that is going on there. This may have an impact on research findings. Consequently, the research is planned to be continued.

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# THE CRYPTOCURRENCY AML CHALLENGE – SANCTION 2022 NEW THREATS

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**Purpose:** Paper reviews changes taking place in the cryptocurrency market after the introduction of further sanctions on the Russian financial market. The author notes that cryptocurrencies are used more and more often by companies operating in Russia. The cryptocurrency market remains largely beyond control despite the AML area. It is a source of many threats of money laundering. The paper recapitulates the status of the global trade market choosing settlement cryptocurrency in the context of anti-money laundering.
**Methodology:** The analysis was based on reports on the market quotation of popular cryptocurrencies.
**Findings:** The paper includes definitions of new challenges for AML areas.
**Practical implications:** (if applicable) What outcomes and implications for practice, applications and consequences are identified? How will the research impact the business or enterprise? What changes to practice should be made as a result of this research? What is the commercial or economic impact? Not all papers will have practical implications.
**Social implications:** The application of the proposed solutions will improve the security systems of financial sector institutions.
**Originality/value:** The paper provides guidance on how to assess institutional capacity and support the anti-money laundering process.

**Keywords:** financial market, cryptocurrencies, AML.

**Category of the paper:** Viewpoint, conceptual paper.

## 1. Introduction

The harsh sanction imposed on Russian Federation after the attack on Ukraine and the resulting crash Russian international trade exchange has Russian companies scrambling to keep the financial liquidity running. At the outset, it is worth emphasizing that the assets of many companies are spread out among different coteries within the Russian establishment. There is a close link between security, political stability, and the economy. The current situation also poses a challenge to Kremlin.

It is reasonable to speculate that the Kremlin forces to move funds through smaller banks, transaction platforms and accounts of the elite not covered by sanctions, deal in cryptocurrency, and continue to deepen international cooperation with China. There are many uncertain factors in the cryptocurrency market. One of them is the geopolitical situation. Evidently, the market expects any new sanctions imposed on the Russian Federation may also affect on e-commerce area.

There are several ways to predict the cryptocurrency rate. Among these, we can mention, applying machine-learning algorithms, Bayesian probability, Bayesian linear regression, etc. (Shah et al., 2014, p. 409). This type of solution is perfect for sustainable and inclusive economic growth. The Russian invasion of Ukraine made the investment environment more uncertain.

The threat of uncontrolled cash flows may cause perturbations in global financial markets. The essence of cryptocurrencies is the mythical anonymity of their owners. The task of units responsible for counteracting money laundering is to identify the risk of using each means of payment in illegal practices. Central banks and financial supervision authorities perceive a threat to the stability of financial systems in trading cryptocurrency assets.

## 2. Legal status of cryptocurrency transactions

Nowadays cryptocurrency and other digital assets are considered to be a financial products. For this reason, authorities of states and international organizations introduce legal solutions. In 2015 Switzerland recognized the world's most popular cryptocurrency, bitcoin, as its currency. Thus, the purchase and sale transactions of Bitcoin in Switzerland were exempt from VAT (Wikarczyk, 2019, p. 154). This issue had not to be left without attention by the European Union institution because citizens of the European Union were actively investing in the Swiss cryptocurrency stock exchange. European Union law regulates the conditions for concluding transactions and strong consumer authentication. EU supervisors aim to propose for cryptocurrency service providers to collect information about transfers of cryptocurrency assets. It also allows supervisors to verify the correct application of Directive 2018/843 (AML V).

There is no single superior institution in the European Union responsible for monitoring cryptocurrency transactions. Regarding cryptocurrency transactions, every financial institution is obliged to comply with the standards set by the Financial Action Task Force (FATF). FATF is an international organization founded to combat money laundering. FATF issues recommendations or opinions on money laundering threats in the financial system. In 2014 FATF published a report *Virtual Currencies Key Definitions and Potential AML/CFT Risk* pointing following areas of cryptocurrency transactions threats:

1. high degree anonymity,
2. cross-border transactions and found transfers,
3. lack of central oversight.

All of the above-mentioned factors can facilitate the process of money laundering (FATF, 2014, pp. 9-14). Money laundering is the process of changing large amounts of money obtained from crimes into origination from a legitimate source. Money laundering also includes attempts to bypass sanctions on companies trading with Russia. Unfortunately, it is possible if cryptocurrency trading mechanisms are used.

From a technical point of view, the digital cryptocurrency system is entirely decentralized. It is based on peer-to-peer technology with no authorities oversight (Madam et al., 2015, p. 1). In turn, the common opinion cryptocurrencies are widely used for anonymous transactions. Each anonymous transaction carries a risk of money laundering.

Regulations and definitions of *anonymity* and status of cryptocurrency transactions used by local governments vary by country. The European Union Directive 2015/2366 (PSD2) defines the technical standards and authentication of transactions (applies to traditional transactions and third-party providers), in the United States federal law is open to interpretation for cryptocurrency status. It should be noted that in the United States, cryptocurrency transactions are a topic of anti-money laundering regulation depending on the person engaged in these activities (Holman et al., 2018, p. 28). Last year The People's Republic of China banned cryptocurrency trading and mining but Salvador adopt the most popular cryptocurrency Bitcoin as an official currency. In many respects, this is due to the difference of views of State authorities of various countries. In the European Union, the United States, Canada, Latin America States, Australia and New Zealand mining and trading of cryptocurrencies are legal. Depending on special circumstances, there may be certain conditions or limitations on the trading or mining of cryptocurrency. The November 2021 Library of Congress identified 42 countries, where are some restrictions on trading or mining cryptocurrencies and 9 which absolute bans on cryptocurrency transactions. Cryptocurrencies in Algeria, Bangladesh, China, Egypt, Iraq, Marocco, Nepal, Qatar, and Tunisia are prohibited (Regulation, 2021, p. 63). Interestingly, the status of cryptocurrencies in Ukraine and Russia was completely different before the war than it is today. The approach of both the Russians and Ukrainian authorities was very restrictive to cryptocurrencies. On 16 March 2022 Ukraine legalized the crypto sector by "On virtual assets Act". Russian Duma passed a bill to remove taxes on digital asset sales. Russia's Sber bank is preparing to launch a cryptocurrency provider platform and the Management othe f Russian Central Bank announcreatingeate the digital ruble (Anderesen, 2022).

One hypothesis suggests the idea behind cryptocurrencies was the creation of currency functioning outside of the main currency market. It is not surprising that exist some cryptocurrency exchanges that operate in countries that do not enforce anti-money laundering standards. When Russian troops invaded Ukraine, most of the West countries imposed

sanctions. All of the western financial institutions (banks, payments institutions, and payments systems like Visa or MasterCard) blocked service to Russian financial institutions. The cryptocurrency trading restrictions in Russia are introduced very slowly. Popular cryptocurrency exchange *Binance* curbed services in Russia.

Ongoing discussions about cryptocurrency and sanctions raise several legislative initiatives. The most important is the project of *Potential sanctions Evasion with cryptocurrency* with was reported in American Congress in May 2022. Some members of Congress have expressed concern that sanctions may be bypassed by cryptocurrency transactions (Busch et al., 2022, p. 1). According to the U.S. Secretary of Treasury Janet Yellen Russian "sanctions, evasion using cryptocurrency exchange has likely been limited in scale". It is worth asking what it really means and how it is possible that The Congress of the United States consider additional oversight to a global cryptocurrency exchange. It is a lot of doubt, but you can read about some proposals for new resolutions in the *Congressional Research Service*. Some of them assume increased supervision of cryptocurrency transactions in light of concerns about their use in evading sanctions by Russian business entitles (Busch et al., 2022, p. 3).

In March 2022, the governments of Western countries considered an attempt to bypass the sanctions Russian suggestions of using payments for gas and oil contracts in cryptocurrencies for settlements. On March 11th Ukrainian vice-Prime Minister Mykahailo Fedorov urged crypto coins companies to stop all dealing with Russians. The concerns and appeals of the Ukrainian authorities in this matter may suggest that it would indeed be possible to use cryptocurrencies in inter-state settlements.

The new legal status of cryptocurrencies is a response to the new threats arising from the use of this market. At the same time, it is part of the progressive deglobalization process. Russia's exclusion from the international system SWIFT resulted in the adoption of new transaction solutions used by that country. The question is whether the international trading partners of Russian companies use cryptocurrencies in their settlements?

## 3. Analysis – cryptocurrency fluctuation rate

The most effective method of examining the effect of economic sanctions imposed on the Russian Federation on the cryptocurrency market is to compare the values of the most popular cryptocurrencies with the dates of sanctions imposed by Western countries.

**Table 1.**

*The impact of sanctions on the cryptocurrency rate*

| The Sanctions timeline | Entity introducing sanctions | Cryptocurrency (closing rate in USD) | | |
|---|---|---|---|---|
| | | Bitcoin | Ethereum | Tether |
| February 22nd 2022 | USA | 38248,2 | 2569,19 | 1,0007 |
| February 23rd 2022 | Australia | 37224,6 | 2637,38 | 1,0006 |
| February 24th,2022 | UK | 38339,2 | 2596,52 | 1,0008 |
| February 24th,2022 | USA | 38339,2 | 2596,52 | 1,0008 |
| February 25th 2022 | EU | 39209,6 | 2767,53 | 1,0007 |
| February 28th,2022 | UK | 43188,2 | 2922,50 | 1,0003 |
| February 28th 2022 | EU | 43188,2 | 2922,50 | 1,0003 |
| March 1st 2022 | Canada | 44420,3 | 2975,81 | 1,0005 |
| March 2nd,2022 | SWIFT(*) | 43912,8 | 2947,14 | 1,0004 |
| March 2nd 2022 | EU | 43912,8 | 2947,14 | 1,0004 |
| March 2nd,2022 | USA | 43912,8 | 2947,14 | 1,0004 |
| March 9th 2022 | EU | 41929,0 | 2726,94 | 1,0004 |
| March 15th 2022 | EU | 39285,7 | 2617,43 | 1,0005 |
| April 8th, 2022 | EU | 42275,0 | 3193,93 | 1,0003 |
| April 15th 2022 | USA | 40560,0 | 3042,01 | 1,0002 |
| June 3rd 2022 | EU | 29700,9 | 1775,29 | 0,9994 |

The abbreviation used in the table: SWIFT – Society of Worldwide Interbank Financial Telecommunication.

Source: own studies based on cryptocurrency exchange investing.com.

Table 1 presents three cryptocurrencies important from the perspective of the theme area of the cryptocurrency market. Bitcoin is the most popular cryptocurrency in the World. Bitcoin's about 44% share of the market cap. Ethereum is considered a second-world cryptocurrency. Tether is a stablecoin cryptocurrency dependent on the USD exchange rate. Thether was very popular in Ukraine and Russian Federation before February 2022 (Salcedo, 2012, p. 18). As you can easily see, the erratic exchange rate fluctuations correspond with the introduction of sanctions. During the Covid-19 pandemic, bitcoin surged by 300% in 2020 in amid speculation (Asumandu et al., 2022, p. 1). Nowadays, the price of Bitcoin and other cryptocurrencies had been dropping, as a result of major turbulences in geopolitical situations for a few decades. There are several sources of this process: investors choose other assets including real estate, commodities and other financial derivatives, inflation after the Pandemic, increasing the interest rate in many countries, and unbound for participation in the issuance of treasury bonds. This could lead to the conclusion that investors look to alternative assets. Changes in the value of cryptocurrencies, especially at the turn of February and March, should be combined with attempts to find alternative payment methods in the ongoing deglobalization process. The current loss of value in the cryptocurrency market may be the result of the actions of Western financial supervision authorities. There is no need to have any particular knowledge of economics to be able to say with certainty that investors had tried to get out of the ruble after its devaluation after all the sanctions at the turn of February and March (Layócsa et al., 2022, p. 14). Then, on the other hand, some people used cryptocurrencies transaction to donate money to the Ukrainian authorities. This only a few factors to cryptocurrency prices.

### 3.1. The Global Cryptocurrency market

Over the past months, there has been visible depreciation in the value of the cryptocurrency market on exchanges registered in countries subject to the procedures of FATF. This depreciation is influenced by new bills in Western countries. It seems that Western countries' governments and Western Centrals banks will seek to reduce investor interest in the uncontrolled cryptocurrencies market.

**Table 2.**
*The market capitalization of cryptocurrencies*

| Month | Capitalization of cryptocurrencies (*) | |
|---|---|---|
| | 2021 | 2022 |
| January | no data | 1748709515429 |
| February | no data | 1907002943263 |
| March | no data | 2077441880313 |
| April | 2198493278845 | 1692783578175 |
| May | 1545927527216 | 1312526898752 |
| June | 1451160927970 | 862901100470 |
| July | 1646869293286 | no data |
| August | 2098985079356 | no data |
| September | 1929190389957 | no data |
| October | 2629910228133 | no data |
| November | 2626093789247 | no data |
| December | 2192936746699 | no data |

Capitalization of cryptocurrencies at the end of the month in USD.

Source: own studies based on cryptocurrency exchange investing.com.

In theory, it can be seen that the cryptocurrency market has depreciated so investors should lose interest in such transactions. It can be forgotten that international settlements by cryptocurrencies are still possible and transfers are made very quickly. The question is whether the Russian term "friendly countries" can also mean countries in whist Russian companies also make cryptocurrency transactions? This can be done in countries where both Russia and China are important parts of the economy or defense policy

### 3.2. Identification of new threats in the Anti-money laundering area

Cryptocurrency providers facilitate a quick exchange of one asset into another by orders on behalf of users. These transactions are difficult to trace. In practice, many providers do not use any KYC (Know Your Customer) procedure. KYC is a process that identifies a customer's activities and nature by verifying identity, suitability, and risks. Russia's exclusion from the international payment system has resulted in the creation of a new underground settlement system. The main task of the AML areas will be the identity verification of cryptocurrency investors. An important task will also be the introduction of legal solutions preventing the functioning in the Western world of assets dependent on political decisions made by-non democratic countries. Cryptocurrencies can be something of an economic weapon. From an economic point of view, without coverage, based solely on political guarantees.

It is necessary to implementation two solutions, in order to verify threats cryptocurrency frauds. The simplest is implementation to cryptocurrency markets of traditional methods of detecting fraud in interbank settlements. It can be simple demographic data (name, surname, identification number of the natural or legal person. In order to determine the beneficial owner of a given transaction. Correct indication of the beneficial owner may be difficult in the case of complicated settlements on the cryptocurrency exchange. It appears that in recognizing the threats of cryptocurrency frauds, the use of customer identification methods based on behavioral data might help. It can be assumed that a criminals using cryptocurrencies are apparent anonymity. For this reason it is better to try to identify suspicious behavior that can be linked to money laundering. On cryptocurrency exchanges, you can theoretically create an infinite number of user accounts and this carries the risk of using the *smurfing* – paying small amounts from many users, the funds posted from the account to the account are de facto to be on the account of one user, the real beneficiary. Another threat that AML teams must pay attention to is *transferpricing*, overstating or underestimating the value of given assets during the transaction. A sudden change in the value of an asset is always suspect. Especially suspicious transactions should be compared in terms of time with the introduced sanctions because cryptocurrencies are the weakest link in the global settlement system.

## 4. Conclusions

The relationship between the value of the leading cryptocurrencies and the geopolitical situation is obvious (Aysan et al. 2019, p. 516). Counteracting dirty money laundering via cryptocurrencies is an element of the security system of the Western world. Western countries likely have to introduce a cryptocurrency controlled by central banks. Already in 2020, the European Central Bank (EBC) was working on the introduction of the cryptocurrency version of the euro. This project was resumed and now is being run by EBC (Panetta, 2022). Therefore, the most dangerous threat to cryptocurrency transactions – the anonymity of users will disappear. The European Central Bank will have access to the data of users.

However, pending the implementation of these solutions Western financial systems will have to contend with threats of the flow from uncontrolled cryptocurrency exchanges to the traditional currency markets. A sudden inflow of financial resources may even lead to speculation with the less significant traditional currencies and increase inflationary factors.

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# THE DIFFICULTIES IN ENSURING JUSTICE IN TEMPORARY TEAMS – MANAGERS' PERSPECTIVE

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**Purpose:** The paper aims to assess difficulties in ensuring justice in temporary teams. Three research questions were asked: do managers think that ensuring justice in temporary teams is difficult?; which determinants of a sense of justice in temporary teams do managers consider the most difficult/easiest?; is the degree of difficulty associated with ensuring each of the four types of justice in the work of the temporary team the same?

**Design/methodology/approach**: The survey was carried out in June and July of 2021. The non-parametric Mann-Whitney U test was used to assess the statistical significance of differences in the difficulty level in ensuring justice in temporary teams.

**Findings:** Managers ranked distributive justice as the most difficult to provide, followed by procedural justice, informational justice and interpersonal justice, respectively. Respondents ranked 4 factors as the most difficult to provide: the information needed for the work of the temporary team is provided just in time; each member of the temporary team is appreciated (tangibly and intangibly) according to their contribution to the team, the task team (as a whole) is appreciated, tangibly and intangibly, according to the effort put into the task and a temporary team leader will customize communication to suit the individual needs of members of the temporary team.

**Research limitations/implications**: The first limitation is related to the research sample. Entities from a few selected industries were included. The second limitation is related to the fact that temporary teams differ, and sometimes these differences are significant. Another limitation is the composition of the research group. It included managers. In order to fully recognize the situation, it would be necessary to know the opinions of other employees.

**Practical implications**: The results of the research may be helpful for managers in various types of organizations. They allow for a better understanding of temporary teams' regulations. In addition, they indicate those issues that should be given special attention in order to manage such teams reasonably.

**Originality/value**: Although the topic of teamwork appears in academic publications, only a few relate justice in temporary work teams. This paper deals with this topic and focuses on difficulties with fair team management.

**Keywords:** organizational justice, temporary teams, teamwork.

**Category of the paper:** Research paper.

# 1. Introduction

Implementing a triangle of economic, environmental and social viewpoints with ethical decisions on responsible corporate activity is one of the most crucial elements in contemporary entrepreneurship. As modern companies around the world experience challenges of sustainability (Santis, Albuquerque, Lizarelli, 2016), their leaders have been encouraged to have an ability to incorporate such strategies which could meet sustainable as well as profitable aims. Relating to issues such as climate change, pollution, depletion of natural resources, increase of human population and in general the threads of human existence, the issue of justice appears as an unquestionable foundation of sustainability to be investigated. Though the principles of justice applied to business activity have been often considered but in practice rather ignored. This might come out of the belief that business management at first should be more concerned about the evident efficiency and total value maximization. In fact, the organizations which have the ability and willingness to function upon sustainable value systems usually prioritize such elements as: reliability, credibility, honesty, satisfaction and relations with stakeholders. Sustainability in organizations requires axiologically oriented attitudes and skills of leadership. It seems crucial for achieving the so-called turning point when sustainable development is permanently employed in the company's business strategies.

Therefore, it should be pointed out that both business effectiveness and sustainability in organizations can be accomplished only on the basis of a mutual and solid grounded activity of a team working. Effective teamwork may bring many benefits to the organization (company) and individual employees (Lichtarski, 2011). This type of performing tasks seems more reasonable because it allows for achieving appointed goals without using extra time and energy. Working in a team also has a positive effect on the motivations of employees to perform their responsibilities. Additionally, based on just and fair principles, teamwork stimulates employees' creativity and strengthens their skill communications. Beyond that feeling, being treated just in a working team reduces stress and provides a sense of belongingness to a group.

On the other side, missing a sense of justice in a teamwork management may cause severe difficulties in achieving established goals. The members of a teamwork experiencing the lack of just principles usually lose their trust, commitment, improved jobs performance, satisfaction from citizenship behaviors, burnout, etc. Beyond that, the most common obstacles for just teamwork management are often connected to poor communication, lack of a clear direction in

achieving goals, failure to develop critical competencies and behaviors, difficulties blending multiple personalities into a solid and unified team, etc.

The paper aims to assess difficulties in ensuring justice in temporary teams. Three research questions were asked:

1. Do managers think that ensuring justice in temporary teams is difficult?
2. Which determinants of a sense of justice in temporary teams do managers consider the most difficult/easiest?
3. Is the degree of difficulty associated with ensuring each of the four types of justice in the work of the temporary team the same?

For the survey the Colquitt scale was applied. It was built with 20 elements regarding four types of organizational justice (procedural, distributive, interpersonal, and informational). Furthermore, the non-parametric Mann-Whitney U test was used to assess the statistical significance of differences in the difficulty level in ensuring justice in temporary teams. The study included respondents (managers) having practical experiences with the functioning of temporary teams. They represented automotive, optics, biotechnology, electronics, IT, aerospace, and pharmaceutical companies.


## 2. Literature review


### 2.1. Justice

Any attempt to conceptualize the concept of justice undoubtedly faces numerous definitional problems. Nevertheless, it also shows the complexity of this issue, placing it next to fundamental problems for the functioning of the social world, such as goodness, truth, beauty, law or happiness (Zimmermann-Pepol, Gregorczuk, 2016). Plato relates the concept of justice to both the individual and social (state) spheres. In the first, individual sense, he regarded justice as a superior virtue among the three other subordinate cardinal virtues, i.e., wisdom, bravery and prudence. In the second case, justice was the basis for maintaining social (state) order. It became apparent when the individuals who made up the state fulfilled the duties that belonged to their state in accordance with their innate or acquired abilities. In addition to understanding justice as an individual ethical (cardinal) virtue, Aristoteles, the Stagirite distinguished between distributive justice, referring to the distribution of economic goods, honors and other things subject to distribution among the participants of the state community, and compensatory justice (Galewicz, 2017). In the late 1970s, the concept of justice was proposed by John Rawls (1994). In his view, a just political system should first ensure two values that are inalienable to human life, namely freedom and equality. Rawls understands justice in a general sense as follows: "All of society's values - freedom, opportunity, income and wealth, and the basics of self-respect - are to be distributed equally, unless an unequal distribution of any, or all, of these values

benefits everyone" (Rawls, 1994). In philosophical thought, throughout its various periods, justice has been variously defined as: a moral virtue (ideal) or social value, duty or obligation, an element of natural law, a guarantor of individual freedom and equality, and an expression of concern for the common good. Justice can also be linked to the currently dominant development concept of sustainable development. Among the Sustainable Development Goals, Goal 16 is called Peace, Justice and Strong Institutions. Its achievement is to be achieved by promoting a peaceful and inclusive society, ensuring access to justice for all, and building inclusive, effective and accountable institutions at all levels.

### 2.2. Organizational justice

Organizational justice is most often characterized by expectations of proper treatment, distribution of responsibilities, assignment of tasks, evaluation, redress of grievances, etc. The literature usually distinguishes three types of organizational justice: distributive, procedural and interactional. (Saunders, Thornhill, 2004; Macko, 2009). Distributive justice manifests itself in the sense of balance in the distribution of rewards and bonuses resulting from a comparison of individual effort or invested resources with the effort or resources of others. Procedural justice refers to the belief that valuing an organization as fair or unfair cannot be done based on principles of distributive justice (even if all individuals feel the distribution of goods is fair). In the case of procedural justice, the principles (procedures) of distribution will be taken into account more than the distribution itself. Interactional justice is concerned with the direct relations between the various organizational stakeholders (Saunders, Thornhill, 2004). With the above typology in mind, the punitive nature of organizational justice is also taken into account. It closely connects with the idea of repairing the wrongs done, that is, restoring the original situation and rebuilding the balance shattered by unjust actions (Macko, 2009). Temporary teams can also be referred to as task forces (Lichtarski, 2011). Several scientific studies have shown that fairness has a positive impact on employees. If an employee feels that he or she is treated appropriately (i.e., fairly) in the organization, satisfaction, commitment and trust in superiors increase. In turn, the tendency to engage in counterproductive behavior decreases (Komari, Sulistiowati, 2020; Mendryk, Rakowska, 2017; Ngeleshi, Dominic, 2020; O'Connor, Crowley-Henry, 2019; Wei, 2020).

### 2.3. Temporary teams

Temporary teams are teams set up for a specific period in an organization. They are a solution to increase the flexibility of the organization. They are also often referred to as task or project teams. These teams are established in the organization's structures for the duration of performing specific tasks, carrying out clearly defined undertakings (projects), or solving specific problems (Bielski, 2001; Bieniok, Rokita, 1984; Mankin et.al., 1996; Pawlak, 2006; Robbins, DeCenzo, 2002; Stoner, Wankel, 1986; Tannenbaum et al., 2012). As a rule, the tasks and problems faced by temporary teams are of a one-time (unique) nature, are unrelated to the organization's routine activities and require the team to possess specific skills. It is in such

situations that temporary teams show the greatest usefulness while at the same time giving way to traditional (functional) teams in situations where it is possible to specialize, use the effect of experience and standardize activities (Saunders, Ahuja, 2006). The establishment of temporary teams in organizations is part of the broad trend of projectification. (Lundin et. al., 2015; Maylor, Turkulainen, 2019), observed in the management practice of business organizations, the public sector, and everyday life. From the point of view of individual individuals involved in the work of temporary teams, participation in them usually increases the number of duties carried out and the so-called plural affiliation (Schad et. al., 2006; Smith, Lewis, 2011). The advantages and weaknesses of the operation of temporary teams can be analyzed from the point of view of the organization, the team and the individual. From the organization's point of view, the biggest advantage is that the temporary team allows for greater flexibility in the organizational structure and provides a vehicle for good cultural patterns and good practices. The weaknesses, however, are the problems of knowledge sharing and learning and the dispersion and impermanence of power. From the team's point of view, the advantage is the possibility of increasing its creativity and the possibility of including the best specialists and experts in the team. On the other hand, the weaknesses are the lack of standardized working methods, communication problems and a shortened team life cycle. From the individual's point of view, the advantage is the possibility of individual learning and development and the possibility of satisfying social needs and recognition. Weaknesses, on the other hand, will be the difficulty of reconciling daily responsibilities and team tasks, the problem of satisfying needs for security and stability, as well as tensions over belonging (Bielski, 2001; Jenny, 2007; Hopej, 2004, Lichtarski, 2007; Lock, 2014, Katzenbach, Smith, 2015).

## 3. Methods

### 3.1. Data collection

The study aimed to assess difficulties in ensuring justice in temporary teams. A relevant questionnaire was developed. Senior and middle managers from medium and large high-tech companies were surveyed. These included the electronics, automotive, biotechnology, IT, pharmaceutical, aerospace and optics industries. At the same time, there was a condition that the surveyed managers had to fulfill: the respondents had to have practical experience regarding the operations of temporary teams. The survey was carried out in June and July of 2021, and a sample was randomly selected.

A Computer-Assisted Telephone Interviewing technique was used to collect information. The sampling operator was the Bisnode database. Interviews with managers were conducted from Monday to Friday and the average completion time of the interviews was 9 minutes and 9 seconds.

### 3.2. Measures

The recognized and commonly used Colquitt scale was used to measure justice in temporary teams. Identified twenty elements relating to four types of justice:

- procedural,
- distributive,
- interpersonal,
- informational.

However, this scale, for this study, has been modified to consider the specificities of temporary teams. The modified scale is presented in Figure 1.

**Procedural justice**

1. Interim team rules give each employee the right to accept or decline an offer to work as a part of the temporary team
2. These rules enable each team member to express their views and feelings about the functioning of the team
3. These rules may be modified at the request of the members of the temporary team
4. These rules are not biased - they do not favour anyone and do not discriminate against anyone
5. These rules are consistently applied to each team member
6. These rules were established based on a thorough analysis reflecting the specifics of the temporary team
7. These rules allow team members to appeal against decisions made in or about the team's operation.
8. These rules are consistent with the ethical and moral norms adopted by the members of this team
9. These rules ensure that the task team can accomplish the task (by selecting appropriate personnel, availability of necessary resources, etc.).
10. These rules ensure a high probability that the decisions made by the team will be implemented

**Distributive justice**

11. The task team (as a whole) is appreciated, tangibly and intangibly, according to the effort put into the task
12. The task team (as a whole) is appreciated, tangibly and intangibly, in line with the results achieved
13. Each member of the temporary team is appreciated (tangibly and intangibly) according to their contribution to the team

**Interpersonal justice**

14. Relationships between all temporary team members are based on mutual respect (manifested by the lack of non-constructive criticism, malice, etc.)
15. Each participant in the temporary team is treated with respect by the leader of that team
16. Participation in the task force does not adversely affect how the employee is treated by both the manager and other employees in the organisational unit to which the employee is permanently assigned

**Informational justice**

17. The temporary team leader speaks honestly and openly with the team members
18. The rules governing the functioning of the temporary team are understood and fully communicated (and explained) to team members
19. The information needed for the work of the temporary team is provided just in time
20. A temporary team leader will customise communication to suit the individual needs of the members of a temporary team

**Figure 1.** Factors determining the sense of justice among temporary team members by type of justice.
Source: own elaboration.

The following rating scale was used to determine the extent to which each of the issues included in the table affects the effectiveness of the temporary team: 1 - "definitely not", 2 - "no", 3 - "rather not", 4 - "neither yes nor no", 5 - "rather yes", 6 - "yes", and 7 - "definitely yes".

### 3.3. Sample

The telephone interviews collected information from 110 respondents, of whom men predominated (71% of the sample size - see figure 2).
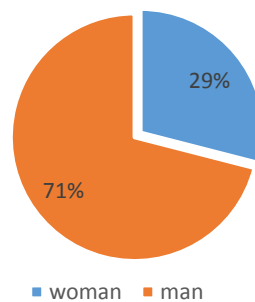


**Figure 2.** Distribution of respondents by gender.
Source: own elaboration.

The most significant number of responding managers were employed in the electronics (39%) and automotive (34%) industries (see figure 3).
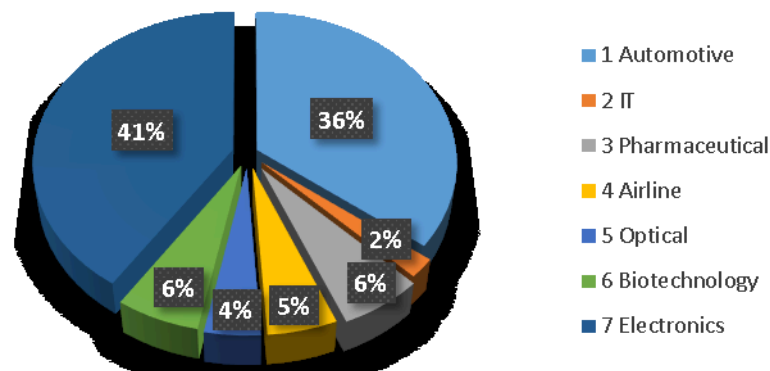


**Figure 3.** Distribution of respondents by industry represented.
Source: own elaboration.

87% of the respondents have participated in temporary teams in the last 2 years and 65% have led them. Among the respondents, managers working in a managerial position for 11 to 20 years (32%) predominated, followed by those working for 2 to 5 years (29%) (see figure 4). The smallest group consisted of those with seniority of up to 1 year (3%).
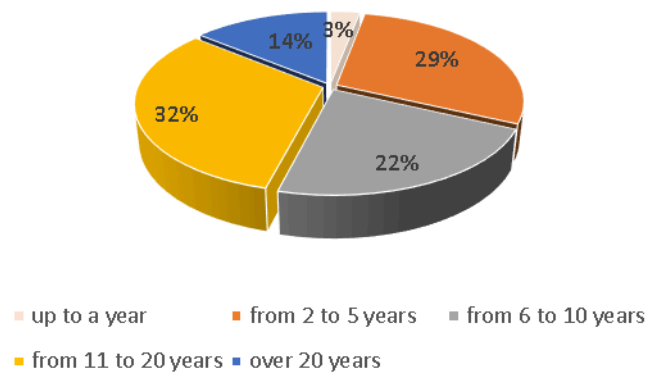
**Figure 4.** Distribution of respondents by length of service in a management position.

Source: own elaboration.

## 4. Results

In the study, one main hypothesis and six partial hypotheses were formulated as follows:

H: The difficulty in ensuring all kinds of justice (procedural, distributive, interpersonal and informational) in temporary teams is the same;

$H_1$: the difficulty in ensuring procedural and distributive justice in temporary teams is the same;

$H_2$: the difficulty in ensuring procedural and interpersonal justice in temporary teams is the same;

$H_3$: the difficulty in ensuring procedural and informational justice in temporary teams is the same;

$H_4$: the difficulty in ensuring distributive and interpersonal justice in temporary teams is the same;

$H_5$: the difficulty in ensuring distributive and informational justice in temporary teams is the same;

$H_6$: the difficulty in ensuring interpersonal and informational justice in temporary teams is the same.

In measuring justice in temporary teams, the Colquitt scale was used (2011). It consists of 20 elements relating to the four types of justice, i.e., procedural, distributive, interpersonal, and informational. For this study, the scale was modified to suit for temporary teams. The modified scale is shown in Figure 4.

The study surveyed managers of companies in the automotive, optics, biotechnology, electronics, IT, aerospace, and pharmaceutical industries. All the managers had practical experience with the functioning of temporary teams.

To determine the level of difficulty in ensuring justice in temporary teams, a 7-point scale was adopted.

It was assumed that the obtained results would be interpreted as follows:

- a rating within the range<1-2,2> - the given factor is not perceived by managers as causing difficulties in ensuring justice in temporary teams,
- a rating within the range<2,21-3,4> - the given factor is perceived by managers as causing minor difficulties in ensuring justice in temporary teams,
- a rating within the range<3,41-4,6) - a given factor is perceived by managers as the one that causes medium difficulties in ensuring justice in temporary teams,
- a rating within the range <4,61- 5,8> - a given factor is perceived by managers as the one that causes difficulties in ensuring justice in temporary teams,

a rating within the range <5,81- 7> - a given factor is perceived by managers as the one that causes the most significant difficulties in ensuring justice in temporary teams.

The level of difficulty (arithmetic mean values and interpretations) in ensuring all factors determining the sense of justice were listed in Table 1.

**Table 1.**

*Assessment of the level of difficulty in ensuring factors determining the sense of justice*

| Item | Factors determining the sense of justice | Arithmetic mean values | Interpretation |
|---|---|---|---|
| Procedural | | Total 3.72 | Causing medium difficulties |
| 1 | Temporary team rules give each employee the right to accept or decline an offer to work as a part of the temporary team | 3.87 | Causing medium difficulties |
| 2 | These rules enable each team member to express their views and feelings about the functioning of the team | 3.55 | |
| 3 | These rules may be modified at the request of the members of the temporary team | 3.97 | |
| 4 | These rules are not biased - they do not favour anyone and do not discriminate against anyone | 3.45 | |
| 5 | These rules are consistently applied to each team member | 3.78 | |
| 6 | These rules were established based on a thorough analysis reflecting the specifics of the temporary team | 3.78 | |
| 7 | These rules allow team members to appeal against decisions made in or about the team's operation. | 3.89 | |
| 8 | These rules are consistent with the ethical and moral norms adopted by the members of this team. | 3.22 | Causing minor difficulties |
| 9 | These rules ensure that the task team can accomplish the task (by selecting appropriate personnel, availability of necessary resources, etc.). | 3.85 | Causing medium difficulties |
| 10 | These rules ensure a high probability that the decisions made by the team will be implemented | 3.84 | |

Cont. table 1.

| Distributive | | | Total 3.99 | Causing medium difficulties |
|---|---|---|---|---|
| 11 | The task team (as a whole) is appreciated, tangibly and intangibly, according to the effort put into the task | | 4.10 | Causing medium difficulties |
| 12 | The task team (as a whole) is appreciated, tangibly and intangibly, in line with the results achieved | | 3.72 | |
| 13 | Each member of the temporary team is appreciated (tangibly and intangibly) according to their contribution to the team | | 4.15 | |
| Interpersonal | | | Total 3.42 | Causing medium difficulties |
| 14 | Relationships between all temporary team members are based on mutual respect (manifested by the lack of non-constructive criticism, malice, etc.) | | 3,69 | Causing medium difficulties |
| 15 | Each participant in the temporary team is treated with respect by the leader of that team | | 3.13 | Causing minor difficulties |
| 16 | Participation in the task force does not adversely affect how the employee is treated by both the manager and other employees in the organisational unit to which the employee is permanently assigned | | 3.43 | Causing medium difficulties |
| Informational | | | Total 3.68 | Causing medium difficulties |
| 17 | The temporary team leader speaks honestly and openly with the team members | | 3.12 | Causing minor difficulties |
| 18 | The rules governing the functioning of the temporary team are understood and fully communicated (and explained) to team members | | 3.33 | |
| 19 | The information needed for the work of the temporary team is provided just in time | | 4.17 | Causing medium difficulties |
| 20 | A temporary team leader will customise communication to suit the individual needs of the members of a temporary team | | 4.09 | |

Source: own elaboration.

In managers' opinion, the most difficult to implement in practice is to provide the information necessary for the task team's work precisely in time. It is also worth mentioning that half of the respondents do not see any difficulties in treating each participant in temporary teams with respect by the team leader. The difficulty in ensuring justice in temporary teams is the lowest for interpersonal justice and the highest for distributive justice. In the opinion of managers, the factor that is most difficult to ensure, in the field of distributive justice, is the appreciation, tangibly and intangibly, of each member and the task team (as a whole) according to the effort put into the task.

Procedural and informational justice were assessed very similarly by managers, but a slightly larger dispersion of responses can be observed within informational justice (see Figure 5). Factors of interpersonal justice generate minor difficulties in ensuring justice in temporary teams. The highest variability also characterized the responses in this field. For distributive justice, the median value is 4 (the highest). Approximately the same number of responses with values less than and greater than the arithmetic mean was observed for all types of justice.

Justice
G_1 – procedural; G_2 – distributive; G_3 – interpersonal; G_4 – informational
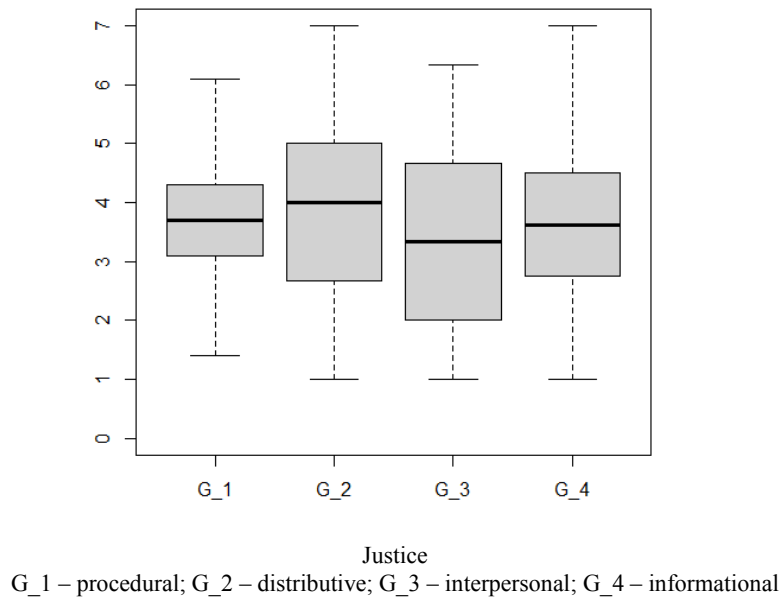
**Figure 5.** Box chart for four types of justice.
Source: own elaboration.

The non-parametric Mann-Whitney U test was used to assess the statistical significance of differences in the difficulty level in ensuring justice in temporary teams. The test was used for all kinds of justice in pairs. Based on the results, it can be stated that there are statistically significant differences in the level of difficulty in ensuring in temporary teams procedural and interpersonal justice ($H_2$) as well as distributive and interpersonal justice ($H_4$). Thus, the research hypotheses $H_2$ and $H_4$ were rejected. It was found that these types of justice did not have the same level of difficulty in ensuring in temporary teams. The test results are summarised in Table 2.

**Table 2.**
*Mann-Whitney U test results*

| Types of justice compared | U Statistics | p-value | Decision |
|---|---|---|---|
| procedural vs distributive | 5334.000 | 0.129 | **Accept H₁** |
| procedural vs interpersonal | 4952.000 | 0.020 | Reject H₂ |
| procedural vs informational | 5833.500 | 0.646 | **Accept H₃** |
| distributive vs interpersonal | 4707.500 | 0.004 | Reject H₄ |
| distributive vs informational | 5283.500 | 0.104 | **Accept H₅** |
| interpersonal vs informational | 5292.000 | 0.108 | **Accept H₆** |

Source: own elaboration.

## 5. Discussion

The study assesses the difficulties of ensuring justice in managing temporary teams. Three research questions were used to achieve the goal. Responding to the first research question: *Do managers think that providing justice in temporary teams is difficult?*, the results of the arithmetic mean for each type of justice were analyzed (see Table 1). The results for all justice types fall within the average difficulty range (mean <3.41-4.6>). Managers ranked distributive justice as the most difficult to provide (arithmetic mean: 3.99), followed by procedural justice (mean: 3.72), informational justice (mean: 3.68) and interpersonal justice (mean: 3.42), respectively.

The view that ensuring all types of justice in temporary teams is a task of medium difficulty may result from the extensive experience of managers in creating and managing temporary teams. However, it may also involve an error of subjectivity, which would need to be verified in further research.

The answer to the second research question: *Which determinants of a sense of justice in temporary teams do managers consider the most difficult/easiest?*, enabled to rank the determinants of a sense of fairness according to the degree of difficulty in providing them (see Table 1).

16 factors out of 20 received a score in the <3.42 - 4.17> range, which indicates an average degree of difficulty. In this group, managers ranked 4 factors as the most difficult to provide (rating higher than 4) (cf. Table 1):

1.  no 19: The information needed for the work of the temporary team is provided just in time (mean: 4,17),
2.  no 13: Each member of the temporary team is appreciated (tangibly and intangibly) according to their contribution to the team (mean: 4,15),
3.  no 11: The task team (as a whole) is appreciated, tangibly and intangibly, according to the effort put into the task (mean: 4,1),
4.  no 20: A temporary team leader will customise communication to suit the individual needs of members of the temporary team (mean: 4,09).

The factors listed are among the more critical issues in ensuring organizational justice (Colquitt et al., 2001; Cohen-Charasch, Spector, 2001; Mesmer-Magnus, DeChurch, 2009; Bakhshi et al., 2009; le Roy et al., 2012; Ismail et al., 2021).

In contrast, 4 factors out of 20 were rated as easy to ensure in the work of temporary teams (rating in the <3.12 - 3.33> range):

1.  no 17: The temporary team leader speaks honestly and openly with the team members (mean: 3,12),
2.  no 15: Each participant in the temporary team is treated with respect by the leader of that team (mean: 3,13),

3. no 8: These rules are consistent with ethical and moral norms adopted by the members of this team (mean: 3,22),

4. no 18: The rules governing the functioning of the temporary team are understood and fully communicated (and explained) to team members (mean: 3,33).

Interestingly, among the factors listed are all those that determine informational justice. Two of them, i.e. 19 and 20, were rated as the most difficult, and two, i.e. 17 and 18, were rated as the easiest. The observed differences may be due to the ability of the interim team leader to influence the individual factors of informational justice. Communicating frankly and openly with team members and explaining the rules governing the team's functioning depends to a large extent on the leader's decision. On the other hand, providing information on time may depend to a high degree on conditions in the organization, and adapting communication to the needs of individual team members requires the leader to have a high level of so-called soft skills.

The answer to the third research question: *Is the degree of difficulty associated with ensuring each of the four types of justice in the work of the temporary team the same?* would be: *it is not*. Even though the scores for all types of justice fall within the range for the average degree of difficulty (3.41-4.6), it is worth noting that interpersonal justice was rated as significantly more manageable than the others - its score (mean: 3.42) is almost at the upper limit of the lower range (3.4). It may be due to the fact that temporary teams have been set up frequently in the surveyed companies, and employees already have experience in forming good relationships in teams. The level of organizational culture in the surveyed companies may also be an essential factor - the higher it is, the easier it is to ensure interpersonal justice (Erkutlu, 2011; Xu et al., 2016). On the other hand, by far the highest average difficulty rating for distributive justice indicates the problems caused by a fair assessment of the contribution of individual team members, which can be characterized by a high degree of subjectivity, both on the part of the leader and the temporary team members being assessed. (Wegener, 1987; Tran et al., 2021).

The negative answer to the third research question was also confirmed by verifying the main hypothesis and six specific hypotheses (see Table 2). The study results indicate that the main hypothesis should be rejected because the difficulty in ensuring all kinds of justice (procedural, distributive, interpersonal and informational) in temporary teams is not the same. Statistically significant differences are found in the level of difficulty in ensuring distributive justice (rated as the most difficult) and interpersonal justice (rated as the easiest to ensure) and between procedural justice (rated as the second most difficult) and interpersonal justice (the easiest).

The results presented should be interpreted considering certain limitations of the research, which simultaneously provide directions for further work. The first limitation is related to the research sample. Entities from a few selected industries were included. However, it is possible that the results obtained could be slightly different for each of these industries (as well as those that were not included in the survey). The second limitation is related to the fact that temporary

teams differ, and sometimes these differences are significant (e.g., differences in duration, the complexity of tasks performed). Managers may have experiences with the functioning of different teams, and this variation may significantly impact the results obtained. Therefore, it is recommended to conduct further research that may lead to an understanding of this variation. Another limitation is the composition of the research group. It included managers. In order to fully recognize the situation, it would be necessary to know the opinions of other employees participating in temporary teams.

# 6. Conclusion

The article is focused on the question of organizational justice with a particular concern of the analysis of the most crucial difficulties in ensuring justice in temporary teams from the manager's perspective. Organizational justice is usually viewed as a sort of motivated behavior that deals with cognitive responses guiding an individual or collective decisions and attitudes in achieving particular aims. Managers and employees ought to feel that everyone is treated fairly and that the same standards are applied to all employees in the workplace where they complete their duties. If such an attitude is broken or neglected, the standards of inequality are permitted in the organization, which usually creates significant organizational difficulties. The perception of fairness and equality always shapes transparency in the organization building its ethical work environment. Such a perspective is crucial for managers who ought to be convinced that their actions are compatible with what they say.

Organizational justice is most often characterized by the expectations of particular treatments, allocation of duties, assessing tasks, repairing experienced damages etc. The literature considered three types of organizational justice: procedural, distributive, interpersonal and informational. This sort of justice is understood as a personal consciousness, including a sense of fairness in the workplace regarding all kinds of distributions (e.g. payments, opportunities of individual development, dismissal, etc.), and social interactions (e.g. communication rules, respect, feedback, etc.). In this sense, justice does not pretend to be an objective norm, nor does it continue a generally applicable characteristic of an organization, it can only refer to subjective judgments and impressions. It lays the foundation for evaluating what happens in a concrete organization.

In the research of assessing difficulties in ensuring justice for temporary teams, the respondents suggested that providing sufficient information necessary for accomplishing the assigned tasks is the most problematic. On the other hand, approximately half of the questioned respondents agreed that interpersonal justice (treating participants in temporary teams with respect by leaders) is relatively high. Though, the highest level of difficulties in ensuring justice in temporary teams was pointed at its distributive type. Procedural and

informational justice were assessed very similarly by managers with slightly bigger dispersion of responses on informational justice.

The results of the research may be helpful for managers in various types of organizations. They allow for a better understanding of temporary teams' regulations. In addition, they indicate those issues that should be given special attention in order to manage such teams reasonably.

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# TOWARDS POSITIVE ORGANIZATION.
# THE EVOLUTION OF GRATITUDE

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**Purpose:** Establishing the way the life history (LH) strategies and gratitude are related to each other.

**Design/methodology/approach:** Life History Theory provides an evolutionary framework for understanding specific developmental paths of species and individuals. There are certain trade-offs during a lifespan of an individual, they must face (for instance, somatic or reproductive effort, quality or quantity of offspring, mating or parenting). Depending on the choices a person makes, they exhibit a slow or a fast life history (LH) strategy. A latent variable underlying a set of solutions (strategy) is called K-Factor and is used to measure individual differences with regard to the pace of one's LH. People with a slow LH exhibit greater prosociality, tend to form long-term sexual relationships and their sexual maturation is slowed down. On the other hand, gratitude facilitates prosociality and altruism, builds social resources and acts as a moral barometer. In recent years we observe an increasing attention to the issue of gratitude both in academic publications and popular press in various fields including economics, management and organizational sciences. All these disciplines draw from relatively new and contemporarily flourishing field of psychology – positive psychology.

We deployed the Gratitude Questionnaire (GQ-6) for the measurement of gratitude and the Mini-K Short Form for the measurement of LH strategies. 197 students took part in the study (138 females, 59 males).

**Findings:** A positive correlation between slow LH strategy and gratitude was found in women.

**Originality/value:** Investigations on the relationship between gratitude and LH strategies show a fragment of the landscape of human personality. Slow LH people seem to be more grateful and thus display more prosocial traits while restraining selfishness which can lead to achieving the delayed social benefits. On the other hand, low-K individuals in organizational context have smaller willingness/ability to reciprocate to their benefactors and to build social bonds. Such individuals presenting exploitative interpersonal style should be detected at the beginning of a selection process by HR specialists.

**Keywords:** life history theory, life history strategies, gratitude, positive psychology, positive psychology interventions in organizations.

**Category of the paper:** research paper.

## 1. Introduction

Over the last few years, the issue of gratitude has become more and more popular among researchers representing various disciplines. Many definitions and concepts of gratitude have been developed (cf. Wolanin, 2019). It is also studied in relation to various phenomena, such as well-being (e.g. Wood et al., 2010; cf. Wolanin, 2020), health (e.g. Wood et al., 2009), or personality traits (e.g. Fagley, 2012). Despite this, there are still many questions concerning this human trait. These questions also concern the biological basis of gratitude. In order to answer them, it seems necessary to refer to the evolutionary perspective. Evolutionary approach suggests that gratitude is a basis for reciprocal altruism (the simple sequence of exchanges of costly benefits between nonrelatives) and, perhaps, upstream reciprocity (those helped by somebody will help a third party - another unspecified player). This might be the way gratitude played a unique role in human social evolution (McCullough et al., 2008).

### 1.1. Gratitude

In psychology, gratitude is most often comprehended as an emotion or personality trait. Gratitude understood as an emotion is an intense and relatively short-term psychophysiological reaction to receiving a favor or being gifted (McCullough et al., 2004). Gratitude understood as a trait, also known as dispositional gratitude (McCullough et al., 2002), is a generalized tendency to respond with the emotion of gratitude to other people's contribution to one's own positive experiences and results.

Gratitude is of great importance for interpersonal relationships, collaboration, pro-social behavior, empathy, and altruism (e.g., Tsang, 2006). Gratitude is considered to be a moral barometer that indicates that someone has acted in the way that increases well-being of another person. Gratitude is also a moral motive that prompts the recipient of the favor to behave prosocially. In addition, gratitude has the function of moral reinforcement, as expressing gratitude prompts the benefactor to further prosocial activities (McCullough et al., 2001). A higher level of gratitude also reduces aggression (DeWall et al., 2012). In the relationship between gratitude and aggression, empathy plays the role of a mediating variable. Gratitude goes hand in hand with a higher level of empathy which explains the lower level of aggression.

### 1.2. Life History Theory

As presented by M. del Giudice et al. (2015), the basic concept that underlies the life history theory is the concept of "energy". Individuals acquire energy through hunting, foraging or cultivating (in modern times also through professional work). The energy budget is limited and there are many competing needs. Selection favours individuals that allocate energy in the way that results in the greatest inclusive fitness. The author describes three trade-offs an organism must face: current vs. future reproduction, quality vs. quantity of offspring and mating vs.

parenting. The first trade-off describes a situation where an organism can either engage in reproduction or focus on themselves, prolonging their life through growth, repairing somatic tissues or allocating energy to immune function – hoping for reproduction opportunities later in their life-span. The second trade-off (quality vs. quantity of offspring) exists because the parents have limited parenting resources. If there are more children, parental investment (care, resources etc.) per offspring drops, lowering their individual quality. Individual quality is defined by body size, health, education or status which is largely an effect of parental investment. The third trade-off is mating vs. parenting. Both mating (finding and attracting potential mates, competing with rivals and securing copulation) and parental investment are costly in terms of energy expenditure, and compete for individual's energy budget (Gadgil, Bossert, 1970; del Giudice et al., 2015; Łukasik, 2021).

## 1.3. Life History Strategies

Particular organisms, as well as entire species, solve trade-offs in energy allocation in various ways (Roff, 2002). They make different choices in the field of maturation, growth, fertility, parenting, and lifespan. Specific solutions form clusters of traits – the strategies. Species (and individuals) that follow fast strategy (r), mature, mate and reproduce earlier; they also produce more offspring. Species (and individuals) that follow slow strategy (K) mature, mate and reproduce later; they also produce fewer offspring. Examples of the fast LH strategy species are fish or frogs; examples of the slow LH strategy species are elephants or humans (Tifferet, 2019). However, as indicated above, the differences in LH strategies refer not only to entire species, but also to individuals within one species. As far as humans are concerned, the intense mating effort reflects the fast LH strategy. Whereas, intense somatic effort and parenting effort represent the slow strategy. In other words, the slow strategy is associated with a tendency to form long-term romantic relationships, retarded maturation, ability to delay gratification, less anti-social behaviour and interpersonal aggression, and fewer attitudes like distrustfulness and being suspicious. Whereas people that exhibit the fast LH strategy tend to form short-term romantic relationships and feature accelerated sexual maturation, pragmatic orientation ("here and now"), weaker control of aggression, external locus of control and proneness to engage in risky actions (Figueredo et al., 2006). The fast LH people also score higher on dark triad traits (Łukasik et al., 2019).

The formation of the specific LH strategy is mostly heritable (Figueredo, 2004), but environmental factors are also of significance. For instance, Pisula et al. (2008) found that the individuals who were brought up with more financial and emotional support, including physical touch from their parents and grandparents, form slower LH strategy.

It is assumed that a latent variable underlying a cluster of LH indicators exists. This hypothetical construct is called K-Factor and is used to measure individual differences with regard to LH strategies in humans (Tifferet, 2019). The most popular scale used for the measurement of K-Factor is the Arizona Life History Battery (ALHB) (Figueredo, 2007).

It is a battery of 199 cognitive and behavioural indicators of life history strategy, grouped into seven categories: 1) Insight, Planning and Control (Example: "I can head off a bad situation before it happens"), 2) Mother/Father Relationship Quality ("How much did they understand your problems and worries"), 3) Family Social Contact and Support ("During the last twelve months, about how many times have you seen them?"), 4) Friends Social Contact and Support ("During the last month, about how many times have they helped you get worries off your mind"), 5) Experience in close relationships ("I prefer not to show a partner how I feel deep down"), 6) General Altruism ("I have important skills I can pass along to others"), and 7) Religiosity ("I'm a very religious person").

In order to reduce research participants burden researchers more often administer the Mini-K Short Form (Figueredo, 2006). Each of the seven ALHB scales is represented by two to three Mini-K items (Tifferet, 2019). However, the drawback of deploying this shortened version is its relatively low reliability (Cronbach's alpha of original English version ≈.70).

## 1.4. Gratitude in organization

One of the most influential contemporary management thinkers, Tom Peters – famous for his classic "In search of excellence" published in 1982, and nowadays called "Red Bull of management thinking", devotes astonishing attention in his recent work (Peters, 2021; but also see Peters, 2010) to the issue of gratitude – noticing and appreciating people's effort, frequent thanking to co-workers, sending them "thank you notes" etc. The author also underscores a direct link between gratitude, human-being centred approach and leadership. The radical title of Peter's latest book speaks for itself - "Excellence Now: Extreme Humanism", showing an essence of this "people-first manifesto". Not only Peters focuses on the issue of gratitude in his printed works but also, almost on a daily basis, shares his on-the-ground observations and reminds his followers on Twitter (175 k. followers, including a number of CEOs of large companies) about the need for expressing gratitude.

Peters is not alone. In recent years we observe an increasing attention to the issue of gratitude both in academic publications and popular press in various fields including economics, management and organizational sciences. All these disciplines draw from relatively new and contemporarily flourishing field of psychology - positive psychology. Positive psychology is the study of positive emotions, positive character traits and positive, enabling institutions. Positive psychology focuses on virtues and character strengths. It advances the science of mental health and well-being (Seligman, Csikszentmihalyi, 2000). Gratitude in positive psychology is one of five "transcendence strengths", along with appreciation of beauty and excellence, hope, humour and religiousness (Seligman et al., 2005). In organizational behaviour theory two fields emerged – positive organizational behaviour (POB) and positive organizational scholarship (POS). Both build on positive psychology (Donaldson, Ko, 2010). Sometimes these terms are used interchangeably (but see Müceldili et al., 2015), however – among other things - they differ in the level of analysis (POB – individuals, POS – larger

structures, organizations). Fehr et al. (2017) proposed a multilevel model of gratitude in organizations. The authors distinguish three types of gratitude: episodic (at the event level), persistent (at the individual level) and collective (at the organizational level).

We couldn't agree more with Fehr et al. (2017), who call gratitude "a valuable emotion with an array of functional outcomes". In other words, there is a link between the tendency to experience gratitude by the individuals within the organization and tangible effects of such a propensity. For instance, contemporary employee is more mobile and less dependent than ever (e.g. Mawdsley et al., 2016). To counteract this phenomenon building collective gratitude may be a key factor to secure employee's loyalty (Müceldili et al., 2015). Promoting gratitude in a workplace can also have many other beneficial organizational outcomes:

- Gratitude can help uprooting the toxic emotions and attitudes in a workplace, such as unhealthy competition or greed, replacing them with strength and harmony through building bonds between people,
- Collective gratitude promotes helping and compassionate behaviour (by emphasizing reciprocity),
- Collective gratitude facilitates team communication, sharing knowledge and team learning - also through the mechanism of social bond (Müceldili et al., 2015).

The role and the significance of gratitude in developing human potential in organization substantiates further research on this phenomenon. We believe that including evolutionary perspective into research agenda can bring significant contribution to better understanding of this perplex phenomenon.

### 1.5. Research question

The research question for this study was: What is the relationship between LH strategies and gratitude?

## 2. Methodology

### 2.1. Measures

### Gratitude Questionnaire (GQ-6)

The GQ-6 by McCullough, Emmons and Tsang (2002) measures dispositional gratitude, i.e. the tendency to experience gratitude. The tool was used in the Polish adaptation of Kossakowska and Kwiatek (2014). The scale contains 6 items rated on a 7-point Likert scale. The psychometric properties of the Polish adaptation are satisfactory. Confirmatory analysis performed on 511 subjects confirms the relative goodness of fit to the original one-factor

structure of the questionnaire, and the reliability coefficient is equal to .72. In our study we received Cronbach's α = .83.

**The Mini-K Short Form**

The scale is used for the measurement of the K-Factor – a latent variable indicating individual differences in LH strategies. The scale comprises 20 items. It can be used together with ALHB as its eighth subscale or separately. The items are rated on a scale between -3 (disagree strongly) to +3 (agree strongly). The items are scored directionally to indicate a slow LH strategy – the higher the score of the scale the slower LH strategy (Figueredo et al., 2006). The Polish-language versions of the tool had the following reliability: α = .73 (Marzec, Łukasik, 2017), α = .76 (Czarna et al., 2016), α = .83 (Kwiek, 2020). In our study we received Cronbach's α = .74.

**2.2. Participants**

197 students, including 138 women and 59 men, participated in the study. The mean age of the respondents was 21.50 with a standard deviation of 3.78.

The vast majority of our study sample were the students at the faculty of management – the rest were attending social sciences/humanities studies. Perhaps this specific sample adds some value to the data we have gathered in the managerial and organisational research context. This is because our subjects are future managers, HR specialists or social workers. It is beneficial in the field organizational behaviour and management to gain some additional knowledge on how this peculiar group functions and perceives social reality.

# 3. Results

In the measurement of gratitude on the GQ-6 scale, a higher score means a higher level of gratitude. On the Mini-K life strategies scale, a higher score means slower LH strategies (higher K-factor).

The intensity of gratitude (Tab. 1) turned out to be significantly higher in women (M = 32.69) than in men (M = 30.73, t(195) = 2.02, p = .04). Also in terms of LH strategies, gender differences were revealed (t(195) = 2.86, p = .01) - women had significantly slower strategies (M = 20.47) compared to men (M = 14.31).

Dispositional gratitude positively correlated at a low level with LH strategies, i.e. a higher level of gratitude coexisted with slower LH strategies. The above result was revealed in the entire group of respondents (r = .35, p <.05). However, after dividing the sample by gender, it turned out that the above relationship was significant only in the female group (r = .41, p <.05).

**Table 1.**
*Gratitude and K-Factor: descriptive statistics and Pearson's r correlations*

| | *N* | *M* | *SD* | **Pearson's *r*** |
|---|---|---|---|---|
| **Total** | | | | |
| Gratitude | 197 | 32.10 | 6.28 | .35* |
| K-Factor | 197 | 18.62 | 14.10 | |
| **Females** | | | | |
| Gratitude | 138 | 32.69 | 6.02 | .41* |
| K-Factor | 138 | 20.47 | 12.66 | |
| **Males** | | | | |
| Gratitude | 59 | 30.73 | 6.71 | .20 |
| K-Factor | 59 | 14.31 | 16.32 | |

\* *p* <.05.

## 4. Discussion

Gratitude positively correlates with slower LH strategy. This result is statistically significant in the whole sample, however after calculating data separately for men and women, this is significant only in women. Fast LH strategy is associated with „here and now" orientation, favours short-term social exchange and correlates with anti-social behaviours (Figueredo et al., 2006). Whereas, gratitude is associated with long-term cooperation (one may be grateful for a received favour for many years and reciprocate after a long time), favours altruism, empathy and prosociality, also in terms of passing along good to third parties (McCullough et al., 2001). It also favours building social bonds and networks (Fredrickson, 2001). Our results correspond with the findings of Gladden and Cleator (2018) who showed that the slow LH strategy is positively associated with moral foundations (universal psychological systems on which cultures construct diverse moralities). Similarly, in our study a positive correlation between gratitude (a moral trait) and the slow LH strategy was found. Slow LH people flourish under stable and friendly ecological conditions, where displaying moral traits while restraining selfishness, leads to achieving the delayed social benefits.

The means in gratitude are higher in women than in men, which is a typical result for this scale (e.g. Kossakowska, Kwiatek, 2014; Wolanin, Rybak, 2021). The means in K-factor are also higher in women than in men. The reason for this seems to be the fact that the participants of our study were students. As far as female students are concerned, they have slower LH strategies by definition. In male students this might not be the case. What do we mean exactly? According to the cultural script a male is supposed to be "productive" and generate financial income. Education is, of course, a mean to achieve this goal. Therefore a male prolongs his education no matter what his K-factor level is. Whereas, our female participants pursue their degree out of their slow LH strategy, compared to their peers who directed their

energetic effort towards reproduction. This unfortunately shows the limitation of our study in the form of its limited generalizability.

The role of gratitude in the "rudimentary", evolutionary layer of human nature is ambiguous and multidimensional. On the one hand, a characteristic of a person, which is their tendency to react with the emotion of gratitude, seems to be crucial in the context of group behaviour, relating to the issues of altruism and group cohesion and durability. On the other hand, gratitude does not seem to correspond to the basic mechanisms of survival. In order to survive, the individual should rather see in the environment things that are potentially threatening, things that require correction, so that they could adequately cope with them – by fighting or flighting. To establish the place of gratitude in the context of other modules of mind postulated by evolutionary psychologists (Buss, 2016), further research is needed.

The follow-up studies should rely on a larger and more balanced, preferably non-students subjects sample, because – looking at the data – it seems that a larger sample would show significant correlation between LS and gratitude also in the male group. This correlation however would probably still be weaker than in women (again, prediction based on our data analysis).

## 4.1. Organizational implications

The positive psychology movement have prompted new applications far beyond the field of traditional psychology, aimed at making substantial improvement in the quality of working life (Donaldson et al., 2010). There are various gratitude-focused HR practices targeted at enhancing employees gratitude – they are termed "gratitude initiatives". Fehr et al. (2017) identify three initiatives facilitating gratitude in a workplace: appreciation programs, contact with beneficiaries and developmental feedback. Appreciation programs are "institutionalized opportunities to endow individuals with expressions of positive affiramition" (Roberts et al., 2005, p. 718, as cited in Fehr et al., 2017). The authors give the example from a consulting firm where managers email descriptions of employees' strengths to the company's head. Later these emails are made public for the organization community. The second gratitude initiative, contact with beneficiaries, assumes that there are jobs that involve frequent and meaningful contact with beneficiaries. For instance, a fire fighter or a physician has a sense of saving/changing people's lives on a daily basis, which gives them the sense of meaning and motivates them for further efforts. But there is a wide range of professions where people, doing hard work, do not have such an experience. These are "invisible" employees no one can see but everyone benefits from their job (e.g. medical laboratory workers, engineer maintaining sophisticated medical equipment etc.). The contact programs are for groups of this sort. One of the programs described by the cited authors was contacting employees at a donations call center with those who finally received scholarships from those donations. It has been proved that such interventions result in bolstering employees' sense of social worth, prosocial motivation and persistence. The third gratitude initiative, developmental feedback, relies on the assumption that the employees

experience gratitude for the possibility of personal growth. Nonetheless, in many institutions the manager provide insufficient developmental feedback, leaving the employees unaware of the progress they are making. Developmental feedback, unlike routine performance evaluations, is conceptualized by the authors as high-quality mentoring relationship based on mutual trust and respect (Fehr et al., 2017).

The scope of positive organizational intervention that create an enabling institution goes beyond gratitude-centered interventions. Positive psychology interventions aim at cultivating positive subjective experiences, constructing positive individual traits and building positive institutions (Meyers et al., 2012). The aforementioned authors (Meyers et al., 2012) in their review of research conclude that organizational positive psychology interventions are a "promising tool" for bolstering employees' well-being and performance. Moreover, these interventions reduce stress and burn-out and – to a lesser degree – anxiety and depression.

Finally, let's look closer how our own findings translate into practical organizational context. We were able to establish that fast low-K people (at least women) have a lesser propensity to experience gratitude. From other research we also know that individuals exhibiting fast LH strategy (low K) have more Dark Triad traits (psychopathy, narcissism and Machiavellianism). To be precise fast LH strategy is associated with antisociality facet of psychopathy and the entitlement/exploitativeness facet of narcissism (McDonald et al., 2012). In organizational context this means that people presenting exploitative interpersonal style have smaller ability or/and willingness: reciprocate to their benefactors, build social bonds, work as a part of a network, conform to the norms in a workplace etc. Thus they lack very basic skills/predispositions to be a contributor to building nourishing, friendly and enabling work environment. That is why we believe that this is crucial for HR departments to identify such problematic individuals at a very beginning of a selection process. What to do once a low-K individual (or a cluster B person) is detected in a selection process? The answer to this question goes beyond the framework of this article, but we know – and this is uplifting – that at least gratitude might be a subject of training (Seligman et al., 2005).

**4.2. Conclusions**

Investigations on the relationship between gratitude and LH strategies show a fragment of the landscape of human personality. These two traits, being a subject of variability, contribute to individual differences between people. In spite of the fact that one (LH strategy) is rather a product of genes and to a lesser extent of environmental pressure (Figueredo et al., 2004; Mendle et al., 2009; see also: Łukasik, 2021) and another (gratitude) comes rather from upbringing and might be a subject of training and formation (Rash et al., 2011; Mercon-Vargaset et al., 2018), they are related to each other. However the nature of this relationship (causation, latent factor underlying both?) is still an open question.

As to the organizational aspect of the subject, we would like to underscore that managers should understand the relationship between collective gratitude and positive organizational outcomes. Organizations should invest in human resource initiatives to enhance the gratitude of employees. Moreover HRM specialists should make an effort to identify individuals presenting exploitative interpersonal style (the Dark Triad traits, low K-factor) at the very beginning of a selection process, because employees with these characteristics have difficulties with experiencing gratitude and, generally, have difficulties to fit in organizational citizenship behaviour. All this, of course, requires an appropriate, research-based university education for economics/management/psychology students, fully informed by new findings from the field of positive organizational psychology.

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# IN SEARCH OF A COMPETENCY GAP IN THE ERA OF INDUSTRY 4.0 – THE CASE OF MANAGER 4.0 IN POLAND

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**Purpose:** The main objective of the research is to identify a competence gap in "Industry4.0" – the difference between the competencies currently acquired by students at universities with a technical and economic profile, and the competencies desired by companies from the industrial processing sector.

**Design/methodology/approach**: Empirical material was obtained in two studies. The first survey was conducted among 120 companies in the industrial engineering sector, while the second was carried out among over a thousand students and graduates of economic and technical universities.

**Findings:** This work contributes to an in-depth understanding of companies' needs regarding "Manager 4.0" competencies, and enables the identification of existing educational gaps. Our research results show that there is a competence gap on the labour market in each of the analysed categories of competencies: social, personal, managerial, technical and professional. At the same time, some differences are visible between students of economic and technical universities. The findings of the study suggest the need to redesign student education programs at universities so as to provide interdisciplinary education taking into account key competencies for Industry 4.0.

**Research limitations/implications**: We identified three limitations of our research, resulting both from the size of the research sample of the analyzed comapnies, the possible ambiguity of the respondents' understanding of the examined competences (ambiguity of their interpretations) and their mutual interdependencies, as well as the subjective assessment of the students themselves.

**Practical and social implications:** The study indicated the need for specific employee competencies, the development of which requires interdisciplinary study programmes in areas including production engineering and management. Besieds, the results of our research are particularly important for adapting employee training systems. We assume that the development of new training programs best suited to the needs of the market (need for specific employee competencies) should be done through cooperation between companies in the industrial processing sector and the academic community.

**Originality/value:** The conclusions of the research shed new light on requirements regarding managerial positions in companies from the industrial processing sector, by indicating the need to modify curricula at universities in selected areas of competence.

**Keywords**: Industry 4.0, Manager 4.0, human resources, managerial competencies.

**Category of the paper**: Research paper.

# 1. Introduction

The Covid-19 pandemic accelerated digital transformation both in the world of education and work. In this fast-changing and turbulent environment, referred to as the Fourth Industrial Revolution, an updated set of competencies (including digital competencies) is needed for university graduates. They will become employees who will face paramount challenges, and who will participate fully in the economic and business life of the modern digital world (Poszytek et al., 2021).

In a knowledge-based economy, competencies are becoming a key non-material resource, with a significant influence on the development of companies (Graczyk-Kucharska et al., 2018), many of which perceive the development of competencies as the key to gaining a competitive advantage and developing transformation strategies for improving individual and company performance. Competencies can also leverage further knowledge at all levels of the organization. In addition, managers in manufacturing companies can more easily manage the risks that occur during the transformation process if they develop the necessary competencies (Jerman et al., 2019).

Technical competencies are one of the attributes of the engineers and managers of the future, however, they must be supplemented with other competencies (Gudanowska et al., 2018). Some researchers forecast that the economy may face a labour crisis such as simultaneous unemployment and the shortage of a skilled workforce. The collaboration of all stakeholders in employee competencies is crucial to preventing this crisis (Śledziewska, 2020). One of the many causes lies in the considerable difference between what is offered by the educational system and what the labour market needs (Kusmin et al., 2018). This conclusion inspired us to study the situation from both perspectives in Poland.

In the debate on implementation of the Industry 4.0 concept, scientists and practitioners have already partly answered the question of what knowledge, skills and attitudes are needed by employees in an Industry 4.0 environment. In this article, we go further and want to identify whether the competencies acquired by students of universities in Poland meet the requirements set by companies.

The main objective of the article is to identify a competence gap in "Industry 4.0 Manager" – the difference between the competencies currently acquired by students at universities with a technical and economic profile, and the competencies desired by companies from the manufacturing sector for managerial positions. The conclusions of the research shed new light on requirements regarding managerial positions in companies from the industrial processing sector, by indicating the need to modify curricula at universities in selected areas of competence. The results of this research are particularly important for adapting employee training systems, as well as the education process. This research area is all the more important as over the years individual competences undergo revaluation and it iis necessary to recognize the current requirements and conditions on the labor market.

The structure of the paper is as follows. First, we discuss the theoretical background, we point to the challenges of Industry 4.0 and the corresponding competencies that companies require when undertaking digital transformation. Then, we present the research methodology and data collection. The third part of the paper presents the results and discussion sections. The competency gap is summarized in Tables 5-8. The paper ends with conclusions as well as managerial implications, limitations and future research directions.

## 2. Theoretical Background and Literature Review

### 2.1. Meaning and typologies of competence

Effective implementation of goals in organizations and the projects implemented within them is ensured by competent managers. The word "competence" in the era of the knowledge-based economy takes on a special meaning and can be defined as a certain resource of knowledge, skills and motivation (attitudes) conditioning behaviours that enable the execution of professional tasks as expected (Filipowicz, 2016).

One very important issue when considering the parameters describing competencies is to place them in the context of the system (e.g. sector, company) or subsystems (e.g. specific department) within which they apply. On the one hand, the system of a specific organization defines the competencies expected of all employees (so-called company competencies) and for specific positions. On the other hand, the organizational system plays the role of a regulator in revealing certain undesirable behaviours among organization employees (Gwarda-Gruszczyńska, Czapla, 2011, p. 6; Gracel, Makowiec, 2018).

Competency research is mostly based on one of three approaches that have been developed independently (Jerman et al., 2020). The functional approach focuses on competencies as requirements for the successful completion of a task by limiting the scope of competence to the necessary skills and knowledge. The behavioural approach focuses on attributes beyond cognitive abilities, including self-awareness, self-regulation and social skills. In turn, the integrated/ multidimensional approach describes competencies as a set of specific competencies that an individual needs, and the organizational skills required at the level of the entire organization in order for the desired results to be achieved (Straka, 2004).

The literature in the field of human resource management lacks clear conclusions as to the number of employee competencies (also managerial) that can be distinguished. Every concept and attempt at classification, if it is to have practical application, must take into account the evolution and deepening diversity of the business world. Some researchers also conduct factor analysis of various sets of competencies in an attempt to try and extract "key competencies" from these sets (see e.g. Levy-Leboyer, 1997, p. 36). In Poland, competence models have been created, among others, by T. Oleksyn (2006), Jurek (2012) and Padzik (2013). Each of these approaches reflects a certain model approach to competencies specific to a particular type of organization. In addition, it is worth noting that the scope and diversity of the described competencies often lead to attempts to systematize them into certain categories, but that in this case also there are significant differences between the authors' approaches. R.L. Katz (...) focuses on managerial competencies, taking into account three types of competencies: 1. Technical, 2. Social and 3. Conceptual. An interesting contribution by Katz was the assigning of separate competence categories to different levels of management. At the level of middle management, social competencies become increasingly important and technical skills become less important. One of the latest typologies was presented by Filipowicz (2016, p. 94), who divided competencies into personal, social, managerial and professional, which form the so-called "Universal Competence Model". Personal and social competencies seem to be more universal than other groups of competencies. It is therefore necessary to assume that they often form the basis for the development of more specialized skills.

## 2.2. Industry 4.0 challenges and the corresponding competencies

The Fourth Industrial Revolution (or the era of Industry 4.0), is inextricably linked with the integration of machines, systems and people. Its characteristic feature is great acceleration in the development of organizations based on the latest technologies. The Fourth Industrial Revolution not only has a huge impact on the changes to the entire industrial system, but also poses significant challenges for employees in the area of the competencies required, without which it will be difficult for them to adapt to the new reality. We are dealing with a revolutionary change in the area of employee competence rather than an evolutionary one, mainly due to the challenges associated with Industry 4.0 faced by companies. Industry 4.0 creates many new opportunities for companies, but at the same time causes certain challenges

to the whole economy to arise from the ongoing automation and digitization (Hecklau et al., 2016).

The challenges resulting from the Fourth Industrial Revolution affect, amongst others, several perspectives (Simic, Nedelko ,2019; Hecklau et al., 2016): economic, social, technical, political and legal. The new conditions force changes in the competency profiles of employees involved in the implementation of the Industry 4.0 concept. Some professions will be replaced, and only qualified and highly educated employees will be able to control new technologies. However, the biggest challenge for industrial leaders isn't technology – the focus is instead on people (Simic, Nedelko 2019).

Among the economic challenges it should be noted that with the ongoing globalization process, companies have to cope with reduced time-to-market, shorter product lifecycles and the need to cut costs to stay competitive. For this purpose, companies need to streamline their innovation processes and transform their business model to ensure a higher level of service orientation. Subsequently, the need for collaboration is more important than before. Companies now have to enter into strategic alliances with their suppliers or competitors to stay competitive (Hecklau et al., 2016). Ongoing globalization requires intercultural skills, language skills, time flexibility and networking skills. In addition, the increasing need for innovation requires entrepreneurial thinking and creativity as well as problem-solving. Consequently, workers experience increased complexity in their daily tasks and are required to be highly flexible and to demonstrate adaptive capabilities in very dynamic working conditions (Longo, 2017). Demand for higher service orientation requires employees to develop communication, conflict solving and networking skills, as well as the ability to compromise. Due to the characteristics of Industry 4.0, it is inevitable that the latest industrial revolution is reshaping industry boundaries, creating entirely new industries and exposing established manufacturing companies to new competitive challenges (Müller et al., 2018).

Among the challenges of a social nature, attention should be paid to demographic changes, employee training and changing social values. Fewer young people are entering the labour market to replace those retiring. Thus, strategies need to be developed to attract young people, whilst retaining the knowledge from older employees. Moreover, younger generations propound different social values, such as the growing importance of a good work-life balance (Hecklau et al., 2016). This goes hand in hand with growing employee flexibility due to changes in work organizations. The flattening of organizational structures, the self-organization of work, multitasking and empowerment make the ability to transfer knowledge, accept work-task rotation, as well as time and place flexibility even more important (Łapuńka, Marek-Kołodziej, 2017). Furthermore, the growth of strategic tasks with more responsibility requires new types of appropriate leadership competencies. Managers of future manufacturing systems will need to transform their management methods from power-driven to value-driven due to highly diverse teams in terms of culture, education and geographical location (Hecklau et al., 2017). Additionally, processes are becoming more complex, which is leading to an increase in jobs

requiring higher qualifications and a decrease in jobs requiring lower qualifications. Therefore, companies need to train their employees to carry out more strategic, coordinating and creative tasks with higher responsibilities (Hecklau et al., 2016).

The technical and technological challenges apply to both the exponential growth of technology and data usage, and also the growth in collaborative work on platforms. The understanding of information and data will have to increase amongst employees so that they are able to implement technical potential within companies. Employees must further acquire skills in virtual communication, media skills and the ability to be cooperative and work in teams. Digital connectivity implies the sharing of data and opening up to a competitive market environment, resulting in a transparent business that is largely facilitated by online platforms. A high level of transparency exposes companies to the risks of cyber-attacks and industrial espionage, and the challenge of securing data rights and access (Simic, Nedelko, 2019). To ensure the fluid exchange of data between partners within a network, it is further necessary to develop standardized interfaces and open architectures which enable collaborative work together on different platforms (Hecklau et al., 2016). Technical skills, as well as analytical and coding skills are essential to meet those challenges.

The political and legal challenges can be considered through the prism of standardization, data security and personal privacy. The most evident political challenge is the increasing need for funding for research programs. Governments need to support organizations in the development of new technologies, as well as the integration of those technologies into the existing environment. Growing work flexibility further requires the establishment of regulations for working times and safety in order to protect employees (Hecklau et al., 2016).

Taking into account the above challenges, it is important from a scientific and practical point of view to create a list of required competencies that will enable an adequate reaction to these challenges. Table 1 lists the competencies relevant to Industry 4.0 identified in the literature review[1]. Among the articles analysed, 10 articles were empirical and 9 articles included conceptual analysis.

**Table 1.**
*Identification of Industry 4.0 competencies based on a literature review*

| Competence | Indication in the literature | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| Ability to quickly analyse data and information | X | X | X | X | X | X | X | X | X | X | X | X | | X | X | X | X | X | X |
| Ability to use ERP / BI / CRM systems | X | | X | X | X | | X | X | X | | X | X | X | X | | X | X | X | X |

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[1] To identify the literature, we used the Google Scholar search engine by entering as key words: 'Industry 4.0 competencies', 'Fourth Industrial Revolution competencies', 'Manager 4.0' and 'Industry 4.0 skills'. After filtering by time range (2016-2022), relevance and title screening, 117 studies were preselected. 24 references were chosen after abstract screening, and after a full text review 19 references were selected for inclusion in the analysis.

Cont. table 1.

| Competency | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ability to work under pressure | X |  |  |  | X |  |  |  | X |  | X | X | X | X | X | X | X | X | X |
| Analytical thinking | X | X | X |  | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Basic programming skills |  | X | X |  | X | X | X | X | X |  | X | X | X | X |  | X | X | X | X |
| Building relationships | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Communicativeness | X | X |  | X | X | X |  | X |  | X | X | X | X | X | X | X | X | X | X |
| Comprehensive (systemic) approach to strategy implementation | X | X |  |  |  | X | X |  | X |  |  | X |  | X | X | X | X | X | X |
| Conflict resolution skills | X |  | X |  | X |  |  | X | X | X | X | X | X | X | X | X | X | X | X |
| Reliability |  |  |  |  | X | X | X |  | X |  | X |  |  | X | X | X | X | X | X |
| Cooperation skills within the whole organization |  | X |  | X | X | X | X |  | X | X | X | X | X | X | X | X | X | X | X |
| Emotional intelligence |  |  |  |  | X | X | X |  |  | X | X | X | X | X | X | X | X | X | X |
| Employee evaluation and development | X |  |  | X |  |  | X |  |  | X | X | X |  | X | X | X |  |  | X |
| Entrepreneurial skills |  | X | X |  | X | X |  |  |  |  | X | X | X |  | X | X | X |  | X |
| Independence/decision making |  | X | X | X | X |  |  |  | X | X | X | X | X | X | X | X | X | X | X |
| Innovativeness and flexibility | X | X |  |  | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Intercultural communication | X |  | X | X | X |  |  |  | X | X | X | X | X | X |  | X | X | X | X |
| Interdisciplinary thinking | X | X | X |  |  | X | X |  | X | X | X |  | X |  |  | X | X | X | X |
| Knowledge of foreign languages | X |  | X | X | X |  | X |  | X |  | X | X | X | X | X |  |  |  | X |
| Leadership skills |  | X |  | X | X |  | X | X |  | X | X | X |  | X | X | X | X | X | X |
| Manufacturing procedures | X |  |  | X | X |  | X | X | X |  | X | X | X | X | X | X | X | X | X |
| Motivating | X |  |  | X | X |  | X | X |  | X | X | X | X | X | X | X | X | X | X |
| Negotiating |  |  |  | X |  |  |  | X |  |  |  |  | X | X |  |  |  |  | X |
| Presentation skills |  |  |  |  | X |  |  |  |  |  |  |  | X | X |  | X |  |  | X |
| Problem-solving | X | X | X | X | X | X | X | X |  | X | X | X | X | X | X | X | X | X | X |
| Process management | X | X |  | X | X |  | X |  | X |  |  | X |  | X | X | X | X | X | X |
| Project management |  |  |  | X |  |  |  |  | X |  |  |  |  | X | X | X | X | X | X |
| Pursuit of results |  |  | X | X | X | X |  |  | X | X | X | X | X |  | X | X | X |  | X |
| Quality management |  |  |  |  |  |  |  |  | X |  |  |  |  |  | X | X | X | X | X |
| Self-management (including time management) | X |  |  | X | X | X |  |  | X |  |  | X |  | X | X | X | X | X | X |
| Sharing knowledge and experience | X | X | X | X | X | X | X | X |  | X | X |  | X | X | X | X | X | X | X |
| Strategic thinking / long-term planning | X | X | X | X |  | X | X |  | X |  |  | X |  | X | X | X | X | X | X |
| Task delegation |  |  |  | X |  | X |  |  | X |  | X | X |  | X | X | X | X | X | X |
| Team building | X |  | X | X | X |  |  | X |  | X | X | X | X | X | X | X | X | X | X |
| Teamwork | X | X | X | X | X | X |  | X |  | X | X | X | X | X | X | X | X | X | X |
| Understanding business models | X | X | X | X | X |  | X |  |  | X | X |  | X | X | X | X | X | X | X |
| Understanding the basic principles of data protection and cybersecurity |  | X |  |  | X |  |  |  |  | X |  |  | X |  | X | X | X | X | X |
| Understanding the principles of manufacturing processes | X |  | X |  |  | X | X |  | X | X | X |  | X | X | X | X | X | X | X |
| Understanding the principles of technologies, functioning and the goals of their implementation | X | X | X | X |  |  | X |  | X |  | X | X | X | X |  | X | X | X | X |
| Lifelong learning | X | X |  | X | X |  | X | X | X | X | X |  | X | X | X | X | X | X | X |

Source: Own elaboration based on: 1 - Erol et al. (2016); 2 - Hecklau et al. (2017); 3 – Łupicka, Grzybowska (2018); 4 - Simic, Nedelko (2019); 5 - Hecklau et al. (2016); 6 - Prifti et al. (2017); 7 - Jerman et al. (2020); 8 - Jerman et al. (2019); 9 - Graczyk et al. (2018); 10 – Łapuńka, Marek-Kołodziej (2017); 11 - Kusmin et al. (2017); 12 – Mdluli, Makhupe (2017); 13 – Imran, Kantola (2018); 14 – Ismail, Hassan (2019); 15 – Dębkowska et al. (2017); 16 – Shet, Pereira (2021); 17 - Saniuk et al. (2021); 18 - Tommasi et al. (2022); 19 – Ribeiro et al. (2021).

In the context of the above list, we chose only those competencies that were indicated by at least four authors, realizing that the above list is not complete. In the case of some competencies, we have used simplified and synonymous treatment of some of the terms used in the articles. As a result of the above procedure, we identified a list of 40 competencies whose frequency of indication varied significantly, ranging from four articles to nineteen (all) articles.

## 2.3. The role and importance of Industry 4.0 Manager

There is no doubt that the modern technologies necessary in the process of implementing the concept of Industry 4.0 are a strong driver of changes in today's economic reality. Managers can either resist global trends or prepare for them properly, giving the companies they manage a chance to gain a competitive advantage by stimulating business processes using modern technologies. However, companies will not be able to use technology 4.0 without the appropriate competencies necessary to properly implement the idea of Industry 4.0. This is a huge challenge at every level of the economy, affecting almost every industry. In the literature, there have been attempts to build a catalogue of necessary competencies, for example, Gracel and Makowiec (2018) and Łupicka and Grzybowska (2018) distinguished the requirements set for managers and the desired competencies in the context of Industry 4.0, with lists of competencies indicating the differences.

What connects current theoretical approaches and the results of empirical research is a clear indication that despite the automation of many processes, the human factor will not be eliminated. People will continue to be essential, amongst others to intelligently control and evaluate reports generated by analytical systems, and to make key business decisions. At the same time, there is no doubt that Industry 4.0 will cause a significant change in employment profiles. It will be necessary to employ people who can handle various, often very complicated processes and elements of production systems, depending on current needs or emerging problems (Śledziewska, 2020). Key people in this respect are Industry 4.0 managers who are able to use their competencies to take a holistic look at the process of implementing modern solutions.

In this article, we understand competency as certain specific resources of knowledge and skills, as well as attitudes that enable managers to implement business goals. For the purposes of the research, we have created an original typology of Manager 4.0 competencies, inspired by the Universal Competence Model (Filipowicz, 2016), conclusions from interviews with practitioners who have successful implementation processes in the field of Industry 4.0 technology, and above all our catalogue of Industry 4.0 competencies based on the literature review (Table 1). On this basis, we have divided the competencies into 1) social - affecting the quality of performed tasks related to contact with other people, 2) personal - determining the speed, adequacy and reliability of activities undertaken, 3) managerial - regarding "soft" and strategic areas of management, and 4) technical and professional competencies – related to business models, procedures in the production environment and efficient use of new

technological solutions, inscribed in the concept of Industry 4.0. Each of the above groups includes 10 competencies (40 in total, Table 2). In addition, each of the indicated competencies has been defined so that there are no doubts how they should be understood (Appendix).

**Table 2.**
*Competencies of the "Manager 4.0"*

| Social competencies | Personal competencies |
|---|---|
| 1. Building relationships | 1. Pursuit of results |
| 2. Sharing knowledge and experience | 2. Entrepreneurial skills |
| 3. Communicativeness | 3. Innovativeness and flexibility |
| 4. Presentation skills | 4. Analytical thinking |
| 5. Negotiating | 5. Independence/decision making |
| 6. Teamwork | 6. Problem-solving |
| 7. Conflict resolution skills | 7. Reliability |
| 8. Intercultural communication | 8. Lifelong learning |
| 9. Cooperation skills within the whole organization | 9. Self-management (including time management) |
| 10. Knowledge of foreign languages | 10. Ability to work under pressure |
| **Managerial competencies** | **Technical and professional competencies** |
| 1. Team building | 1. Understanding business models |
| 2. Emotional intelligence | 2. Understanding the principles of how 4.0 technologies function and the goals of their implementation |
| 3. Employee evaluation and development | 3. Understanding the principles of manufacturing processes |
| 4. Task delegation | 4. Manufacturing procedures |
| 5. Motivating | 5. Ability to use ERP / BI / CRM systems |
| 6. Strategic thinking / long-term planning | 6. Basic programming skills |
| 7. Leadership skills | 7. Ability to quickly analyse data and information |
| 8. Interdisciplinary thinking | 8. Understanding the basic principles of data protection and cybersecurity |
| 9. Comprehensive (systemic) approach to strategy implementation | 9. Quality management |
| 10. Project management | 10. Process management |

Source: Own elaboration.

# 3. Research Method

Implementation of the basic research objective, i.e. determining the competence gap between the competencies currently acquired by students at universities and the competencies desired by companies from manufacturing industries, was possible thanks to quantitative research among two research groups. One included students of economic and technical universities in Poland (mainly state universities), while the other included companies from the industrial processing sector. The choice of this sector is due to the fact that it is characterized not only by an increasingly higher level of automation and robotization, but is also more likely to implement other modern solutions using artificial intelligence and BIG Data (Yasin et al., 2021; Deloitte, 2020). Thus, there are huge competence needs. Students of technical and economic universities

constitute potential middle and senior staff dealing with Industry 4.0 solutions in industrial processing companies.

### 3.1. Empirical setting and data collection

The adopted research procedure consisted of 8 stages presented in Figure 1. After creating the conceptual framework for the study, i.e. a complete list of Manager 4.0 competencies, a pilot study was carried out, followed by the main survey questionnaire among companies and students. In both cases, the same sets of competencies were used, which were assessed on a 5-point Likert scale (1 - very low, 2 - low, 3 - neither low nor high, 4 - high, 5 - very high), with students assessing the intensity of developmental activities at the university (compulsory classes, optional classes, training, etc.), while companies assessed the required level of a given competence for Manager 4.0 positions.

Companies had the opportunity to complete the questionnaire in electronic form. The EMIS Professional database was used as a sampling frame. From the database, access was obtained to a list of current companies (the studied population) along with contact details. Invitations to participate in the study were sent by e-mail. The study was conducted at the turn of 2019/2020. What is important, we took into consideration only those companies, which confirmed the knowledge about Industry 4.0 concept and have implemented at least some of the I4.0 solutions.

Two forms of the questionnaire were adopted for the students – paper and electronic. At the same time, various channels of reaching the research group was used, i.e. seminar groups and student organizations from across Poland. The part of the study involving students was carried out between March and October 2020.
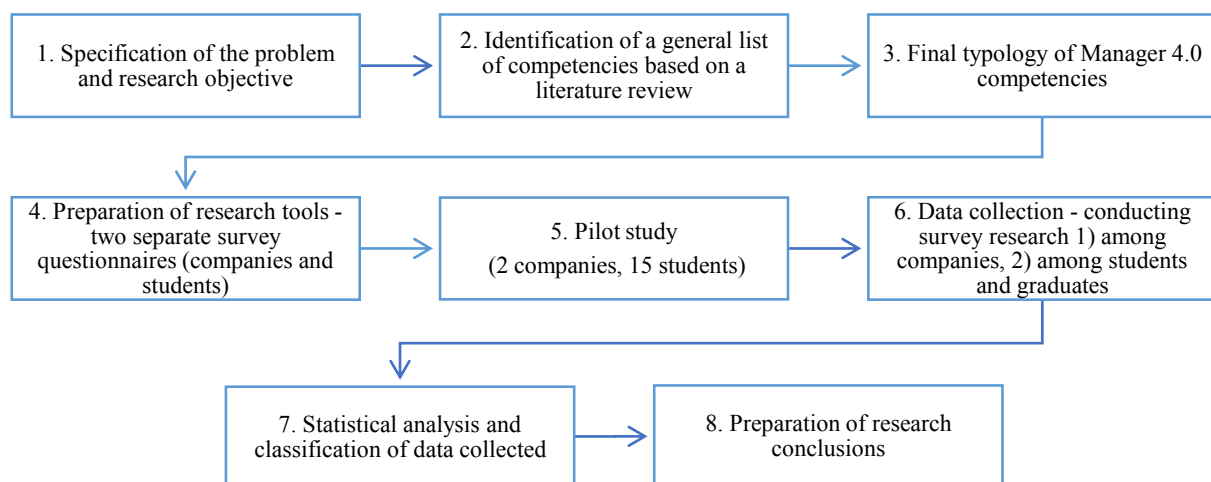


**Figure 1.** Research procedure.

Source: own elaboration.

The empirical data obtained was statistically analysed using the one-way ANOVA method. The distributions of the examined variables were presented in tabular and graphical form, and the structure, intensity and measurements of the descriptive statistics were defined. The results made it possible to identify competency gaps and verify whether they are statistically significant.

## 3.2. Research sample

The analysed empirical material was obtained as part of two studies. The survey of 120 companies included owners, board members, CEOs, executive directors, strategic directors and managing directors. The respondents represented manufacturing companies from the industrial processing sector that conduct business activity in Poland. Over 52% of the entities studied have already implemented some Industry 4.0 solutions or plan to start the process of digital transformation in the medium term, which – in our opinion, confirms the implementation of the adopted research goal. Detailed features of the companies studied are presented in Table 3.

**Table 3.**
*Characteristics of the companies examined*

| Feature | | Number | % of N in column |
|---|---|---|---|
| **Age of companies** | Created before 1989 | 41 | 34.1% |
| | Founded between 1989 and 2004 | 45 | 37.5% |
| | Established in the years 2004-2011 | 16 | 13.4% |
| | Established after 2011 | 18 | 15.0% |
| | Total | 120 | 100% |
| **Employment** | Fewer than 50 employees | 48 | 40.0% |
| | 50 to 249 employees | 46 | 38.3% |
| | More than 249 employees | 26 | 21.7% |
| | Total | 120 | 100% |
| **Source of capital** | Polish capital | 90 | 75.0% |
| | Foreign capital | 16 | 13.3% |
| | Mixed capital | 14 | 11.7% |
| | Total | 120 | 100% |
| **Industry / Economic Classification (PKD)** | Electrical appliances | 27 | 22.5% |
| | Groceries | 22 | 18.3% |
| | Machinery and equipment | 12 | 10.0% |
| | Chemical products | 7 | 5.8% |
| | Computers & Accessories | 6 | 5.0% |
| | Furniture | 7 | 5.8% |
| | Clothing | 5 | 4.2% |
| | Drinks | 4 | 3.3% |
| | Other | 30 | 25.0% |
| | Total | 120 | 100% |

Source: own elaboration.

The research sample was dominated by small and medium-sized companies founded before the popularization of the concept of Industry 4.0. The vast majority are entities with Polish capital representing various branches of the industrial processing sector, with more than half from the electrical appliances, foodstuffs, machinery and equipment industries.

The second research sample included students and graduates (up to 1 year after graduation) of economics (718 respondents) and technical (421 respondents) universities. State universities dominate – in particular in the case of students of technical faculties (Table 4). At the same time, it is worth noting that the sample is represented by students of all years of study, which allows for a holistic look at the educational program concerning the competencies required for Manager 4.0 positions.

**Table 4.**
*Characteristics of the student survey participants*

| Students | | Number | % of N in column |
|---|---|---|---|
| 1. University profile: | Technical | 421 | 37.0% |
| | Economic | 718 | 63.0% |
| | Total | 1139 | 100.0% |
| 2. Type of university: | State | 962 | 84.5% |
| | Private | 177 | 15.5% |
| | Total | 1139 | 100.0% |
| 4. Current year of study: | 1 | 166 | 14.6% |
| | 2 | 96 | 8.4% |
| | 3 | 195 | 17.1% |
| | 4 | 330 | 29.0% |
| | 5 | 259 | 22.7% |
| | Graduate | 93 | 8.2% |
| | Total | 1139 | 100.0% |

Source: own elaboration.

## 4. Research results

The results of the study confirm that education at every level as well as the personal development of today's and future managers should be focused on strengthening the key resources of knowledge, skills and attitudes necessary for acting as a manager in the process of implementing 4.0 technologies.

The results allowed us to identify statistically significant differences in the importance of the social, personal, managerial and technical-professional competencies of the survey respondents. The results indicate a lower perceived intensity of development activities for all the examined competencies in the group of students compared to the assessment of their importance (competence needs) made by companies.

The perceived intensity of development activities in the field of social competencies shows slight differences in the case of students of both types of universities (Table 5). Differences in this area are visible in the case of sharing knowledge and experience (2), presentation skills (4) and teamwork (6), where the average perception of the intensity of the conducted development activities of these competencies is statistically higher in the group of economics students. In addition, the highest importance for all respondents (including companies) was for teamwork, the average importance of which (3.77) was much higher than in the case of the other competencies studied. In turn, the lowest average importance for students (both economics and technical) was attributed to negotiation – this is interesting because companies considered this competence to be important (3.98) and desirable among employees responsible for implementing Industry 4.0 solutions. The biggest competence gap between students (in general) and companies is visible in building relationships and conflict resolution skills. In the case of the latter competence, there is a noticeable lack of preparation of future managerial staff to deal with conflicts and disputes among cooperation partners, as well as in relations with external stakeholders. The development of conflict resolution skills is gaining importance, especially in the context of the high assessment by companies of teamwork, which is a commonly used form of work in today's business environment. It is worth paying attention to the relatively small competence gap in the case of presentation skills and teamwork, which indicates a strong inclusion of these competencies in university teaching programmes.

**Table 5.**

*Comparison of the importance of social competencies between groups of students of technical universities (T), students of economics universities (E) and companies (F)*

| Social competencies | Average overall | Groups T \| E \| F | ANOVA | T — E — F |
|---|---|---|---|---|
| 1. Building relationships | 3.05 | $2.76^1 \approx 2.95^1 < 4.07^2$ | 84.505*** | 2,76  2,95  4,07 |
| 2. Sharing knowledge and experience | 3.35 | $2.99^1 < 3.32^2 < 4.09^3$ | 55.688*** | 2,99  3,32  4,09 |
| 3. Communicativeness | 3.41 | $3.19^1 \approx 3.32^1 < 4.23^2$ | 58.732*** | 3,19  3,32  4,23 |
| 4. Presentation skills | 3.44 | $3.16^1 < 3.44^2 < 3.79^3$ | 16.066*** | 3,16  3,79  3,44 |
| 5. Negotiating | 2.93 | $2.68^1 \approx 2.81^1 < 3.98^2$ | 80.663*** | 2,68  2,81  3,98 |
| 6. Teamwork | 3.77 | $3.41^1 < 3.77^2 < 4.24^3$ | 32.776*** | 3,41  4,24  3,77 |
| 7. Conflict resolution skills | 3.03 | $2.76^1 \approx 2.89^1 < 4.18^2$ | 99.659*** | 2,76  2,89  4,18 |
| 8. Intercultural communication | 3.00 | $2.78^1 \approx 2.94^1 < 3.68^2$ | 29.978*** | 2,78  2,94  3,68 |
| 9. Cooperation skills within the whole organization | 3.26 | $3.14^1 \approx 3.16^1 < 4.04^2$ | 46.352*** | 3,14  3,16  4,04 |
| 10. Knowledge of foreign languages | 3.31 | $3.24^1 \approx 3.23^1 < 3.90^2$ | 23.765*** | 3,24  3,23  3,90 |

Groups: T - students of technical universities; E - students of economics universities, F - companies
ANOVA - F statistic value; Post hoc S-N-K test (Student-Newman-Keuls) - belonging to groups [1,2,3] - the higher the value of the decimal point means the higher the mean in the group; statistical significance level (p-value): *** p≤0.001, ** p≤0.01, * p≤0.05

Source: Own elaboration.

In the case of the personal competencies assessed by both groups of students studied, the results indicate even smaller differences than in the case of social competencies (Table 6). A slight discrepancy is noticeable only in the case of entrepreneurial skills and the ability to work under pressure. These differences are understandable, taking into account the different fields of study and teaching programmes. The biggest competence gap in the area of personal competence can be seen in the case of problem-solving (6) and reliability (7). Expectations in the labour market regarding attention to quality, commitment to the tasks carried out, as well as identification of problems and the ability to effectively solve them, are much higher than the preparation of students in this area. This is an unquestionable conclusion because reliability is also a competence that companies considered to be the most important (4.43) of the analysed personal competencies. Interestingly, the smallest competence gap is visible in the case of the ability to work under pressure, which is an optimistic result in the context of the need to work in an unpredictable and changing business environment in the era of Industry 4.0.

**Table 6.**
*Comparison of the importance of personal competencies between groups of students of technical universities (T), students of economics universities (E), and companies (F)*

| Personal competencies | Average overall | Groups T \| E \| F | ANOVA | |
|---|---|---|---|---|
| 1. Pursuit of results | 3.41 | $3.33^1 \approx 3.30^1 < 4.17^2$ | 50.608*** | |
| 2. Entrepreneurial skills | 3.40 | $3.07^1 < 3.37^2 < 4.08$ | 42.522*** | |
| 3. Innovativeness and flexibility | 3.27 | $3.13^1 \approx 3.16^1 < 4.12^2$ | 53.448*** | |
| 4. Analytical thinking | 3.44 | $3.44^1 \approx 3.30^1 < 4.18^2$ | 46.741*** | |
| 5. Independence/decision making | 3.48 | $3.34^1 \approx 3.38^1 < 4.21^2$ | 44.767*** | |
| 6. Problem-solving | 3.44 | $3.28^1 \approx 3.33^1 < 4.29^2$ | 62.922*** | |
| 7. Reliability | 3.42 | $3.30^1 \approx 3.27^1 < 4.43^2$ | 79.667*** | |
| 8. Lifelong learning | 3.38 | $3.32^1 \approx 3.27^1 < 4.13^2$ | 44.036*** | |
| 9. Self-management (time management) | 3.41 | $3.25^1 \approx 3.32^1 < 4.09^2$ | 33.840*** | |
| 10. Ability to work under pressure | 3.41 | $3.54^2 > 3.27^1 < 4.02^3$ | 28.509*** | |

Groups: T - students of technical universities; E - students of economics universities, F - companies
ANOVA - F statistic value; Post hoc S-N-K test (Student-Newman-Keuls) - belonging to groups [1,2,3] - the higher the value of the decimal point means the higher the mean in the group; statistical significance level (p-value): *** p≤0.001, ** p≤0.01, * p≤0.05
Source: Own elaboration.

Slightly more differences are visible in the case of the intensity of development activities perceived by students in the context of managerial competency (Table 7). Students of economics universities rated the level of development of competencies such as team building (1), emotional intelligence (2), employee evaluation and development (3), task delegation (4) and motivating (5) higher than students of technical faculties. It is worth noting that emotional intelligence obtained the lowest average importance (2.91) among all the studied managerial competencies in the opinion of both students and companies. This conclusion indicates a low level of the use of this competence for the implementation of Industry 4.0 processes, which is partly confirmed by the lack of full agreement among researchers regarding the importance of this competence. In the literature review, only 12 out of 19 publications indicated its key importance for the effectiveness of Manager 4.0 activities (see Table 1). Some authors, in turn, believe that emotional intelligence is the basic competence for other competencies (Filipowicz, 2016, p. 78). The impact of emotional intelligence is wide - it affects almost all aspects of functioning in a managerial position. In the case of this competence, the largest competence gap between companies' expectations and the declared development activities in economics and technical studies in Poland is also noticeable. Emotional intelligence is a competence that is difficult to develop during the classic didactic forms adopted at universities (lectures), as it requires interaction with another person, knowledge of their needs and high self-awareness. The other two competency gaps and competencies in this category concern motivation and delegation of tasks. Both of these competencies support teamwork, a high level of which is required by companies. What is surprising, however, is the large gap in the area of motivating others, as it is an issue that is very often addressed within the framework of various subjects in study programmes, especially economics. Nevertheless, the problem may lie in the transmission of only theoretical knowledge and students' awareness of their lack of ability to put it into practice. The smallest competence gap was noted in the case of project management competency, which indicates that students are well prepared in planning and organizing project work, and know the principles of project management and building project teams.

**Table 7.**

*Comparison of the importance of managerial competencies between groups of students of technical universities (T), students of economics universities (E), and companies (F)*

| Managerial competencies | Average overall | Groups T \| E \| F | ANOVA | T — E — F |
|---|---|---|---|---|
| 1. Team building | 3.36 | $2.96^1 < 3.37^2 < 3.93^3$ | 37.550*** | 2,96 / 3,37 / 3,93 |
| 2. Emotional intelligence | 2.91 | $2.51^1 < 2.85^2 < 3.81^3$ | 66.170*** | 2,51 / 2,85 / 3,81 |
| 3. Employee evaluation and development | 3.10 | $2.74^1 < 3.05^2 < 3.88^3$ | 54.060*** | 2,74 / 3,05 / 3,88 |
| 4. Task delegation | 3.17 | $2.86^1 < 3.09^2 < 4.08^3$ | 64.912*** | 2,86 / 3,09 / 4,08 |
| 5. Motivating | 3.09 | $2.69^1 < 3.03^2 < 4.01^3$ | 66.524*** | 2,69 / 3,03 / 4,01 |
| 6. Strategic thinking / long-term planning | 3.36 | $3.09^1 < 3.31^2 < 4.03^3$ | 36.371*** | 3,09 / 3,31 / 4,03 |
| 7. Leadership skills | 3.19 | $2.90^1 < 3.13^2 < 3.95^3$ | 46.702*** | 2,90 / 3,13 / 3,95 |
| 8. Interdisciplinary thinking | 3.19 | $3.02^1 \approx 3.11^1 < 3.90^2$ | 41.763*** | 3,02 / 3,11 / 3,90 |
| 9. Comprehensive (systemic) approach to strategy implementation | 3.32 | $3.18^1 \approx 3.22^1 < 4.02^2$ | 41.181*** | 3,18 / 3,22 / 4,02 |
| 10. Project management | 3.55 | $3.29^1 < 3.53^2 < 4.03^3$ | 24.055*** | 3,29 / 3,53 / 4,03 |

Groups: T - students of technical universities; E - students of economics universities, F - companies
ANOVA - F statistic value; Post hoc S-N-K test (Student-Newman-Keuls) - belonging to groups $^{1, 2, 3}$ - the higher the value of the decimal point means the higher the mean in the group; statistical significance level (p-value): *** p≤0.001, ** p≤0.01, * p≤0.05

Source: Own elaboration.

In the case of technical competencies, there are many more differences in the intensity of development activities perceived by both groups of students (Table 8). These differences are particularly evident in the case of the competencies: understanding principles of manufacturing processes (3), manufacturing procedure (4) and basic programming skills (6), which may result from differences in curricula. An interesting result of the study, however, is that basic programming skills obtained the lowest average rating (2.30) in the opinion of all respondents. On the one hand, universities do not emphasize the development of these competencies (perhaps they also do not have adequate resources to teach them). On the other hand, the companies studied do not have high expectations in this area, although IT skills are the basis of technological progress − also in the manufacturing environment. Perhaps for companies, of greater value and more needed are specialists whose skills far exceed the basic level, and whose competencies allow them to implement advanced data programming activities. The most significant gaps in the area of technical competence can be seen within three competencies: understanding principles of manufacturing processes (3), manufacturing procedures (4) and the ability to use IT systems such as ERP, BI, and CRM (5). This shows that the education programme on the principles and procedures of production processes are not adapted to real market needs. The cost and variability of software solutions can be a financial problem and a competence challenge for university staff. The smallest competence gap was recorded in the case of understanding business models (1), which indicates a satisfying preparation of students to face the challenges of building and maintaining a competitive advantage in the market.

**Table 8.**

*Comparison of the importance of technical and professional competencies between groups of students of technical universities (T), students of economics universities (E), and companies (F)*

| Technical and professional competencies | Average overall | Groups T \| E \| F | ANOVA | T ●—E ▲—F |
|---|---|---|---|---|
| 1. Understanding business models | 3.19 | $2.93^1 < 3.17^2 < 3.73^3$ | 25.275*** | 2,93 / 3,17 / 3,73 |
| 2. Understanding the principles of technologies 4.0 functioning and the goals of their implementation | 2.49 | $2.41^1 \approx 2.33^1 < 3.49^2$ | 65.426*** | 2,33 / 2,41 / 3,49 |
| 3. Understanding the principles of manufacturing processes | 3.17 | $3.32^2 > 2.95^1 < 4.15^3$ | 79.040*** | 2,95 / 3,32 / 4,15 / 3,14 |
| 4. Manufacturing procedures | 2.69 | $3.14^2 > 2.38^1 < 3.78^3$ | 108.325*** | 2,38 / 3,78 |
| 5. Ability to use ERP / BI / CRM systems | 2.43 | $2.40^1 \approx 2.22^1 < 3.58^2$ | 77.255*** | 2,22 / 2,40 / 3,58 |
| 6. Basic programming skills | 2.30 | $2.89^2 > 2.04^1 < 2.93^2$ | 56.384*** | 2,04 / 2,89 / 2,93 |
| 7. Ability to quickly analyse data and information | 3.06 | $3.11^2 > 2.89^1 < 3.91^3$ | 48.894*** | 2,89 / 3,11 / 3,91 |
| 8. Understanding the basic principles of data protection and cybersecurity | 2.80 | $2.81^1 \approx 2.61^1 < 3.84^2$ | 65.088*** | 2,61 / 2,81 / 3,84 |
| 9. Quality management | 3.37 | $3.25^1 \approx 3.26^1 < 4.15^2$ | 42.368*** | 3,25 / 3,26 / 4,15 |
| 10. Process management | 3.34 | $3.21^1 \approx 3.25^1 < 4.09^2$ | 42.273*** | 3,21 / 3,25 / 4,09 |

Groups: T - students of technical universities; E - students of economics universities, F - companies
ANOVA - F statistic value; Post hoc S-N-K test (Student-Newman-Keuls) - belonging to groups [1, 2, 3] - the higher the value of the decimal point means the higher the mean in the group; statistical significance level (p-value): *** $p \leq 0.001$, ** $p \leq 0.01$, * $p \leq 0.05$

Source: Own elaboration.

## 5. Conclusions

It can be assumed that as a result of progressive automation and robotization, the scope of necessary work for low-skilled line workers will decrease. At the same time, managers will have to face greater complexity and abstractness in their environment, as well as increasing demands on problem-solving as interaction and connecting systems increase. The competencies assessed as part of the study form the basis for shaping an effective Manager 4.0, characterized by the appropriate knowledge, skills and attitudes desired for this position. At the same time, it is worth mentioning that the discussion on the results of the research is limited due to the small number of literature sources that directly refer to the competence gap in Industry 4.0.

Regarding the survey among companies in the industrial processing sector, it is worth noting that respondents do not expect from managerial candidates the ability to use IT systems, understand the principles of I4.0 or programming skills (which belong to the category of technical and professional competencies), which is also confirmed by the results of a study by Łupicka and Grzybowska (2018). On the other hand, the research results may seem quite surprising in the current era of progressive digitization (Rof et al., 2022). Most companies

expect employees in a managerial position to be able to solve problems as part of teamwork, to be reliable, and to have the willingness to participate in continuous learning. The high importance of long-life learning is also highlighted by Saniuk at al. (2021), according to whom such an approach requires the promotion of a climate of innovation, a change in learning culture and a new approach to talent development (Sivathanu, Pillai, 2018). Looking at the four competency categories analysed in general, the greatest needs are reported in the field of personal competencies, however, the differences between the competency categories are relatively small.

Looking at the four competence categories from the point of view of student evaluations, there are clear differences in the case of social, managerial, technical and professional competencies. A higher perceived level of shaping social and managerial competencies is declared by students of economics universities, in contrast to technical and professional competencies, which are developed to a greater extent at technical universities. It is interesting that in the case of personal competencies there is a visible convergence in the respondents' assessment, which may be due to the fact that the real impact of curricula on the formation of these competencies is limited.

Referring directly to the aim of the article, it should be noted that there is a competence gap in the labour market in each of the forty competencies analysed, although with some differences between technical and economics students. It is worth noting that analysis of the gap within individual competencies may be of greater cognitive value than the assessment of gaps within entire categories of competencies. The study proved that there are competencies within which the gap is small, e.g. teamwork and project management. This may be due to the nature of university learning experiences – frequent tasks carried out as part of project work. At the same time, some competencies indicate deep deficiencies in the knowledge, skills and attitudes of students with regard to the expectations of companies in the industrial processing sector, e.g. building relationships, conscientiousness and conflict resolution skills. From our point of view, these are competencies whose development often requires many years of experience in environments with joint responsibility for the implementation of common goals.

The results of the study confirm that the position of Manager 4.0 requires interdisciplinary employees who have competencies in many areas. Their education requires the adaptation of staff training systems and the process of educating students. We believe that both economics and technical universities do not sufficiently prepare future managers to take responsibility for the implementation of Industry 4.0 solutions and technologies. Universities, courses and training often artificially separate technical competencies from social or managerial ones (Saniuk, 2021), while in business practice they are interdependent.

### 5.1. Managerial implications

The conclusions of the research suggest the need to restructure student education programmes at universities with both an economics and technical profile. The study indicated the need for specific employee competencies, the development of which requires interdisciplinary study programmes in areas including production engineering and management. This, in turn, requires closer cooperation between companies in the industrial processing sector and the academic community. Such cooperation may naturally include practical classes and the implementation of team projects and activities in the field of R&D. The basis for such joint activities is the appropriate level of competence needed for cooperation, communication and the ability to build relationships. Increasingly, the literature mentions the legitimacy of introducing personalized and customized learning, which takes into account individual differences and needs (Shemshack, Spector, 2020, p. 6). Personalized learning aims to tailor the learning experience to the needs of different groups by adapting the content, structure and presentation to each individual person (Treiblmaier et al., 2004).

### 5.2. Limitations and further research areas

Firstly, the size of the research sample of companies does not allow the results to be generalised for the entire manufacturing sector in Poland due to the lack of entities representing all parts of this sector. Secondly, despite the glossary of definitions of competencies used during the survey, it is possible that individual competencies – in particular, the level of their development – may have been ambiguously understood by respondents. Thirdly, the degree of acquisition of some competencies may depend on the development of others, not necessarily from the same category (e.g. emotional intelligence as the basis for building relationships). Fourthly, the students' answers were declarative – the perspective of academic teachers could be a good supplement. Fifthly, we are aware of the debatability of the qualification of certain competencies to particular categories, which results from possible differences in interpretation. Finally, we should be aware that not every graduates from technical or economic universities expects to work on the managerial position.

The results of the study show potential directions for further research. First of all, future research could focus on the search for an optimal set of teaching tools that will allow the academics and companies to comprehensively build managerial competencies. Secondly, it would be worth repeating the research, in particular to assess the effects of the Covid-19 pandemic on the development or regression of certain competencies. Thirdly, there is also the idea of comparing the results of the research in Poland to the results obtained in other countries.

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# Appendix

**Table**

*Definitions of "Manager 4.0" competencies*

| Social competencies | Definition |
|---|---|
| 1. Building relationships | Establishing and building good relationships. Care for contacts and effective cooperation. |
| 2. Sharing knowledge and experience | Providing practical knowledge and advice in a useful way that makes it easier for others to achieve their goals. |
| 3. Communicativeness | Proper understanding of other people's statements, the ability to listen to and display information. |
| 4. Presentation skills | Ability to use techniques and principles of presentation in the process of effective communication. |
| 5. Negotiating | Developing mutually beneficial solutions for negotiations and maintaining positive contacts. |
| 6. Teamwork | Active participation in the work of the team is based on commitment and striving to achieve a common goal. |
| 7. Conflict resolution skills | Resolving disputes among colleagues, in the team and in relations with clients. |
| 8. Intercultural communication | The ability to effectively conduct interactions with members of different cultures, aimed at establishing relationships. |
| 9. Cooperation skills within the whole organization | Cooperation with other organizational units based on trust and willingness to pursue common strategic goals. |
| 10. Knowledge of foreign languages | Communication in speech and writing in a language other than the mother tongue in a way that is understandable to the recipients. |
| **Personal competencies** | **Definition** |
| 1. Pursuit of results | Striving to achieve set goals, facing difficulties, and looking for new opportunities. |
| 2. Entrepreneurial skills | Undertaking new, unconventional projects, and showing initiative in their research and implementation. |
| 3. Innovativeness and flexibility | Taking new initiatives and looking for innovative solutions in the case of deviation from standard situations. |
| 4. Analytical thinking | The ability to analyse information, think insightfully and to solve problems. |
| 5. Independence/decision making | Making the right decisions on time, based on the data and premises we have. |
| 6. Problem-solving | Identify the sources of problems and find optimal solutions for given situations. |
| 7. Reliability | Attention to quality and commitment to tasks. Readiness for a long-term effort. |
| 8. Lifelong learning | Willingness to constantly renew, develop and improve knowledge and skills. |
| 9. Self-management (including time management) | Effective self-implementation of tasks without detailed guidelines, and with efficient use of time resources. |
| 10. Ability to work under pressure | Dealing with time or other resource constraints, the difficulty of the task or having insufficient knowledge required to complete the task, or unforeseen changes or problems. |

Cont table

| Managerial competencies | Definition |
|---|---|
| 1. Team building | Create, integrate and organize team activities. |
| 2. Emotional intelligence | Recognizing your own and others' emotional states. |
| 3. Employee evaluation and development | Setting goals and expectations, monitoring performance, task inspection, coaching, consulting, mentoring and coordination of development activities. |
| 4. Task delegation | Delegate tasks to employees. Providing adequate information and powers and the support necessary for their implementation. |
| 5. Motivating | Building commitment and a positive attitude among employees in the implementation of tasks. |
| 6. Strategic thinking/long-term planning | Shaping the strategy of action based on data, analysis of the situation and trends. |
| 7. Leadership skills | Implementation of inspiring concepts, building the involvement of teams and individuals in the process of achieving goals. |
| 8. Interdisciplinary thinking | The ability to draw insights from many disciplines and apply them to one's area of interest in a way that challenges traditional views and enriches the conversation about it. |
| 9. Comprehensive (systemic) approach to strategy implementation | The ability to look at a complex system (and subsystems) from a global point of view without focusing on details, and to make effective strategic decisions based on this. |
| 10. Project management | Determination, coordination and control of project activities under the adopted methodological assumptions. |
| **Technical and professional competencies** | **Definition** |
| 1. Understanding and introducing business models | Ability to acquire and analyse the knowledge necessary to achieve a competitive advantage for the company and provide better insight into the functioning of the organization based on the planned business model. |
| 2. Understanding the principles of technology 4.0 implementation | Knowledge of the scope of technology 4.0, opportunities and threats related to their implementation in manufacturing companies. |
| 3. Understanding the principles of manufacturing processes | Understanding the principles and elements common to all manufacturing industries, e.g. making operational decisions at all levels of production in the context of series production, where speed, quality, cost and flexibility are key indicators. |
| 4. Manufacturing procedures | Practical knowledge and adherence to operating procedures and regulations for working at production workstations. |
| 5. Ability to use ERP / BI / CRM systems | Practical skills in using advanced, organization-wide computer software for enterprise resource management. |
| 6. Basic programming skills | Skills needed to write a computer-enabled program. |
| 7. Ability to quickly analyse data and information | Data analysis and drawing conclusions - understanding complex situations and relationships. |
| 8. Understanding the basic principles of data protection and cybersecurity | Understand the need to conduct business safely in the current cyber threat environment using the available range of supporting technologies. |
| 9. Quality management | Overseeing the activities and tasks that need to be performed to maintain the desired level of excellence in the organization. |
| 10. Process management | Define, control, coordinate and improve processes in your organization. |

Source: own elaboration.

# THE CHALLENGES OF HR DEPARTMENTS
# IN HYBRID WORK CONDITIONS

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**Purpose:** The aim of this paper is to present the challenges faced by HR departments in the hybrid work system. In particular new tasks set for HR departments in the conditions of hybrid work organization and competencies necessary for HR professionals to effectively deal with new tasks and challenges caused by the hybrid work settings were analyzed.

**Design/methodology/approach**: A systematic review of world literature was carried out using the following databases: Proquest, EBSCO, Emerald, JSTOR, Science Direct and BAZEKON. The results were supplemented with conclusions from two research conducted by the author on samples of over 100 companies operating in Poland.

**Findings:** A list of tasks anticipated for HR departments as a result of the introduction of a hybrid work system was created. A set of competences necessary for the effective performance of tasks was also proposed.

**Research limitations/implications**: The limitation of research is a very short research time span and large differences in the specificity of companies making it difficult to propose a universal model for each company.

**Originality/value:** The paper presents list of tasks and set of competences necessary in new conditions created by the introduction of hybrid working systems. It can be valuable for researchers and practicians.

**Keywords:** hybrid work, HR department, HR professionals.

**Category of the paper:** research paper.

## 1. Introduction

The concept of remote work or hybrid work, where stationary and remote work is combined, is not a new idea. Already in 1974, the term "telecommuting" was used to describe work performed using ICT tools (Nilles, 1974) and in 1983, remote work was defined as organizational work, performed outside the normal boundaries of space and time (Olson, 1983). The possibility of so-called teleworking allowed for temporary work at home, for various reasons. However, as a result of the outbreak of the COVID-19 pandemic, the situation has

changed dramatically, due to the fact that it was mandatory to switch to remote work, and thus somehow force employees to perform work from home. Adhering to new work arrangement was not the same in different EU countries, depending on their level of adaptability (Iordache et al., 2021). Nevertheless, HR departments everywhere had to implement new procedures even though there were yet no legal regulations available (Zaręba, 2021), office work had to be reorganized and other challenges such as: balancing multiple stakeholders needs, tensions between strategic and operational roles were faced (Collings et al., 2021).

The necessity to create new models for hybrid work is another step in the process of evolution of HR function (Ramlall, 2009), and this step requires creating a list of new tasks and acquiring by HR professionals appropriate competences (Bell et al., 2006), allowing them to effectively meet new challenges. Research gap concerns exact tasks and competences needed by HR professionals in this new circumstances. Thus, the aim of this paper is to present the challenges faced by HR departments in the hybrid work system. The following research questions were formulated:

1. What new tasks have been set for HR departments in the conditions of hybrid work organization?
2. What competencies are necessary for HR professionals to effectively deal with new tasks and challenges caused by the hybrid work settings?

## 2. Methods

To achieve the goal of this paper, a systematic review of world literature was carried out. The methodology of systematic literature review involves the implementation of several specific stages (Czakon, 2011) which was shown in Table 1. In the first phase, the above-mentioned purpose of the research was defined. Initially, the basic literature was selected using a review of the following databases: Proquest, EBSCO, Emerald, JSTOR, Science Direct and BAZEKON. In the next step, the selection of publications was made by searching for the following keywords in abstracts: "hybrid work", "remote work", "Human Resources", "HR", "HR department" in a group of scientific articles published since 2019 in Polish and English. It was decided to narrow down to the last three years, due to the desire to obtain the latest research results, showing the impact of changes caused by the COVID-19 pandemic. In this phase of the study, 114 articles were obtained for analysis.

Search results were developed by checking possible repetitions of articles or non-scientific articles and verification of the content of abstracts. It was decided to remove 59 articles. It should be underlined that many papers covering this subject are published in non-scientific journals which shows interest in the issue but lack of reviewed research. In the next stage, an analysis of the full content of the articles was carried out and on this basis it was decided to remove another 28 articles with content inadequate to the area of research. As a result, 27 studies were obtained. It is worth mentioning the limitations of the method used related to limited access to certain content. It was decided to choose the databases to which the author had access at least in part full-text, and the search mechanism made it possible to select the title and abstract. Data on the selected articles are included in the bibliography. The selection of publications was carried out in June 2022. In the next phase, a content analysis was carried out. Subsequently, the results of the research were developed.

**Table 1.**
*Research methodology*

| Stage number | Description | | | | |
|---|---|---|---|---|---|
| Stage 1. | Defining the purpose of the research | | | | |
| Stage 2. | Selection of databases: PROQUEST, EBSCO, EMERALD and BAZEKON | | | | |
| Stage 3. | Selection of articles with criteria as follows: a scientific article, published after 2019 in English or Polish. Keywords: hybrid work, remote work, HR, Human Resources, HR department | | | | |
| Stage 4. | Selection of 114 articles: | | | | |
| | Proquest 37 art. | Bazekon 5 art. | EBSCO 37 art. | Emerald 7 art. | JSTOR 17 art. | Science Direct 11 art. |
| Stage 5. | Removal of 87 articles (including 2 repetitive, 28 inadequate, 57 unscientific) | | | | |
| Stage 6. | Analysis of the remaining 27 articles' content | | | | |
| Stage 7. | Conclusions, summary of research | | | | |

Source: own study.

The results were supplemented with conclusions from the research conducted by the author on samples of over 100 companies operating in Poland. Details of the research have been presented in Table 2.

**Table 2.**
*Details on empirical research*

| No. | Number of respondents | Respodents' characteristics | Main area of research | Research tool | Year |
|---|---|---|---|---|---|
| 1. | 102 HR professionals (managers, specialists) | large organizations operating in Poland and representing 10 industries | Impact of COVID-19 on HR activities | CATI interview | 2020 |
| 2. | 103 HR professionals (managers, specialists) | large and medium organizations operating in Poland and representing 10 industries | Wellbeing in HR strategy | CATI interview | 2021 |

Source: own study.

# 3. Results

## 3.1. New tasks set for HR departments in the conditions of hybrid work organization

Performing teleworking resulted in an obligation for the employer to provide the employee with appropriate equipment with insurance, training in its operation and technical assistance (Gierszon, 2021; Pokojski et al., 2022). Meanwhile, it was only in 2020 that the remote work (or so-called home office) began to be regulated. Further legal regulations in this area should be expected, while tasks related to ensuring appropriate working conditions at home are usually performed by HR departments. There may be debates around discrimination, infringement of human rights and breach of contract claims thus employers should implement policies to uphold non-discriminatory practices in home-working system (Nath, Lockwood, 2021). Organizations preparing for hybrid work (managers, HR professionals, staff members) should take into account the risk of creating inequality in employee's visibility which may influence work assignments (Macke et al., 2022).

It seems though that the very first task of HR in cooperation with the management boards of companies in the post-pandemic era is to determine which model of work organization to adopt. Numerous ideas emerged lately e.g.: fully onsite (with or without rotating teams), hybrid/partially remote (with onsite "anchor" days and "flex" days or fixed in and out) or primarily remote (periodic – onsite once per month, seasonal, fully fluid where an employee decides about the location or the model with no possibility of working onsite) (BCG, 2021). Many factors should be taken into consideration such as, the industry, specifics of job position, performance effectiveness (Aslan et al., 2022) and employees characteristics: gender, position (Wong et al., 2021) and age (Murphy, 2021), which makes the tasks complex and difficult to implement. According to research the majority of employees are expecting changes of work settings voting for flexibility and the hybrid model (Diab-Bahman et al., 2020) seeing this as a benefit for a better work-life balance, greater responsibility for working time and independence.

Telework and hybrid work models affect i.e. reduce the building occupancy and raise new questions about office space, and energy consumption (Duarte et al., 2022). As telework grows, it is important to address also energy efficiency and CO2 emission and that will also be work performed by HR departments. For HR employees, this can be a completely new area of activity that they have not dealt with before.

An important task that will be carried out in a hybrid way by HR departments is the acquisition and onboarding of new employees. A large part of the recruitment process may be automated and organizations may use tools based on artificial intelligence, analytics, augmented or virtual reality, such as: ATS (applicant tracking systems), CV screening, first screens with chatbots, online tests which were a novelty to many before COVID but may stay as "new-normal" for good (Kuzior et al., 2022). A virtual helpdesk in the form of multilingual

chatbots may be very supportive not only for candidates but also for employees (Gatan et al., 2021). The readiness of candidates – especially of different ages – to use this type of technology in recruitment in a separate issue.

During the COVID pandemic, internships were carried out online or in e-learning form by some employers, which was met with positive opinions of students (Grzeszczak, 2021). However, such process requires from HR creating new online programs and implementing them properly considering candidates' and company's needs (AlGhamdi, 2022). Another issue is the onboarding of new employees as the key issue of creating bonds with the organization may be weakened due to the lack of direct contact with employees and the office. Nevertheless, HR professionals should design the process in such a way to respond to changed expectations for more personal, digital, timely and rewarding experience (Jeske, Olson, 2021). Flexible work may result in the need of implementing novel approach based on bi-level modeling in recruitment when flexible and hybrid work plans are offered for candidates.

Another area is implementing and operating HRIS, i.e. Human Resource Information Systems which was increased as a result of pandemic. There are numerous advantages that HRIS is offering such as improving service quality, calculating efficiency, speed, bringing value to the position of HR in organizations and saving costs (Vahdat, 2021). For different organizations COVID has acted as a "technological catalyst" in HR departments (Tursunbayeva, 2021). Apart from recruitment and onboarding, which have already been mentioned also employee training, employee data management, tracking attendance, payroll management, expense management, maintaining compliance, exit management and performance management are listed as HR processes that may be automated (Turcu, Turcu, 2021).

The issue which is often risen is wellbeing of employees working remotely (Juchnowicz, Kinowska, 2021; Rožman et al., 2021; Wierzchowska, 2021). Both researchers and managers discussed such challenges as: managing work-life balance (Yang et al., 2021), lack of social relations (Tuzovic, Kabadayi, 2021), problems with effectiveness, time and tasks management, so called "always-on" life (Risi, Pronzato, 2021), and others. At the same time, HR departments implementing activities supporting the wellbeing of employees report the following challenges: lack of employees' involvement (33%), treating the idea of well-being as a temporary fashion (32%), lack of financial resources (28%), lack of legal solutions (13%), lack of managers' involvement (10%), pressure on quick results (5%) (Tabor-Błażewicz, 2021).

Research on HR Business Partners tasks conducted by the author has shown changes caused by the COVID pandemic. The introduction of changes and building relationships with employees were indicated as most important both before and during the pandemic. On the other hand, the order of importance of these tasks has changed and the essence of introducing changes by HRBP has definitely strengthened ("implementing changes", indicated as the first priority by 52% of respondents and the second priority by 46% of respondents). The process of "building relationships with employees" fell to the second place, but was still important for

organizations (34% indicated it as the first priority, and 28% as the second priority) (Tabor-Błażewicz, 2022).

### 3.2. HR professionals' competencies necessary to deal with new tasks and challenges

Digital competence is the first group of competences necessary to carry out tasks related to the hybrid workplace. The need to carry out many personnel processes using ICT tools, organize virtual onboarding, develop employees using e-learning platforms, or support HRIS programs resulted in a rapidly accelerated development of digital competences, as employees were forced to learn how to use digital work tools and work platforms (Chafi et al., 2022; Vahdat, 2021). In this context, the attitude of employees, especially their willingness to cooperate with machines is also important. For some people, the possibility of algorithms taking over some of the tasks may pose a perceived threat to work safety.

Secondly, there is a need to possess legal competence concerning new rules and regulations implemented as a result of new working models. Changes in the law occur very quickly and these competences must be updated on an ongoing basis. Certainly, there will be a need to organize trainings for HR employees covering the scope of legal changes and ways of implementing them in business practice.

In the contemporary business environment, analytics play an increasingly important role understood as providing management boards with specific calculations of the costs and benefits of the actions taken. The HR department or HR Business Partner is often involved in this role. As a result of the adoption of the hybrid model, the competences related to analyzing the effects and calculating the results of the transition to remote work will gain in importance (Diab-Bahman et al., 2020; Radonić et al., 2021).

Last, but not least, it is propose to implement skunks works approach in HR departments as a response to non-routine people-related challenges and the need to operate quickly and effectively. Skunks works structures are understood as flexible, self-driven teams of employees empowered to work rapidly with minimal management constraints and achieve innovations (Biron et al., 2021).

## 4. Discussion and conclusions

The review of the literature resulted in listing a framework of tasks anticipated for HR departments in connection with the introduction of hybrid work. The most important element is to decide in cooperation with the management boards which model of hybrid work is suitable for a given organization. This task is not easy, due to the changing economic, social and personal conditions. The future may show that the chosen model is not entirely suitable and needs to be re-adapted, taking into account the attitude of employees and new circumstances.

Next, it is necessary to review personnel processes and introduce automation and support for two groups of employees: those staying in the office and working remotely. In this situation, we are dealing with two separate groups of employees, which is also not beneficial from the point of view of building organizational ties, an atmosphere of trust and cooperation between employees.

On the basis of the tasks, an outline of competences necessary for employees of HR departments has been created. Digital competences, which are necessary to perform tasks in a hybrid work organization, play a special role. This can lead to inequality among HR employees caused by lower digital knowledge by older employees who have been working in HR departments for many years and their possible negative attitude towards such changes. It is necessary to train these people so that they can fully effectively carry out the tasks entrusted to them and give them support in the process of changes.

There are research limitations caused by:

- a very short period of time of observation,
- multiplicity of approaches to the hybrid work system due to the characteristics of companies, workplaces and employee needs, which results in problems with creating a universal set of tasks,
- differences in the "starting position" of companies – some organizations have already introduced the possibility of remote work for years and had well-established rules and procedures, while for some companies hybrid work was a complete novelty, requiring a comprehensive change in the organization of work,
- dependence on organizational culture and national culture influencing the willingness of employees to switch to hybrid work, managers' approach to employee control, and HR's ability to propose and implement changes.

The research contributes to filling the research gap considering the next phase of the development of the personnel function resulting from the transformation of the work organization from a stationary to a hybrid model. They point to changes in the traditionally understood HR function and its modernization and adaptation as a result of external changes.

In practical business terms, research contributes to a better understanding by companies what roles HR can play in the transformation to a hybrid work system, what tasks can be assigned to HR and HRBP and of what competencies should be required of candidates for positions in HR departments so that they can fully effectively carry out new tasks.

Further research are needed to recognize other aspects of implementation of hybrid work system, especially how wellbeing of employees changes over time while performing work in remote way.

## Summary

The article presents challenges faced by HR department resulted from implementation of the hybrid work system. The systematic review of literature along with results of research made it possible to create a list of tasks and set of competencies required from HR professionals. The most important task is to decide which model of hybrid work would be appropriate for the organization. Then, which personal processes may be automatized or performed in a hybrid way. Thus, digital competences play a crucial role in managing HR issues. The problem is new and further research are needed to recognize different conditions for implementation of hybrid work systems.

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# LEAN JOURNEY SUCCESS FACTORS –
# A CASE STUDY OF LEAN TOOLS IMPLEMENTATION SEQUENCE IN A MANUFACTURING COMPANY

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**Purpose:** The study aim is an in-depth investigation of a Lean tools implementation sequence in an organisation as an expression of a Lean journey within that organisation. The success factors of Lean tools implementation and the relationship between them are studied. A model of Lean tools implementation in an organisation is aimed to be developed.

**Design/methodology/approach:** A case study method is employed in this study. It is conducted in a manufacturing company from the fast-moving consumer goods (FMCG) industry. The employed method allows exploitation of a variety of techniques in the investigation process: in-depth interviews, observations, documents and data analysis. The study takes into consideration a systematic literature review and bibliometric network analysis supported by the Vosviewer software tool.

**Findings:** The implementation of Lean Manufacturing approach, along with accompanying tools and methods, is aimed at efficiency and/or quality results of the processes within a company. Selected tools, to be successfully implemented, should support the elimination or reduction of losses related to current process flows. There are many Lean tools available, but most do not fit all organisations and all the kinds of manufacturing processes. Therefore, proper preparation before implementation is an essential issue for any organisation striving for Lean outcomes. The available Lean tools, along with their implementation sequences, are not studied comprehensively in the literature.

**Originality/value:** An organisational-development-driven model of Lean tools implementation is elaborated, based on the literature and empirical investigations. The decision to choose the appropriate Lean tool should be guided by general organisational development. Several factors need to be considered before the implementation process, namely, capabilities, resources, gains and return on expenditure. Top management engagement, appropriate communication and listening to line employees look to be key success factors in Lean tools implementation.

**Keywords:** Lean Manufacturing, Lean tools, Lean implementation.

**Category of the paper:** Research paper, Case study.

## 1. Introduction

Lean is a methodology that delivers superior performance for an organisation. This entails delivering for customers more value from existing resources with fewer additional costs. An extensive review of the literature on Lean implementation identified many managerial and organisational factors that should be developed in order to implement all Lean practices in effective ways (Aij, Teunissen, 2017; Antony, Gupta, 2019; Yadav, Desai, 2017).

Previous research has focused on a detailed and comprehensive understanding of which factors are key to Lean implementation and how they impact performance improvement (Netland et al., 2019). However, the researchers did not conclude whether and to what extent these factors are implemented in practice (Knol et al., 2018). Therefore, it seems that research that focuses on a detailed examination of implementation practices and identification of success criteria is necessary. Special attention has to be focused on Lean tools, which are tangible forms of the Lean approach's existence in the organisation.

The Lean Manufacturing approach reveals the proper tools to be used for starting and sustaining a continuous-improvement culture across an organization (Karem, 2017). There are many Lean tools available, but most do not fit all organisations and all the kinds of manufacturing processes. The choice of a Lean tool possibly depends on the specific production process in a company; however, this is not reported in the literature. Another closely related issue is the success factors that should be met in order to effectively implement given Lean tools. This study is an in-depth investigation of a sequence of Lean tools implemented in an organisation as an expression of the Lean journey within that organisation. The study presents a systematic literature review and bibliometric network analysis supported by the Vosviewer software tool. A case study method is employed; it is conducted in a manufacturing company from the fast-moving consumer goods (FMCG) industry. The work towards a management useful model of Lean tools implementation is undertaken.

## 2. Lean tools interconnection according to bibliometric measures

Lean tools are designed to reduce the main losses in organisations and improve quality control. They also strive to eliminate processes that are not valuable. Lean tools are utilised across many industries from manufacturing to engineering to finance and medicine. Some of them are techniques for managing people, and some are frameworks for solving problems, while others offer ways of thinking about structuring work (Brandenburg, Ellinger, 2003). All of these Lean tools are designed to eliminate waste, increase efficiency and make the most

of resources. Nowadays, for many manufacturers, Lean is an essential system that helps them maximise their potential while reducing their carbon footprint and overall spend.

Lean tools focus on efficiency improvement and continuous improvement of processes (Dresh, 2018). For example, according to some sources Kaizen is also perceived as a Lean tool, which customises correctly according to an organisation's need and can support continuous improvement in safety, quality, processes and productivity (Womack, Jones, 2003). At the same time, a whole improvement movement within the organisation is also named 'Kaizen'. The idea behind Kaizen is that every employee, regardless of position in the hierarchy, can share ideas which could help improve processes.

All these tools have significant meanings in a Lean implementation; however, tools must not be copied directly from the literature. Lean practices and tools should be adapted carefully for each organisational framework to achieve continuous improvement and long-term results in the enterprise. To identify the most popular Lean-manufacturing methods and terms discussed in literature, analysis of the articles has been conducted from the database Web of Science. Figure 1 below presents the results of such research as a network diagram. To prepare this, the visualisation software tool Vosviewer has been employed. The analysis includes 1471 articles published after the year 2000. The search has been narrowed by using keywords such as: 'continuous improvement', 'implementation' and 'performance' or 'lean manufacturing tool'. Additionally, in this research, attention has been paid to three main categories connected with the production and manufacturing areas: 1) management or industrial engineering, 2) mechanical and 3) multidisciplinary or manufacturing engineering.
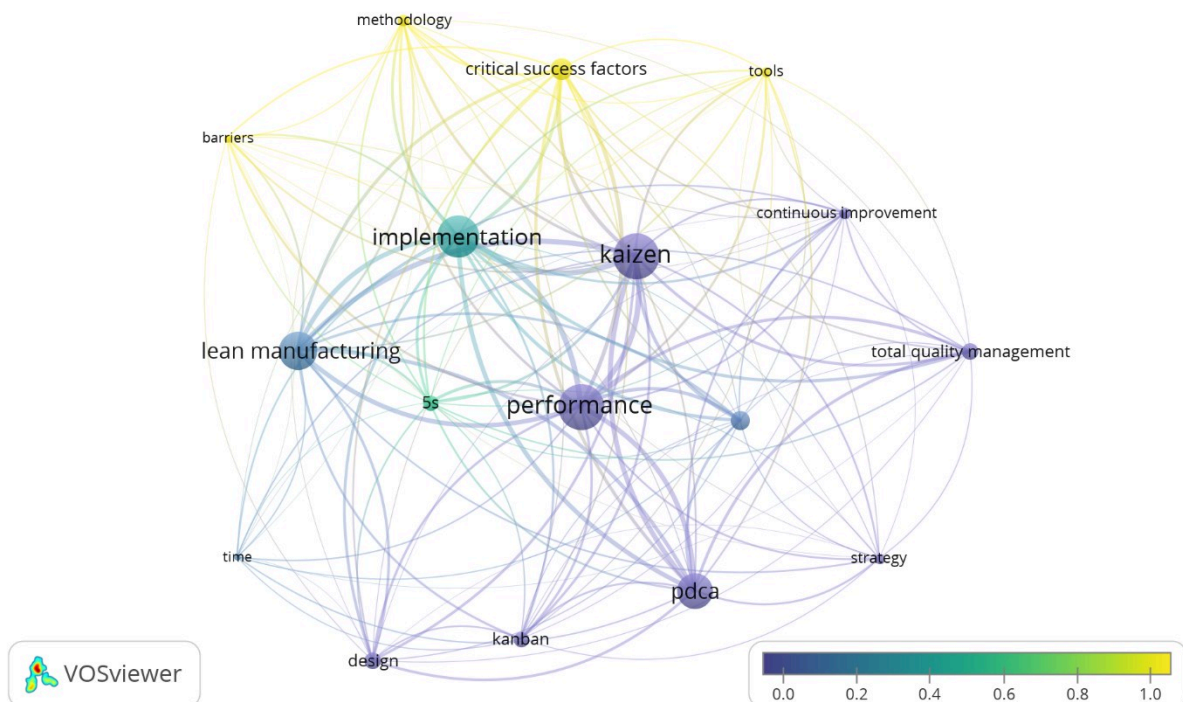


**Figure 1.** Bibliometric network diagram.

Source: own elaboration.

The network diagram (Figure 1) introduces the most popular Lean Manufacturing methods and terms based on the Web of Science Core Collection. The number of connections are of special importance in its analysis. In the same group, PDCA and Kaizen were identified as having strong connections with total quality management, performance and implementation. In total quality management, PDCA is a fundamental tool to improve processes in organisations. The PDCA cycle effectively provides a feedback mechanism about the current status of the implementation and helps develop continual quality improvement. In the second group, a strong connection was identified between the general term 'implementation' with Kanban, 5S and time. In the third group, critical success factors have a network of connections around elements such as barriers, tools and methodology. This means that the Lean method should be selected appropriately to the needs of the company, depending on the problems that need to be eliminated. The success of implementation depends not only on the tools applied or the new processes mapped out but also on how willing the organisation is to undergo a cultural change and reach organisational maturity. The methods for implementing this approach come from the experts – such quality leaders as Philip B. Crosby, W. Edwards Deming, Armand V. Feigenbaum, Kaoru Ishikawa and Joseph M. Juran (Deming, 2012; Ishikawa, 1985; Juran, Godfrey, 2000).

5S implementation as part of daily life within a company means much more than improved organisation, sustained cleaning routines and efficient activity flows. By using the 5S methodology, operators are encouraged to improve their overall work environment and reduce waste (muda) (Gupta, Jain, 2014). For example, 5S is a foundational part of the Toyota Production System because until the workplace is in a clean, organised state, achieving consistently good results is difficult. The lack of properly managed space may lead to mistakes, slowdowns in production and even accidents, all of which interrupt operations and impact the company in many negative ways. The PDCA cycle is a method used to coordinate a continuous improvement project. This approach helps companies to carry out improvements systematically. It leads the improvement towards the direction of preventing error recurrence by establishing cyclical standards of work and continuing standardization (Moen, Norman, 2009).

Kanban in the manufacturing industry is considered a Lean Production method by managing the production and supply of components according to the demands of the specific production order (Moen, Norman, 2009). The size and sequence of production orders are adjusted to market demand. In this way, exactly as much is produced as is currently needed (Weiss, 1988). Kanban was developed at Toyota and revolutionised their production. Kaizen is a management approach focused on continuous improvements in operations. Different elements of Kaizen are being utilised by the manufacturing industry to improve the performance of current manufacturing-system processes (Singh J., Singh H., 2017). Kaizen can be considered a strategy where employees at all levels of the company work together proactively to achieve regular, incremental improvements to the manufacturing process.

## 3. Views in the literature on Lean tools implementation success factors

Based on survey data from 1757 large, medium and small US manufacturing firms (Shah, Ward, 2003), the synergistic effect of all Lean practices was associated with better operational performance. When products are produced in a single-piece flow and value-added activities follow each other continuously, operational performance increases. To successfully implement Lean practices, organisations need to continuously improve their processes. Thanks to this research, it should be known which of these methods are the most popular and which key success factors are the most important during Lean implementation.

During the implementation of Lean projects in an organisation, functional team leaders assume responsibility for it (Coetzee et al., 2019). Another important element is the fact that successful implementation involves many factors. It should be taken into account which tools have been selected, what approach has been used, and what is the current state of knowledge and experience of managers and production workers about Lean (Seidel, Saurin, 2020). Most studies nowadays take a broad perspective when analysing critical implementation factors. Leadership practices are presented as a general list of recommendations (Katayama, 2017). Therefore, in order to gain a more thorough understanding of specific relevant factors, it is necessary to focus on the subset of factors that are most relevant to the organisation and study them in more detail during practical implementation.

After systematic analysis of the literature, key success factors for an effective Lean implementation can be summarised. The results are presented in Table 1.

To identify the key success factors during Lean implementation, a review of scientific articles published in last 20 years was carried out and the 10 most common factors in the literature were selected. Many factors affect the implementation of Lean initiatives. An analysis of the literature reveals that three factors emerge as being particularly important: commitment of top management, learning focus and an appropriate communication model. Nevertheless, all 10 factors are extremely important during Lean implementation. Depending on the size of the organisation and the company's advancement in a culture of continuous improvement, these factors are conducive to achieving higher results during implementation. Identification of these factors is an important part of the case study conducted on the research object (company). Thanks to this, it is possible to verify if managers can confirm that these key success factors have a connection with practical Lean implementation in the company.

**Table 1.**
*Key success factors in Lean implementations*

| Key success factor | Description | Connor, Cormican, 2021 | Yadav, Desai, 2017 | Laureani, Antony, 2017 | Jedynak, 2015 | Tari, 2005 | Garcia et al., 2014 | Rymaszewska, 2014 | Knol, et al., 2018 | Morito et al., 2017 | Sim, Rogers, 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Commitment of top management** | Top management take part in Lean activities on production lines and have an open approach to new ideas. They consider all effective ideas elaborated by shop-floor employees. | X | | X | | | | X | | | X |
| **Realistic success criteria** | Lean activities support achieving the main goals of the company. Lean focuses on the biggest bottlenecks in the company (top three losses). | X | | | | X | X | X | X | X | |
| **Appropriate communication model** | Each employee has access to information and the same understanding of Lean. Ideas and knowledge are exchanged honestly, clearly and transparently. | X | X | X | | | | X | | | X |
| **Education and training** | Managers and shop-floor employees take part in training focused on improvement concepts, tools, techniques and team building. Each identified lack of knowledge is supported by training. | X | | X | X | | X | | | | |
| **Effective system of awards and recognition** | The organisation recognises the most engaged employees and creates a positive environment to support them in development. | X | X | X | | | | | | X | X |
| **Appropriate selection of the implementation team** | The team responsible for implementation has knowledge and experience in production processes and fully understands Lean methodology and opportunities. | X | | X | | X | X | | X | | |
| **Performance management system** | Process data from all levels is measured and visualised to control production, prevent defects and indicate opportunities for improvement. | | | X | X | X | | | X | | X |
| **Focus on production workers** | All accurate suggestions are considered and implemented to improve business performance. There is an open model of communication in the organisation. | X | X | | X | | | X | | X | X |

Cont table 1.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sufficient resources** | Sufficient time and money are available for training, analysis and improvement activities. Top management is open to new implementation solutions. | X | | | | X | | X | | X |
| **Learning focus** | Both positive and negative experiences are discussed, and mistakes are considered opportunities for improvement rather than deserving of punishment. | X | | X | X | | | | | X |

Note. In table "X" means that authors identified given factor in the study.

## 4. Case study investigation protocol

In this research, case study methodology has been chosen to examine the practical sequence of implementing methods in the company and verify why the company decided on this order. Also, another important issue is to check the correctness of implementing the methods, in accordance with the methodology and assumptions. This approach allows usage of different techniques when analysing the data: quantitative and qualitative, depending on the context.

This case study was conducted in a FMCG manufacturing company. It is a company that has been implementing Lean Manufacturing over the last six years, gradually expanding the scope of implementation with new tools and methods. About 1,500 employees work at the studied facility. The respondents for in-depth interviews were employees and managers who were deliberately selected from the departments related to the implementation of Lean, namely: production, administration, planning and logistics. Data collection was performed within the company through observation and structured-interview techniques with these respondents. Additionally, interviews were conducted with managers to understand the production processes and obtain better knowledge of the Lean functionality and the benefits that had been achieved. There was also a physical on-site visit to the manufacturing facility. The investigation will be focused on four Lean methods: 5S, Kanban, Kaizen suggestion system and PDCA.

While collecting data in the company, the managers took part in open-ended interviews based on the research scenario. A sequence of queries had been prepared to ensure the accuracy and quality of the field investigations. Each of the queries served as the beginning for a series of 'digging' questions asked of an interviewee; the list of queries is presented below:

1. Which methods were practically and effectively implemented in your company?
2. What was the motivation to introduce each of the methods?
3. How the implementation process was going on, what were the implementation steps?
4. Were the methods modified and/or adjusted to suit the company's needs? What exactly was changed?

5.  What benefits have the organisation achieved thanks to the methods?
6.  What were the difficulties and obstacles during implementation and later use?
7.  What were important factors that enabled smooth and efficient implementation of the methods?

To perform the evaluation of Lean implementation even better, deep analysis of the provided documentation was conducted. In order to understand it correctly it was essential to conduct interviews with employees from a variety of departments, as indicated above.

## 5. The case study findings

Figure 2 shows a visualisation of the implementation of particular Lean tools in the investigated manufacturing company. At the beginning, in 2015, the company decided to implement the 5S method to improve safety and provide proper organisation at the workplace. 5S allows achievement of higher efficiency by faster execution of orders, quality improvements and most importantly – less likelihood of accidents. After a positive impact on daily work was achieved, the decision about PDCA implementation was made. It was responsible for timely problem solving and elimination of the lack of standardisation in terms of action-taken and results achieved. The company wanted to build a continuous improvement culture to manage problems in an effective way. Seeing the business benefits of previous development projects in 2018, the organisation decided on a Kanban implementation in response to waste (material losses for production orders). This decision was based on deep analysis of the potential benefits. Before implementation, managers elaborated the success factors for this initiative. Finally, after four years of developing a continuous improvement approach in the company, they decided on one. It was a Kaizen technique – a suggestion system, referred to as 'Kaizen cards'. Employees were allowed to report suggestions and ideas that could improve safety, quality and efficiency in the organisation.



**Figure 2.** Lean tools implementation sequence in the studied company.

Source: own elaboration.

### 5.1. The 5S method

At first, the studied company decided on this method because it is a basic method that shows production workers the benefits of organising the workplace and complying with standards in a simple and inexpensive way. The organisation struggled with the problem of disorderly workplaces and losses in production, which were related to the search for basic fast-rotating parts to be replaced on production machines and appropriate tools for cleaning, inspection and lubrication of components on the production line. After some training for managers, the first production line was selected, since it had the greatest mess according to the production workers. The most important element of the line training was to convince the participants that this solution could help them in daily work and they would be better able to work in a standardised workplace. All participants of the training spent the entire day on the production line together with the project leader. It started with taking photos, to be able to make a comparison of before and after the implementation. Another task was to separate the things needed from those that were unnecessary in the workplace. Then, the places for individual tools and items were designated and signed using coloured tape and purchased containers/drawers. All suggestions of what should stand (and where) were suggested by the employees of the production line. It was they who designed the perfect workplace for themselves. Only in this way were they able to accept such a big change and get used to the new order. After the entire workplace was standardised and a summary photo was taken, the opinions of the entire production team were collected. This took place one week after work on this system was completed. After positive recommendations, a 5S implementation plan was created on other production lines, as well as on communication routes. This solution was also introduced for the positions of office workers. Three months after the implementation, the company had a problem with maintaining the 5S standard in its original form. The problem was connected with the differing levels of employee motivation and also with new production workers in the organisation. The project manager responsible for 5S has now developed a 5S mini-audit as a control element, which is performed monthly on each production line by the managers responsible for particular production areas. This helps to keep the 5S plan working properly. The main benefits that the company has achieved are the improvement of working conditions on production lines, production machines maintained in better condition (in terms of cleanliness) and thus better efficiency results. As reported by interviewed managers, some cost components have been slightly reduced after 5S implementation across the entire factory. The key success factor during 5S implementation was appropriate communication between all sites engaged.

## 5.2. The PDCA method

After the successful implementation of 5S, the organisation was ready to take another Lean initiative but were not sure in which direction to go. Therefore, they decided to conduct a loss analysis in each of the departments and select the main loss that should be eliminated (or reduced to a minimum). When each department had selected a problem to be solved, it conducted an internal workshop of high-level managers with over 10 years of experience in manufacturing companies. Together with the external company that specialises in Lean methodology, they decided to implement PDCA. For this purpose, an organisational PDCA model board was designed, according to which each department should work. Individual elements had been selected in such a way as to create an endless cycle of continuous improvement supporting the work of each department. In order to ensure timely implementation and to have full control over work progress, regular meetings (once every two weeks) of the head of the department were scheduled, with members from the department responsible for implementation of individual elements. In the event of any activities being delayed, the team considered together what they should change or who else should be asked for help. In this way, the department manager had full control over solving the given problem. After completing the implementation phase, the functionality of the solution was checked for the next four weeks. The organisation designed this PDCA model by considering their business needs. If it turned out that full success was achieved, they moved to the next problem. If not, an analysis was performed to identify errors during implementation, with the creation of a recovery plan that supported achievement of the goals. The main barriers to implementing PDCA focused on the planning phase, namely, there was a problem with erroneous data collection and identification of the root cause of the problem. The organisation sees huge potential in the application of the PDCA cycle and constantly invests in training employees in appropriate understanding of individual elements of the cycle. The culture of continuous improvement, identifying main losses and eliminating them positively influences the improvement of business results. This solution influenced problem-solving time, reducing it on production lines by 20%. The key success factors in PDCA implementation were the commitment of top management and the use of an appropriate communication model.

### 5.3. The Kanban method

After conducting the annual loss analysis, the company identified waste with the amount of material losses for production orders. It often happened that the ends of the materials stored in the warehouse took up pallet places or were disposed of and did not return to production on the same order. By analysing the available Lean methods, Kanban responded to the needs of this problem. A project group had the task to design a solution that would reduce material losses in the organisation. They started with an analysis of data for individual production orders. On this basis, it was possible to determine what amount of a given material was needed to produce a particular order. Kanban cards were created for each type of end product. In addition, an analysis of the size of materials used in production was carried out and special Kanban trolleys were designed, which were delivered to a given production line with the appropriate amount of material for the order. In the event of a change of orders, the warehouse worker delivered a new Kanban cart with the materials for the new order, and the Kanban from the previous order was taken back. Thus, the utilisation of warehousing work equalled 100%. The greatest difficulty in implementing this solution was to indicate the percentage of stock that should be accepted for each production order so that the material loss was as small as possible and the production order was 100% fulfilled. Production workers were engaged to determine this figure using all available detail. Compared to other tasks, it was the most time-consuming. Ultimately, the project turned out to be a success; the company reduced material losses by about 20% and reduced material stock in the warehouse by 15%. In this Kanban implementation, the key success factor was a focus on production workers.

### 5.4. Suggestion system

Earlier Lean projects showed how big effects can be achieved due to the appropriate implementation of particular tools. In order to implement the Kaizen approach on a wider scale, they decided to choose the project manager responsible for analysis of the available tools and development of a solution that would meet the company's expectations. As the first element of the project, he organised a workshop with production workers to learn in-depth about their needs. It turned out that some of the solutions that employees proposed to their superiors for implementation on the production line were not implemented due to lack of time to analyse them. This was a kind of waste. To take advantage of this, a suggestion system was developed; within it, each of the employees could describe their improvement proposals. After the Kaizen card was filled in, it was assessed by an experienced maintenance mechanic in terms of the feasibility of a given solution and in terms of profitability. When the solution was not implemented due to low profitability, the person who submitted the given solution always received feedback on the status of their application so that they would not lose the motivation to submit new ideas. This method was referred to by the organisation as a Kaizen suggestion system. In the case of solutions that were implemented, the already functioning PDCA cycle

was used as a process overseeing the planning, execution, verification and collection of the final results of the implementation of a given innovation. The Kaizen card was initially very popular in the organisation. Almost every employee reported at least one improvement that they would have liked to have seen implemented during the year. At one point, some barriers occurred, such as low commitment of top management in appreciating employees for their ideas and a financial barrier that prevented the implementation of all submitted ideas. After this, a reward system for solutions was introduced. The process had been improved and the changes were communicated to all employees. In some cases, the proportion of defective finished products was reduced from 0.9% to 0.4%. In other cases, the replacement of parts of the drive component was saved by 12% due to the self-cleaning solution. The key success factors in the suggestion-system implementation were a focus on production workers and the commitment of top management.

## 6. Discussion

The Lean tools implemented in the analysed organisation required a high level of employee involvement at the shop-floor level. To do this, high-level managers had to show their commitment to this change and provide appropriate resources, namely, training line employees, purchasing appropriate tools for the implementation of individual solutions (tape, containers, stickers, boards) and being open to employee suggestions. The management board of this company is sure that Lean is a necessary step to improve competitiveness. Brandenburg and Ellinger (Brandenburg, Ellinger, 2020), in their review of human-resource development issues, suggested that companies that want to implement Lean effectively should plan for a proactive organisational learning experience; this was confirmed in the investigated company. The variety of observations, along with literature studies, allow the researchers to conceptualise a model Lean tools implementation, as it is presented in figure 3 below.

**Lean tools implementation model subordinated to the organization's development**
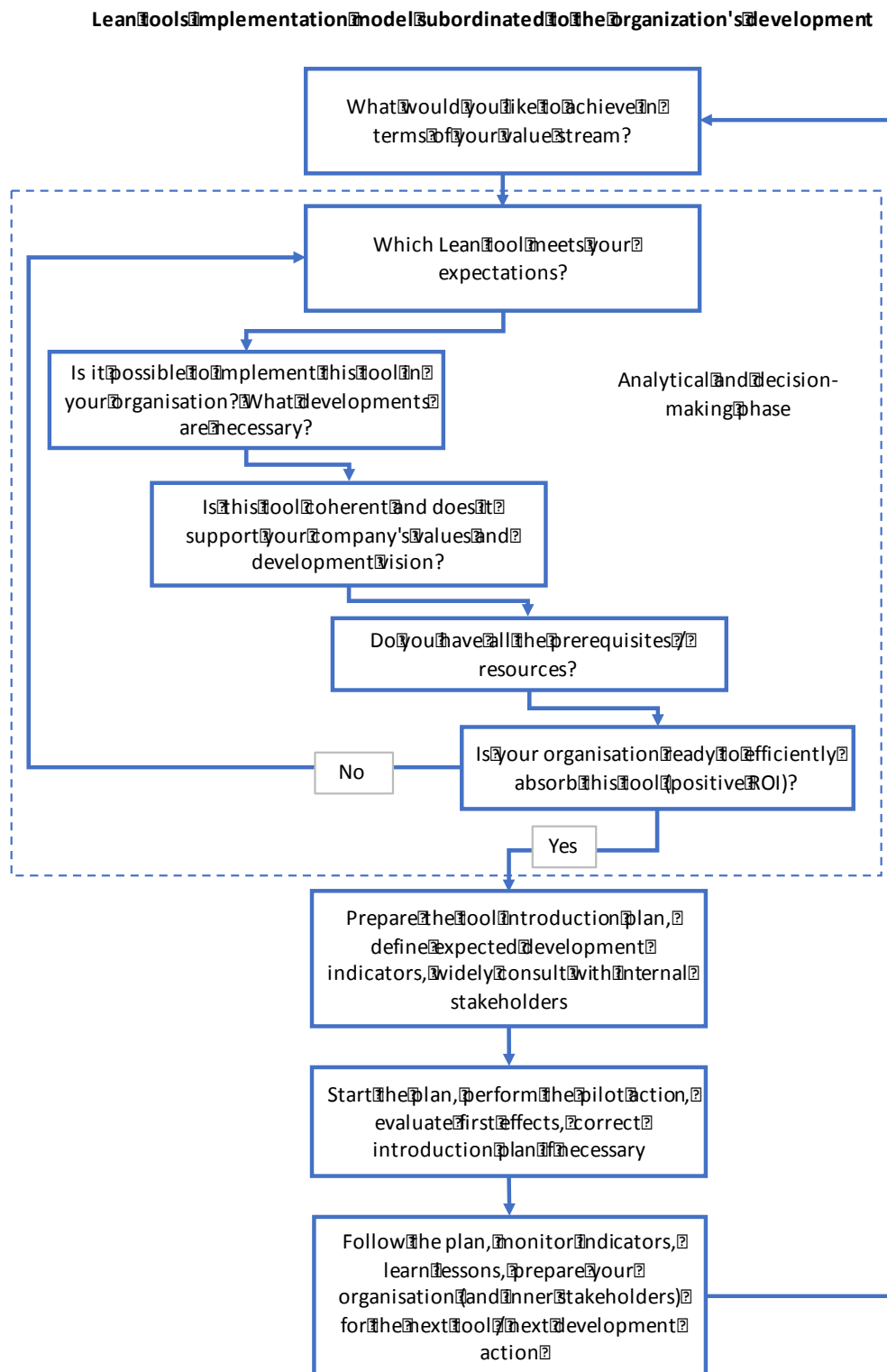


**Figure 3.** Organizational development driven Lean tools implementation model. Source: own elaboration.

During Lean-method implementation in any company the important issue is always the preparation. Top management should communicate why they decided to do it, what the benefits will be and who will be participating; they should also offer their full support to the project (Safayeni et al., 1991). Figure 3 introduces an approach (algorithm) of how Lean tools have to

be well chosen and implemented. This is a practical approach, subordinated to whole-organisation development. The model starts with business-needs identification; what is fully coherent in the Lean approach needs to be reflected in the value stream. Another set of steps is devoted to comprehensive analysis of the Lean tool that is being considered for implementation (analytical decision-making phase). A very important step is meticulous planning of the introduction, which includes inner-stakeholders' engagement, wide training and a pilot phase. All initiatives should be understood by each employee. After that, in the pilot implementation, the key element is a full focus on engagement and suggestions from employees because this provides essential direction on what should change in any given method to adjust it for the needs of the particular organisation.

A key point during Lean tools implementation is to fully understand the philosophy of the given tool and link it with identified business needs in the organisation. If all employees understand the value of a given tool, it is easier to achieve engagement and create a system that enables a work culture to develop. On the other hand, without understanding Lean philosophy, it is very hard to manage implementation because employees have a problem with believing in the potential benefits. The value stream has to be a first and the only reference point for any changes (improvement) within the organization. So, as it was argued above the Lean tool considered as possibly to be implemented within the organization is valuable as much as it will bring hard benefits in the stream of value. The authors' experiences are that the implementation of a Lean tool needs to be preceded by a rigorous benefits analysis, based on facts as much as it possible on particular stage of organizational Lean maturity.

An additional purpose of the field investigation was to verify the importance of factors of Lean success found in the literature. Interviewees in the company suggested these three main success factors:

1. A real commitment from top management.
2. Targeted and comprehensive communication with all engaged parties and inner stakeholders.
3. Providing encouragement for and actually following line-employee suggestions.

The two first factors above are aligned with top literature key success factors. The third one is identified in fifth position in the literature as a focus on production workers. Employees agreed that the example of attitude and commitment to Lean must come directly from the management of the organisation. Their approach to Lean guides the organisation and sets priorities. The study confirmed to a great extent the observations presented by Lean literature.

## 7. Conclusions and limitations

It is important that the selected Lean methods implemented in a production company respond to the current problems, challenges and main losses affecting the organisation. If, after implementing the first Lean method, a manufacturing company sees a business effect, it might wonder which method to implement next. As they make Lean decisions, managers should evaluate the impact and capabilities of each Lean method and the difficulties of implementing them in the specific organisational context. This should be based on an in-depth analysis of organisational losses and gains; the voices of experienced managers are of the most importance. At the same time, it is important that these managers understand the possibilities of various Lean principles. Additionally, an important point is to have clear communication about the need for change and the main targets.

The main contribution of this study is that it has enriched knowledge about the practical implementation of Lean tools in manufacturing organisations. It proposes an organisation-development-driven approach to Lean tools implementation. The study suggests that implementation success largely depends on appropriate preparation and adaptation of a tool to the needs of the organisation.

The main limitation of this study comes from the research methodology employed; the case study methodology has been focused on only one research object (company). This company has implemented four Lean tools, and it was confirmed that they had a positive impact on the business results. It is hard to provide accurate business results due to the lack of information about expenses of Lean implementation tools and levels of profit. Future research could use the built-in factor model and guiding questions to verify how the same research will perform in other production companies.

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# NETWORK ORGANIZATIONS ON THE SPORTS MARKET – THE CASE OF WTA

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**Purpose:** The aim of the article is to present an example of a solution applied in economic practice in the field of the structure of the global WTA network organization, with particular emphasis on the relations between its main participants – the organizers of tennis tournaments.
**Methodology:** Considerations in the article, beyond the theoretical part, based on a review of the literature on the subject, were carried out with the use of the descriptive method. For the purposes of the article, available source materials from the resources of the WTA organization were used, as well as the co-author's own observations made during many years of cooperation with this organization.
**Findings:** The study allowed for the identification and relatively rich description of the structure of the WTA as a network organization. It explains how the WTA organization functions on the global tennis market, on which general and theoretical principles it is created, and what benefits it brings to both the WTA and its members.
**Originality/value:** The WTA network presented in the article and the "coalitions" of its members brings forth the diversity of the structures of network organizations. This signifies that a network integrator must skillfully shape and manage relations with emerging subgroups of stakeholders with different priorities, needs and goals.

**Keywords:** Network organization, network of relations, sports market, tennis.

**Category of the paper:** case study, general review.

## 1. Introduction

A look at modern management concepts leaves no doubt that the measure of success of any organization is primarily its openness to the environment, the ability to cooperate, drawing on the resources of other entities and the readiness to share one's own.

Not bilateral contacts anymore but omni-directional and multi-level networks of relations are a typical phenomenon in various industry markets, regardless of the size of an organization or its place in the value chain. For this reason, the problem of the network of relations or its functioning has become the subject of numerous studies and scientific analyzes in the world of. This article is also devoted to the issue, this time the authors focused their attention on one of the world's largest sports organizations operating in the field of tennis which is the Woman's Tennis Association. The professional sports market is characterized by conditions that are rare or unheard of in other industry markets, therefore sports organizations building networks of relations must be guided partly by different principles. This dissimilarity as well as the fact that sports market relatively rarely is explored from the perspective of the network of relations constitute an interesting case worth analyzing.
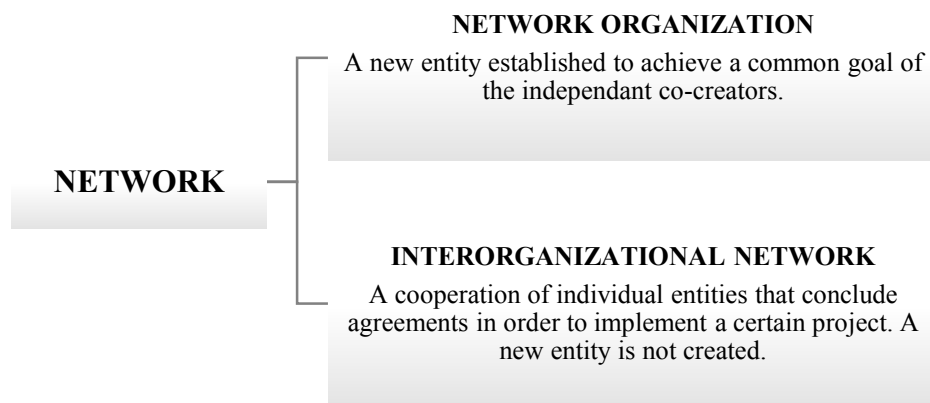
The aim of the article is to present an example of a solution applied in economic practice in the field of the structure of the global WTA network organization, with particular emphasis on the relations between its main participants - the organizers of tennis tournaments. The global circuit operates on the well-established in theory concept of a network of relations and so it can be an interesting example of the operation of a network organization in practice. Considerations in the article, beyond the theoretical part, based on a review of the literature on the subject, were carried out with the use of the descriptive method. For the purposes of the article, available source materials from the resources of the WTA organization were used, as well as the co-author's own observations made during many years of cooperation with this organization. The method used allowed for the identification and a relatively rich description of the structure of the WTA organization along with the principles of its functioning on the global tennis market.

## 2. Network organizations

In the literature, the concept of network has a very wide meaning, and its definition differs depending on the field of science in which it is analyzed. The ambiguity of the term can also be seen in the sub disciplines of management sciences, which results, among others, from different views on the number and types of entities forming the network, the nature of the bond, the level of control, the boundaries, the purpose of functioning and the level of analysis (Niemczyk, Stańczyk-Hugiet, Jasiński, 2012; Ratajczak-Mrozek, 2010; Światowiec-Szczepańska, Kawa, 2018). It confirms the complexity of the problem of the network of relations.

It should be noted that the term network in management sciences is most often understood as one of the two organizational forms: interorganizational network or network organization (Figure 1).

The interorganizational network is a form of a cooperation between many entities that does not result in creating a new entity. Subjects included in the interorganizational network communicate with each other or conclude agreements with varying degrees of formalization in order to implement a specific project. On the other hand, a network organization is a newly created entity whose co-creators and at the same time components remain independent while focused on achieving a common goal (Niemczyk, Stańczyk-Hugiet, Jasiński, 2012; Ratajczak-Mrozek, 2010). Due to the purpose adopted in the article, further considerations will focus on the problem of the network treated as a network organization.

**NETWORK ORGANIZATION**

A new entity established to achieve a common goal of the independant co-creators.

**NETWORK**

**INTERORGANIZATIONAL NETWORK**

A cooperation of individual entities that conclude agreements in order to implement a certain project. A new entity is not created.

**Figure 1**. Organizational forms of a network.

Source: „Sieci międzyorganizacyjne. Współczesne wyzwania dla teorii i praktyki zarządzania" by J. Niemczyk, E. Stańczyk-Hugiet, and B. Jasiński. Copyright 2012 by Wydawnictwo C.H. Beck.

The interorganizational network is a form of a cooperation between many entities that does not result in creating a new one. Subjects included in the interorganizational network communicate with each other or conclude agreements with varying degrees of formalization in order to implement a specific project. On the other hand, a network organization is a newly created entity whose co-creators and at the same time components remain independent while focused on achieving a common goal (Niemczyk, Stańczyk-Hugiet, Jasiński, 2012; Ratajczak-Mrozek, 2010). Due to the purpose adopted in the article, further considerations will focus on the problem of the network treated as a network organization.

It is worth adding that network organizations have structures in which vertical coordination and formal relations have been partially or entirely replaced by horizontal links between partners, and its assets have been divided so that the creator of the end result is the network, not its individual participants (Czakon, 2012; Hatch, 2012; Ratajczak-Mrozek, Zieliński, 2013; Rudny, 2013). The members of a network organization are in most cases economically interdependent but legally autonomous. Its goal is to achieve a competitive advantage, and what distinguishes it from other structures is a special type of relationship. The participants of a network are connected by complex and mutual ties of a more cooperative than competitive nature, which cross the boundaries of individual enterprises, and at the same time in a structural context resemble the internal relations of an organization. The way in which a network

organization operates depends on how and under the influence of what factors it was created, as well as what experience it has. Failures and conflicts can lead to disintegration, while cooperation is strengthened by positive experiences (Partanen, Möller, 2012; Sydow, Wirth, 1999; Windmill, 2003). Contrary to the common, self-emerging networks, network organizations are characterized by deliberately build structures and roles negotiated between their participants that must be managed in order to achieve the set goals (Moller, Rajala, 2007; Skowron, 2013).

On the other hand, Czakon (2012) points out that in order to be able to distinguish a network organization from others, one should focus on the features that characterize relations. Otherwise, any structure with several entities and ties between them could be called a network organization. The network organization is distinguished by vertical disintegration, i.e. a departure from the hierarchical system in favor of horizontal relations; the emergence of new entities, the so-called brokers who by taking various positions in the network, coordinate its activities; access to information instead of long-term trust building; the value and the rules for its distribution are determined by all participants; complementarity of participants leading to a synergy effect (Child, Faulkner, Tallman, 2005; Czakon, 2012; Mikuła, Pietruszka-Ortyl, 2006).

Diversified needs and goals of cooperation allow to distinguish five types of network organization (Brilman, 2002; Wiatrak, 2003):

- An integrated network is a set of dispersed entities belonging economically or legally to one economic group, created as a result of, inter alia, a merger.
- A federated network based on solidarity and cooperation resulting from the shared needs of participants. It is created as an outcome of horizontal integration and cooperation of entities with a similar nature of activity.
- A contractual network created between statutorily independent entities in order to expand their competences and reduce risk. It is based on franchise and concession agreements, but it can also arise as a result of vertical disintegration.
- A network created in an incubator such as local authorities, institutions and enterprises, technology parks or research laboratories.
- A network of direct relations that implements the strategy of penetration and occurs, inter alia, in trade, politics or religion.

Networks have been studied from different perspectives, but relatively little attention has been paid to managing the entire network. This may be due to the assumption that networking is voluntary, which traditionally means that it should not be considered in the context of hierarchy and control (Kenis, Provan, 2006). Antivachis, Angelis (2015) draw attention to different methods of network management, which depend on the nature of the network manager.

Creating new network layouts or entering existing ones enables individual participants as well as the entire network to achieve specific strategic goals. The motives of joining the network are considered by researchers in the context of the potential benefits that a participant may obtain (Brilman, 2002, Child, Faulkner, Tallman, 2005; Czakon, 2017; Grant, Baden-Fuller, 2004; Niemczyk, Stańczyk-Hugiet, Jasiński, 2012; Rokita, 2005; Shoemaker, 1990; Tubielewicz, 2013).

## 3. Network of relations in the sports market

It is estimated that at the turn of the 20th and 21st centuries, the global sports market generated annual revenues in excess of USD 400 billion (Greenwell, Danzey-Busell, Shonk, 2014). This value included the sale of sports products and services, the sale of rights to broadcast sports events, as well as fees for participation in mass sports events performed by participants acting as fans or players. Such significant financial results may indicate at least two issues. First, there is a very large number of entities on the sports market, such as: producers, distributors, organizers of sports events, the media; and secondly, there are numerous interactions or relations of a competitive or cooperative nature between them. It is confirmed by B. Mullin, who claims that one of the features of the sports market is the simultaneous competition and cooperation of entities operating on it (Mullin, Hardy, Sutton, 2000).

On the other hand, Hunt and Morgan (1995) state that the long-term development of sports organizations, which will be subject to further consideration, is determined primarily by having non-material attributes in the form of reputation, tradition, know-how and an extensive architecture of relations with the environment. Currently, market structures are characterized by an increasing number of relations between its participants, the progressive process of the disappearance of the distance between space and time, blurring of the zones of influence and interpenetration. The consequence of this is the growing importance of partnership relations and developed ties between organizations and entities that may be directly or indirectly interested in it (Eiriz, Wilson, 2006).

Nowadays, the need to build relationships is not a subject of discussion. Every organization, including sports, is assumed to be an open system that reacts to incentives sent from its surroundings, actively participates in the processes of exchange of information, services and values, is subject to the constant influence of the environment and powers its shape at the same time (Gronroos, 2011). At the early stage of creating a network of relations, the contacts of a sports organization with entities from its closer environment take an episodic, irregular, fragmented and rarely controlled form. With time, however, they gain importance, their number grows, some of them take the form of complex communication processes in which more than two entities expressing different demands and expectations are involved. In such a situation,

a need arises to consciously shape the network of relations and methodically manage this intangible resource of a sports organization (Epp, 2013).

In the sports market, the usual networks of relations between stakeholders are formed in three areas: internal, external, and networking. In the case of sports organizations, internal relations result from the relations within it and usually develop from the beginning of its existence in a vertical, horizontal, or cross pattern. On the other hand, external relations refer to contacts that an organization establishes with entities from its environment, such as suppliers, cooperators, sponsors, local government organizations, public institutions, media, etc. (Wemmer, Emrich, Koenigstorefer, 2016). Based on these interactions, because of their large number and frequent repetition, a network of relatively permanent relations will be formed of entities which, due to their competences or emerging expectations, are even more involved in the sports market. The connections existing in such networks can be described as relative links because the interactions between entities, to be effective, require the establishment of common goals, and then periodic or permanent cooperation (Ford, Hakansson, 2006).

It is worth adding that on the sports market, the links of organizations forming the network of relations may take a market (business), social (socializing) and cultural character, depending on the type of stakeholder and their position in the network or the expectations expressed towards it (Evans, Movondo, 2002). Information, financial or material streams flow between network participants in one, two or more directions, which play a key role in achieving mutual benefits and strengthening further relationships (Ritter, Walter, 2012). These ties may be permanent, but in some cases, due to the cyclical nature of organized sports events, the intensity of these contacts varies considerably over time. This phenomenon distinguishes networks of relationships in the sports market from those that can be found in other industry markets. Moreover, it is noted that even within the sports market, the architecture of relations is not homogeneous. For this reason, understanding it requires many separate studies and analyzes (Watt, 2003; Gadde, Hakansson, 2008).

## 4. Woman`s Tennis Association as an example of a network organization

The history of the WTA dates to the second half of the 20th century, when a group of nine players led by Billie Jean King took up the fight against gender inequality in the distribution of prize money awarded to women and men at professional tennis tournaments. As a result, in 1973, the Women`s Tennis Association (WTA) was established, which is now one of the two, next to ATP, largest global sports organizations operating in tennis (Ruth, 2021).

WTA is an example of an organization constituting a unique partnership in professional sport because it brings together two types of entities, i.e., players and tournament organizers. A consciously created structure and clearly defined roles of its individual members serve the effective management of the highest-level competitions and representing the interests of the WTA in the world of sport.

According to the strategic approach, there are networks created on a non-accidental basis, which are sets of entities with defined roles, having a common goal. In such a network organization there is a leader who coordinates and manages the activities of the entire network. To this end, it selects appropriate partners with whom it creates and then develops a network of a more formal and long-lasting nature. This does not mean, however, that there are no fewer formal relations within the network organization or that its members lose their independence. Networks of this type are based on closer cooperation of their participants, who, as already mentioned, remain independent and usually establish informal relations with each other (Brandenburger, Nalebuff, 1996; Jarillo, 1995; Möller, Rajala, 2007; Ratajczak-Mrozek, 2010).

In this understanding of the problem of the network, the WTA can be called a network organization, associating players and tournament organizers, who constitute its core and play a decisive role in the success of operating on the tennis market. Despite the formal structure of the WTA, its members, according to the network definition, remain independent market participants while establishing and maintaining informal ties with each other.

The network organization of the WTA has a dual nature, combining elements of the contractual and federated networks. It is based partly on solidarity and cooperation resulting from the common needs of participants, and partly on licensing agreements of statutorily independent entities. The cooperation of entities with a similar nature of activity allows them to expand their competences.

To obtain the membership status and become a formal participant of the WTA network, players must meet certain ranking criteria and take part in the required number of tournaments. Whereas the tournament organizer becomes a formal member of the network after obtaining a sanction for an event (WTA Tour, 2021).

It is worth adding that the most important, supreme body responsible for the management, strategic directions of WTA development and undertaking activities is the Board of Directors. It is composed of three Player Class Directors who are players' representatives, three Tournament Class Directors representing tournament organizers and one delegate from the International Tennis Federation (WTA Tour, 2021).

The WTA network is open, which means that apart from the above-mentioned, it also includes other entities that contribute to the success of the entire organization to a greater or lesser extent. Moreover, not only the number but also the variety of partners in the WTA network may change over the time. This makes the network being a dynamic structure ready to react to market signals and to take advantage of opportunities or avoid threats appearing in its environment.

The analyzed network organization in the context of its internal structure can be viewed in a narrow or a broad perspective (Figure 2). As mentioned before, the narrow perspective of the WTA network covers two main groups of its participants, i.e., WTA tennis players and WTA tournament sanction holders[1]. This is complemented by the Board of Directors, representing both groups of entities in management matters.
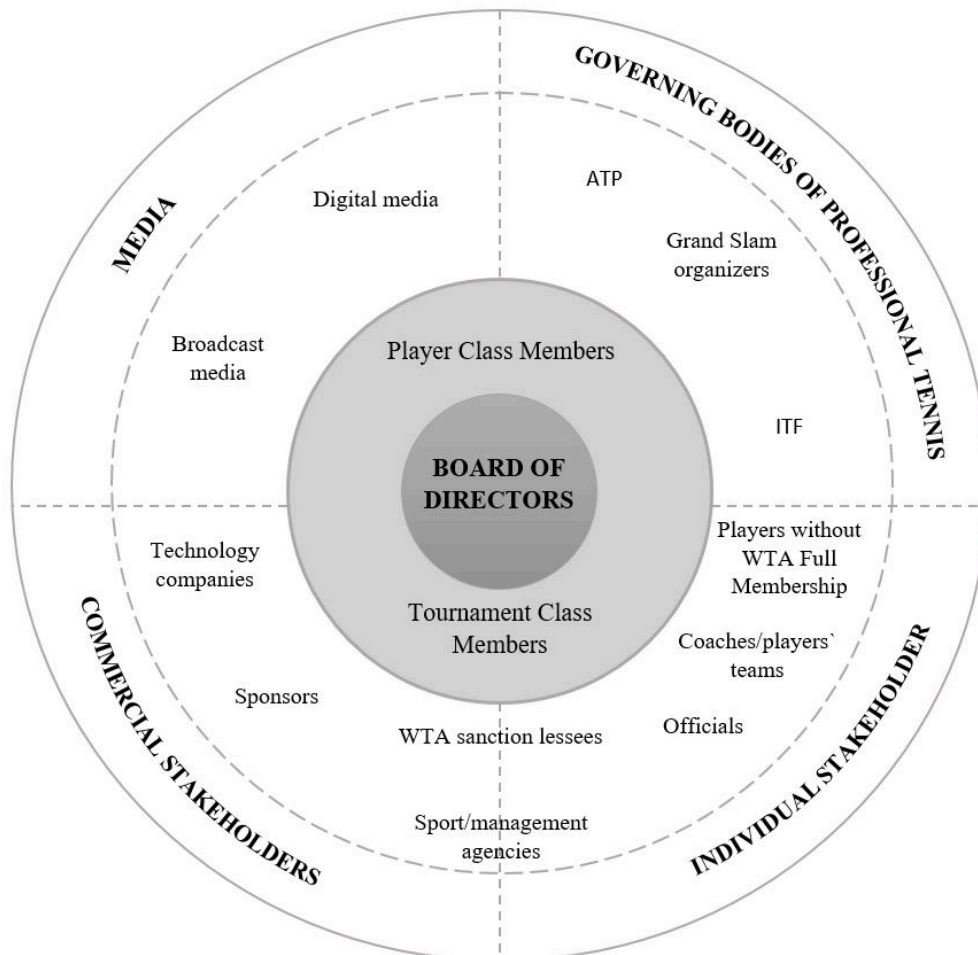


**Figure 2**. Narrow and broad perspective of WTA network.

Source: own elaboration.

Apart from tennis players and organizers of the tournaments, who have formal connections in the network, the WTA is supported by other stakeholders who often have a direct impact on the implementation of many sports undertakings. Stakeholders that are part of the WTA network can be broadly classified into four groups:

1. Governing bodies of professional tennis at the global level. They cooperate with each other on an ongoing basis, e.g., during the development of the tournament calendar or the regulations in force in the sport, as well as within the framework of a joint anti-doping and anti-corruption program.

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[1] The WTA Tournament Class Member is the sanction holder who does not necessarily have to be the tournament organizer. The rights to organize the event may be lent to another entity.

2. Media acquiring television and digital rights. Together with governing bodies, they participate in the preparation of the annual calendar of events and schedules of individual tournaments, to obtain the most optimal schedule, considering the needs of fans watching the struggles of players in different parts of the world.

3. Individual stakeholders. These can be tennis players who have not yet obtained WTA full membership, coaching staffs and other people cooperating with the players. This group also includes the judges necessary to conduct the tournament, as well as some licensees and independent managers who do not belong to sports agencies.

4. Other commercial stakeholders. This highly diverse group includes sponsors, business partners, companies providing specialized equipment or services, agencies representing groups of players, as well as tournament organizers with WTA sanction who are not Tournament Class Members.

The WTA Tour, which is the season of professional women's tennis competitions, includes four categories of events held all over the world (WTA Tour, 2021):

**WTA 1000 Mandatory** is a category of tournaments in which participation is obligatory for any player who qualifies based on the ranking. There are four such events during the season taking place in the following cities: Indian Wells, Miami, Madrid, and Beijing; constituting the most prestigious WTA tournaments to which a sanction can be obtained. The WTA 1000 Mandatory tournaments offer players not only the greatest prize money, but also the highest number of ranking points.

**WTA 1000** is the second-highest category of WTA tournaments, with five such events taking place a year: Doha/Dubai (they change statuses every year: WTA 1000/WTA 500), Rome, Toronto/Montreal (each location takes place every other year, changing with the ATP tournament), Cincinnati and Wuhan.

**WTA 500** is a category of about dozens of tournaments that take place every year around the world, and this number changes each year. Their prestige is lower than the categories described above, and their organization is also burdened with lower WTA requirements.

**WTA 250** is the lowest tournament category with the highest number of events in the season. These events are the least prestigious in the WTA Tour catalog, offering players the lowest points and the lowest financial prizes.

## 4.1. Tournament responsibilities and benefits to WTA

The main goal of establishing the WTA network was to coordinate women's tennis tournaments held around the world and to promote the sport. The goal defined in this way required the involvement and close cooperation of many entities, in this case mainly players and organizers. While the role of tennis players is primarily participation in sports competitions and creating spectacles for the audience, the role of the organizers is more complex. WTA sets certain expectations for them, which must be met if the organizer wants to be a formal member of the network and derive benefits from it. Each tournament organizer must meet at least the

minimum standards set out in the WTA Official Rulebook. Moreover, the expectations differ depending on the category of the tournament the organizer is running. The requirements are much higher for WTA 1000 Mandatory tournaments, and less restrictive for the tournaments of the lower categories.

Requirements of key importance to enter and then remain in the WTA network can be defined on two levels: sports and marketing.

At the sports level, requirements are strictly related to the facility and the operations of a tournament.

WTA determines how the infrastructure of the event should be prepared, including match and practise courts, lighting of the facility, WTA offices, medical space, and other operational spaces, etc. The minimum number of seats for fans in the stands is also indicated, as well as media facility.

The operations of a tournament include the processes of planning, implementing, and controlling the various stages of organizing the tournament which should result in an efficient and professional event under the auspices of WTA. In the context of WTA requirements, the key logistic elements are providing players and their teams, WTA staff and officials with hotel rooms of an appropriate standard, access to the tournament restaurant, transportation from and to the airport, as well as from the hotel to tennis facilities. The fulfillment of these conditions is verified by the WTA delegates partially prior to the start of the tournament.

On the marketing level, WTA sets mandatory and optional requirements towards the organizers. The mandatory marketing activities, distinguished in the WTA Official Rulebook, oblige a tournament organizer to undertake minimal promotional activity. However, to be successful, WTA recommends and encourages the tournament organizer to engage in additional initiatives and projects.

Mandatory activities include branding, ACES program (various activities with the participation of players aimed at promoting the tournament, WTA, or WTA sponsors), a properly equipped press center and corporate hospitality addressed to WTA or its sponsors. A tournament organizer receives remuneration from WTA for meeting the requirements for branding and corporate hospitality activities; while failure to meet them or any delays may result in a reduction in the benefit or even a penalty. Sponsorship is a separate, no less important issue for WTA. There are two main groups of sponsors: WTA sponsor, which has an agreement with WTA organization, and the sponsors of individual tournaments with which the organizers are contracting.

Optional marketing activities are undertakings that go beyond the standards set out in the Official Rulebook. Although they are not compulsory, they play an important part in organizing a tournament and may translate into its success. WTA recommends or indicates practices that work well at other events, if necessary, but an organizer may also come up with their own ideas. Optional promotional activities can be one of the factors contributing to the effective and efficient conduct of a tournament, allowing it to remain on the WTA network for an extended period. At the same time, failure to use the potential of this area can lead to a quick setback and abandonment of the network. Optional marketing activities include ticket sales system, social media activity, merchandising, selling TV rights on the domestic market, or organizing fan zones.

Membership in WTA, apart from prestige, is associated with several tangible benefits, which make the interest in belonging to the network invariably very high. The benefits of participating in the WTA network can be classified into three categories:

- Access to new resources – entering the WTA network allows for a much better cast of the tournament. The higher the category of the event, and thus the larger prize money and ranking points pool to be won, the higher-rated tennis players will want to take part in it. However, access to new resources is not limited to players. It also includes professional support from WTA experts and representatives, as well as access to more advanced technological solutions and the knowledge and experience of other tournament organizers belonging to the network.

- Increasing the marketing range – by entering WTA, the tournament participates in the international broadcasting rights pool, obtaining not only financial benefits, but also partially transferring responsibility for promoting the tournament. It is WTA responsibility to engage spectators around the world and interest them the with every single broadcasted event. Thanks to WTA channels, the tournament extends its reach on a global scale and becomes a brand recognized throughout world. This translates into strengthening the image of the tournament and its brand, as well as increasing access to new business partners.

- Financial benefits – although participation in the WTA involves the costs of obtaining a sanction and organizing the tournament, each organizer can count on certain financial benefits related to the sale of international broadcasting rights and sports data obtained during the season. The tournament organizers could also count on financial support from WTA during the resumption of the tour interrupted by the pandemic in 2020. The organizers could then apply not only for an exemption from certain obligations, but also, if necessary, for financial assistance in the event of withdrawal of a sponsor.

The above-mentioned benefits not only increase the stability of each of the organizers on the market, but also increase the chance for its development and gaining even greater prestige.

## 4.2. Reports of the tournament organizers in WTA

Many factors influence the position of each tournament organizer in WTA network but only some of them depend on the organizers themselves. That being the case, it is reasonable to divide the position of an organizer in the network into micro and macro. Micro-position refers to the value of the developed relations between the individual participants of the network, such as gaining access to resources or creating new opportunities thanks to the existence of a given relationship. On the other hand, the macro-position reflects the role in the entire network and the ability to shape relations. It is a constellation of the internal effects of a participant's actions as well as the results achieved from cooperation with others. The position of each participant of a network is dynamic and changes not only as a result of the strategy used, but also of the actions taken by other participants (Ratajczak-Mrozek, 2010; Niemczyk, Stańczyk-Hugiet, Jasiński, 2012).

Tournaments whose representatives sit on the Tournament Council, or the Board of Directors generally have a stronger macro position in relation to the others. Nevertheless, entities with active and passive electoral rights are characterized by strong heterogeneity. WTA Full Members, i.e., license holders, have the right to vote. However, there might be agreements between licensors and licensees or third parties that assign this right to another entity. Thus, there are members on the WTA network who hold several licenses and therefore several electoral votes, but there are also license holders who have ceded their voting rights. A candidate for a Council member does not have to be actively involved in any tournament, although to be nominated, they must have the support of at least two different tournament organizers in addition to the category they represent.

Determining the exact position in the network of each tournament organizer requires a precise analysis of their relations and an analysis of the relationship between the organizer and WTA. Such an analysis, however, goes beyond the scope of this article.

Based on the general rules prevailing in WTA network, considering slightly different regulations applicable to different categories of tournaments, as well as different expectations of their organizers, an original model describing the relations between tournament organizers was developed (Figure 3). After using two variables, i.e., the tournament category and the regional location of the tournament, a four-field matrix was created, describing four types of relationships in which participants, interacting with each other, report various expectations towards the WTA network organization.

**Tournament category**

Equal                                        Different

|  | Equal | Different |
|---|---|---|
| **Same region** | **I. Multidimensional Cooperation** | **II. Regional Cooperation** |
| **Different region** | **III. Horizontal Cooperation** | **IV. Easy cooperation** |

**Tournament location**

**Figure 3**. Types of relationships between tournament organizers in WTA network.

Source: own elaboration

**Multidimensional cooperation**. Tournament organizers of the same category in each region having a common representative in the Tournament Council cooperate more closely with each other than with other participants in the network. An example of this may be all the organizers of WTA 250 tournaments in Europe. They are united not only by the converging interests of the region, but also by the issue of conditions and regulations for a common category of tournaments. Their influence on the organization of the WTA and the decisions made in it is relatively the greatest.

**Regional cooperation**. Tournament organizers of different categories taking place in the same region, having a common representative on the Board of Directors, cooperate with each other in the common interest of the region, e.g., the organization of the tournament calendar. The influence of these organizers on WTA may be slightly weaker due to the potential divergent interests of the organizers of various categories of tournaments.

**Horizontal cooperation**. Tournament organizers of the same category but from different regions, cooperate with each other because they share a common interest - improving conditions or changing the rules for a given category. As mentioned earlier, each category of the tournament is characterized by different standards and conditions, and the organizers, using their position in the network, can pressure WTA to make changes favorable to the organizers.

**Easy cooperation**. The loosest relations are between the tournament organizers of different categories that take place in different regions. Although they share the tour and the good of WTA, the direct relations between them are weak or do not occur at all, so the impact on the organization of the WTA is also very small.

### 4.3. Assessment of the functioning of WTA network

Women's professional sport is quite a challenge for the bodies managing it, and WTA is a strong leader among them, associating nearly 2,000 tennis players representing approximately 85 countries. The solution in the form of a network adopted in the organization allows for the coordination of a very large number of activities, respecting the rights of all its members, and at the same time making optimal decisions. The constant flow of information, ensured by properly designed structures, the categorization of tournaments, or regular meetings of their representatives make the WTA network able to react quickly to signals picked up from both inside the network and its surroundings. Having such a strong, dominant position on the tennis market, WTA is an important partner in dialogue with other sports organizations, exerting a real influence on the development of sport on a global scale.

The weaknesses of the WTA organization include the lack of sufficient control over the fulfillment of the obligations of the tournament organizers, as well as a relatively weak influence on their behavior outside the duration of the sporting event. Too much of independence can potentially pose a threat to the image of the network, for example in a situation where its members do not care for its good name. With different positions in the network of its members, antagonisms appear and create smaller groups representing different, sometimes contradictory interests. Such conflicting situations are difficult to deal with in such a large network as the WTA.

In the opinion of the authors of the article, the organizational solutions adopted in the WTA are correct as a whole and allow it to effectively achieve the set goals. The position of the WTA in the sports market is unquestionable and too many entities from inside and from its environment care about the proper functioning of this organization. This specific imbalance of those interested in stabilizing the WTA towards its opponents, in favor of the former, means that even the existing shortcomings or risks will be jointly solved with a view to reaping further common benefits.

## 5. Summary

Women's Tennis Association is an example of a consciously built network organization that uses the potential and resources of its members and partners to achieve its goals. Clearly defined obligations of tennis players and tournament organizers, mutual benefits achieved by the entities involved, an efficiently functioning control system and an incentive system make the WTA network a major driving force for the development of world-class women's tennis. The WTA network organization has an open formula, which means that new members can join it, while those currently residing in it may lose this status if they do not fulfill their obligations. It is an additional element motivating that its individual members bring the value expected of them to the WTA, thus enriching the total value of the entire network. Occurring conflicts of interest, typical for the existence of any network, are resolved primarily by collegial bodies representing all network members, i.e., by the Board of Directors, Players Council and Tournament Council. This self-control mechanism allows to discharge tensions quickly and efficiently, while at the same time taking care of the interests of the entire network. It is worth emphasizing that individual members of the network, especially tournament organizers, because of extensive relationships with each other, often informal in nature, support each other by sharing their experiences, specialist knowledge, contacts with cooperators or access to the necessary resources. Therefore, it can be concluded that they benefit from two sources: one of them is the WTA organization offering several benefits, both those related to prestige, image and strictly economic, and the other source is the mutual support shown by members of the network.

The case of WTA illustrates well the principles and conditions of the functioning of a network organization. It may constitute a seed for further, in-depth research of this organization, as well as a contribution to further research devoted to the problem of the network of relations, implemented in other areas of the sports market. The more so as this market is extremely extensive, still recording high growth dynamics and still largely unrecognized in terms of the management mechanisms applicable in it.

The WTA network presented in the article and the "alliances" of tournament organizers operating within it reveal the heterogeneity of the structures of network organizations, which is very poorly emphasized in the literature on the subject. This means that the network integrator, in this case the WTA, must not only manage relations with its individual members, but also skillfully shape relations with informally emerging subgroups of members with similar interests and expectations towards the network. This finding may become a contribution to further research in the field of dependencies and forces of influence within network organizations. So far, this problem has not been the subject of both empirical and theoretical research and analysis.

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# DIGITAL TRANSFORMATION OF THE LABOR MARKET – A CHALLENGE FOR YOUNG POLES

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**Purpose:** The purpose of the article is to assess the level of digital competence of young Poles against the background of selected European countries in the context of changes occurring in the labor market.

**Design/methodology/approach**: The level of digital competence of young people from 30 selected European countries was diagnosed on the basis of the development pattern method by Z. Hellwig. To develop a synthetic Z. Hellwig measure, 23 diagnostic characteristics that reflect the level of skills of young Europeans in creating digital content, using databases, communicating and collaborating online, using ICT in different types of online activities, and protecting privacy and personal data online were selected. The study covered a group of young people aged 16-24, representing a potential labor supply that is particularly relevant to the development of the digital economy.

**Findings:** In the light of the characteristics adopted for the study, the level of digital competence of young Poles is low. Young Finns, Maltese, Dutch, Spanish and Icelanders have the highest levels of digital competence. In contrast, particularly low levels of these competences are seen among young Bulgarians and Romanians.

**Research limitations/implications**: The presented research can contribute to further in-depth analysis of the impact of the digital competency deficit on the economic development of the countries included in the analysis in the long term, including Poland in particular.

**Practical implications:** The results of the research can provide guidance to public authorities in creating and evaluating strategies for the development of digital competences in Poland and the other countries covered by the study.

**Originality/value:** The article indicates the changes that the labor market is undergoing as a consequence of the digital transformation of the economy. A synthetic indicator of digital competence was constructed, taking into account the diagnostic characteristics selected by the author of the article, which in their opinion are particularly relevant to the development of the digital economy. Leaders in the level of digital competence of young people have been identified. The distance between them and Poland was also diagnosed. The findings are addressed to the public authorities of the European countries surveyed. They can provide guidelines for the creation and evaluation of strategies for the development of digital competences in Poland and the other countries covered by the study.

**Keywords:** digital competences, labor market**,** Z. Hellwig's method, digital transformation.

**Category of the paper:** Research paper.

## 1. Introduction

The Internet of Things, 5G, big data, blockchain, artificial intelligence are just some examples of the application of digital technologies, transforming the economy and labor market rapidly and radically. The Covid-19 pandemic intensified this process, but at the same time revealed a deficit in digital competence. Surprisingly, it also applies to young people, who, after all, are referred to as the generation of two parallel worlds – the real and the virtual one. Hence, for many of them, exclusion from the primary segment of the labor market, which offers high-paying jobs with opportunities for advancement and career fulfillment, becomes a real threat.

The purpose of the article is to assess the level of digital competence of young Poles against the background of selected European countries in the context of changes occurring in the labor market.

The level of digital competence of young people from 30 selected European countries was diagnosed on the basis of the development pattern method by Z. Hellwig. To develop a synthetic Z. Hellwig measure, 23 diagnostic characteristics that reflect the level of skills of young Europeans in digital content creation, online communication and collaboration, and online privacy and data protection were selected. The study covered a group of young people aged 16-24, representing a potential labor supply that is particularly relevant to the development of the digital economy.

When considering the effects of implementing new digital technologies, reference was made to international research and analysis conducted in this area.

## 2. Substitutability and complementarity of labor in the digital economy

A 2018 report by the International Monetary Fund highlighted that digitalization encompasses a wide range of new information technology applications in business models and products that are transforming economies and social interactions (IFM, 2018). The digitalization of economic processes is fundamentally transforming the labor market. In addition, the Covid-19 pandemic clearly accelerated this process by spreading ICT-based remote work, among other things.

Automation and digitization of work are occurring in three overlapping waves – algorithms, enhancements and autonomy (PricewaterhouseCoopers, 2018), and the specificity of the changes they bring with them determines the necessary adjustments on the supply side of the labor market.

The wave of algorithms manifests itself in the automation of simple tasks in the areas of information processing and communication, as well as the increasing use of analysis of structured statistical data in so-called controlled environments. Subsequently, it is characterized by the use of increasingly sophisticated applications for processing large data sets and running machine learning algorithms (Frey, Osborn, 2013).

The wave of improvements entails a more dynamic change in the way many tasks are carried out than was the case in the wave of algorithms. It especially applies to work of a routine and repetitive nature. The physical transfer of information is increasingly becoming supported by technology. On the other hand, further development of robotics makes the emerging solutions economically applicable and operational, not yet fully autonomous, but in cooperation with humans (PricewaterhouseCoopers, 2018).

The wave of autonomy is associated with the large-scale introduction of artificial intelligence and robotics, which are intensifying the process of automating routine tasks that require manual labor or dexterity. More importantly, however, analytical modeling of structured data creates the opportunity to solve complex problems in the dynamic real world (Frey, Osborn, 2013; PricewaterhouseCoopers, 2018).

Currently, there are changes characteristic of the wave of algorithms and the wave of improvements, however, the culmination of the changes brought by the latter wave is predicted for the second half of the 2020s. The autonomy wave, on the other hand, includes technologies currently undergoing testing that are expected to be deployed on a large scale in the 2030s (PricewaterhouseCoopers, 2018).

Economists point to three particularly significant stages of labor market perturbations arising in the wake of the waves of automation and digitization of work outlined above (del Rio-Chanona et al., 2021; Acemoglu, Restrepo, 2019; Brynjolfsson., McAfee, 2014).

The first stage is the substitution of human labor by technology, mainly concerning routine work, where workers are replaced by autonomous devices and AI algorithms. As a result, job cuts are occurring in many sectors of the economy.

The second and third stages – based on the recognition of the complementarity of human labor to new technological solutions – assume a successive increase in employment. What distinguishes these two stages is the distinctly different mechanism for creating new jobs and the nature of the jobs created.

For stage two, it is assumed that employment growth is the result of an increase in demand for goods and services following a drop in their prices, achieved by improving productivity and reducing production costs. As a result, this brings an extensive increase in labor demand, mainly for jobs where work has not been automated.

In the case of the third stage, it is assumed that new jobs will be created in the implementation of tasks, functions, jobs that previously played a marginal role or did not exist at all, while the demand for them is generated by the increasing processes of automation, digitalization and digital development.

However, it should be emphasized that new jobs, as the experience of previous technological revolutions shows, are being created with some delay. In the short term, the effect of substitution of human labor with objectified labor based on new technological solutions is more evident, as reflected in the growing structural unemployment. The increase in labor demand, characteristic of the second and especially the third of the stages outlined above, raises the need for radical changes in the qualifications of the workforce. The context raises questions – Will the rapid and radical changes occurring in labor demand be in sync with qualitative changes in labor supply? Is it possible to avoid skill gaps?

Research conducted between 2000 and 2018 in the United States confirmed the phasing of changes in the labor market outlined above (del Rio-Chanona et al., 2021). In the first period, companies cut jobs, leading to an increase in unemployment, while in the second period there was a growing demand for labor in the operation and service of new technology and the new services created after its application. At the same time, the study's authors point out that despite the 19-year period they included in their analysis, the labor supply in qualitative terms has not fully adjusted to the changed demand for labor, which was reflected in the occurrence of a clear skills gap. Despite relatively high unemployment, it has been impossible to fill the growing number of vacant jobs due to a lack of adequate workforce competence.

This is confirmed by McKinsey Global Institute research showing that current technological potential already enables automation of about 50% of current work activities worldwide. However, its use is not possible, due to the lack of adequate professional skills on the part of the workforce (Manyika, Chui et al., 2017). The authors of the study forecast that the adjustment of labor supply, allowing full use of new technologies, will be possible around 2037 according to the so-called early scenario, and according to the so-called late scenario – as late as 2055(Manyika, Chui et al., 2017).

Given that the research presented above was conducted during a period of moderately intensified automation processes and the implementation of new advanced digital technologies, there is a legitimate concern that in the digital transformation of the economy, the 4.0 revolution taking place, the desired qualitative changes on the supply side of the labor market will not be synchronized with the rapid, even sudden qualitative changes on the demand side of the labor market. The competency gap cannot be completely avoided, but it can be reduced through strategic efforts to develop digital competences.

## 3. Methodology of own research

The aim of own research is to try to assess the level of digital competence of young Poles against the background of selected European countries. The study covered the 16-24 age group, assuming that they are the ones who will be primarily affected by changes in the labor market

following the digital transformation of the economy. The level of their current digital competences will determine the adaptability of the labor supply to the already observed and steadily intensifying changes in labor demand.

For the purposes of this study, it was assumed that digital competency is "a set of information competences that includes the ability to search for information, understand it, and assess its reliability and usefulness, and digital competences that consist of the ability to use a computer and other electronic devices, use the Internet, and use various types of applications and software, as well as create digital content" (Ministry of Administration and Digitization, 2014).

A synthetic Z. Hellwig indicator was used to determine the level of digital competence of young people from 30 European countries, developed on the basis of 23 diagnostic characteristics. They form three groups illustrating digital competences from three areas: 1) creation of digital content, 2) use of the Internet for communication and collaboration, and 3) protection of privacy and personal information online (Table 1).

**Table 1.**
*Diagnostic characteristics adopted in the study of digital competence of young people*

| Feature no. | Name of the diagnostic feature |
|---|---|
| | **Digital content creation skills** |
| $x_1$ | People who write code in a programming language. |
| $x_2$ | People who copy or move files between folders, devices or in the cloud. |
| $x_3$ | People who download or install software or applications. |
| $x_4$ | People who change the settings of a software, application or device. |
| $x_5$ | People who use word-processing software. |
| $x_6$ | People who create files that integrate elements such as text, images, tables, charts, animations, sound. |
| $x_7$ | People who use spreadsheet software. |
| $x_8$ | People who use the advanced characteristics of spreadsheet software to organize, analyze, structure or modify data. |
| $x_9$ | People who edit photos, video or audio files. |
| | **Skills related to the use of the Internet for communication and collaboration purposes** |
| $x_{10}$ | People using the Internet for participation in social networks (creating a user profile, posting messages or other posts on facebook, twitter, etc.). |
| $x_{11}$ | People using online materials for learning. |
| $x_{12}$ | People taking online courses. |
| $x_{13}$ | People selling goods or services over the Internet. |
| $x_{14}$ | People using the Internet to participate in online consultation or voting for specific civic or political issues (e.g., urban planning, signing a petition). |
| $x_{15}$ | People using the Internet to communicate with instructors or students via educational websites/portals. |
| | **Online privacy and data protection skills** |
| $x_{16}$ | People who know that cookies can be used to track people's movements on the Internet. |
| $x_{17}$ | People changing the settings on their web browser to prevent or restrict cookies on any of their devices |
| $x_{18}$ | People who use software that limits the ability to track their online activities. |
| $x_{19}$ | People who read privacy policy statements before providing personal information. |
| $x_{20}$ | People who have restricted or denied access to their geographic location. |

Cont. table 1.

| $x_{21}$ | People who have restricted access to their profile or content on social networks or data stored online. |
|---|---|
| $x_{22}$ | People checking whether the site where they provide personal information is secure. |
| $x_{23}$ | People who check the veracity of information or content found on online news sites or social media. |

Source: Own elaboration.

The selection of diagnostic variables meets three basic criteria: substantive, formal and statistical (Strahl, 2006). It is both a product of data availability and the arbitrary decisions of the researcher. The choice of diagnostic characteristics was also inspired by the European Commission's Digital Economy and Society Index study (European Commission, 2020).

The own study used diagnostic features from the Eurostat database entitled "Youth in the digital world". The study includes statistics from Eurostat databases primarily for 2021. In the absence of data for that year, 2020 data was used.

Z. Hellwig's synthetic measure was used for identifying four groups of European countries with different levels of digital competences of youths. These are accordingly:

- group I – countries with the highest level of digital competence index, where $d_i \geq \bar{d}_\iota + S_{di}$,

- group II – countries with an average level of digital competence index, where $\bar{d}_\iota \leq d_i < \bar{d}_\iota + S_{di}$

- group III – countries with a low level of digital competence index, where $\bar{d}_\iota - S_{di} \leq d_i < \bar{d}_\iota$

- group IV – countries with the lowest level of digital competence index, where $d_i < \bar{d}_\iota - S_{di}$,

where:

$d_i$– value of the synthetic indicator,

$\overline{di}$ – average value of the synthetic indicator $d_i$,

$S_{di}$– standard deviation of the indicator $d_i$.

## 4. Study results

### 4.1. Ranking of European countries in terms of the level of digital competence of young people

Own study showed a moderate degree of variation in diagnostic characteristics. The coefficient of variation ranged from 6.9% to 56.5%. Young Europeans are particularly characterized by similar levels of competence related to Internet use in terms of participation in social networks (creating a user profile, posting messages or other posts on facebook, twitter, etc.). For this diagnostic characteristic, the coefficient of variation reached the lowest value.

The highest number of young people using the Internet for these purposes was in Iceland (98%), while the lowest was in France (71%). In Poland, the coefficient was 91%.

The spreads in this regard are, among others, the result of differences in preferred forms of contact. In the case of the French, they are more often direct. On the other hand, Icelanders have a much harder time finding this form of contact, if only due to geographic conditions. Hence the importance of on-line communication there. In this context, one should also pay attention to the negative attitude of the government towards Fecebook, which is observed, especially in France. It could also have an impact on the value of the diagnostic feature adopted in the research

The percentage of young people who said they used the Internet to sell goods and services was the characteristic that most differentiated Europeans. The highest number of young people declaring the above activity was in Malta (64%), while the lowest were in Greece (3%) and Cyprus (3%). In the light of the diagnostic characteristics adopted for the study, the highest level of digital competence of youths was characteristic of five countries, namely Finland, Malta, the Netherlands, Spain and Iceland (Table 2). Another group of nine countries (Estonia, Norway, Austria, Latvia, Croatia, Lithuania, Switzerland, Portugal, Denmark) are characterized by the average level of digital competence of its young citizens (Table 2). The largest group of countries, which included Poland, are those with low levels of digital competence (Table 2). Poland ranked 18th in terms of the value of the synthetic Hellwig indicator. It was more than 1.5 times lower than that of ranking leader Finland. Young Poles represent a level of digital competence most similar to the French, Greeks and Czechs.

Analyzes of activities undertaken by leaders in the field of development of digital competences prove that the key factor in the success of their activities is a systemic approach to their development (Tarkowski, Majdecka et al., 2018). Finland owes its advantage to the consistent implementation of coordinated and long-term activities developing digital competences They are undertaken as part of the socio-economic development strategy and implemented public policies). The other ranking leaders approach the development of digital competences in a similar way.

**Table 2.**
*Ranking of European countries in terms of the level of digital competence of young people (16-24 years old), 2021*

| No. | Country | Hellwig's synthetic measure value |
|---|---|---|
| Countries with the highest indicator of digital competence of young people | | |
| 1. | Finland | 0.708 |
| 2. | Malta | 0.612 |
| 3. | Netherlands | 0.597 |
| 4. | Spain | 0.576 |
| 5. | Iceland | 0.572 |

Cont. table 2.

| | Countries with an average indicator of digital competence of young people | |
|---|---|---|
| 6. | Estonia | 0.550 |
| 7. | Norway | 0.508 |
| 8. | Austria | 0.508 |
| 9. | Latvia | 0.500 |
| 10. | Croatia | 0.497 |
| 11. | Lithuania | 0.491 |
| 12. | Switzerland | 0.487 |
| 13 | Portugal | 0.469 |
| 14 | Denmark | 0.429 |
| | Countries with a low indicator of digital competence of young people | |
| 15 | Czech Republic | 0.418 |
| 16 | Greece | 0.417 |
| 17. | France | 0.414 |
| 18. | Poland | 0.411 |
| 19. | Hungary | 0.371 |
| 20. | Italy | 0.369 |
| 21. | Sweden | 0.369 |
| 22. | Slovakia | 0.353 |
| 23. | Luxembourg | 0.353 |
| 24. | Belgium | 0.338 |
| 25. | Slovenia | 0.302 |
| | Countries with the lowest indicator of digital competence of young people | |
| 26. | Serbia | 0.265 |
| 27 | Germany | 0.256 |
| 28. | Cyprus | 0.241 |
| 29. | Bulgaria | 0.124 |
| 30. | Romania | 0.096 |

Source: Own research.

Young people in Serbia, Germany, Cyprus, Bulgaria and Romania have the lowest level of digital competences (Table 2). However, it should be emphasized that there is a wide variation in the level of digital competences in this group. Bulgarians and Romanians show significantly lower levels of digital competences than Serbs, Germans and Cypriots. Hellwig's synthetic index for Romania is more than 2.5 times lower than for Serbia and Germany.

However, it should be emphasized that there is a wide variation in the level of digital competences in this group. Bulgarians and Romanians show significantly lower levels of digital competences than Serbs, Germans and Cypriots.

The reasons for the poorly developed digital competences in Romania are primarily the low level of socio-economic development of the country and the relatively low demand for these competences in the labour market. In addition, general assumptions of the "National Digital Strategy. Agenda for Romania 2020" regarding the development of digital competences perpetuate the demonstrated disproportions.

## 4.2. Digital competences of young Poles in the light of a self-study

In the rest of the article, attention is focused on a detailed analysis of the digital competences of Poles, diagnosing skills with relatively low and high levels. For this purpose, synthetic Z. Hellwig indicators were also calculated ($d_{i1}$, $d_{i2}$, $d_{i3}$,) for the three groups of diagnostic

characteristics included in the study (Table 1), and the corresponding rankings were developed (Tables 3-5). The first group includes digital competences in the creation of digital content ($d_{i1}$ Indicator – Table 3), the second group includes digital competences in the use of the Internet for communication and collaboration ($d_{i2}$ – Table 2), and the third group includes digital competences in the protection of privacy and personal data online ($d_{i3}$ – Table 3).

Young Poles are characterized by a relatively *high level of digital competences in creating digital content*. In a ranking that included 30 countries, Poland ranked 14th, while the synthetic $d_{i1}$ index reached 0.549 for this range of competences, 1.4 times lower than that of the ranking leader Finland. The majority of young Poles say they have basic skills in creating digital content, i.e. copying and moving files between folders, devices or in the cloud (87%); downloading and installing software, applications or devices (79%); using word-processing software (77%); creating files that integrate different elements, i.e. text, image, chart, animation, etc. (73%). Despite the relatively high percentage of Poles declaring the first two of the skills indicated above, there is still a significant distance between our young people and the leaders in this regard. As many as 100% of Croatians and 91% of Maltese were characterized by their ability to copy and move files. In contrast, the highest number of youths handling installing software or applications was in Malta (93%) and Finland (91%).

Far fewer Poles, but also young people from the other countries surveyed, are characterized by more advanced skills tied to the use of spreadsheet software and coding in a programming language.

The highest number of young people with spreadsheet software skills was in Croatia and Iceland. The rate in this case was 86% and 71%, respectively. Against their background, Poland fared far less well, with skills in this area pertaining to 55% of young people. Attention is further drawn to the fact that the disparity increases if one takes into account the possession of the ability to use advanced functions of spreadsheet software to organize, analyze, structure or modify data. This type of skill characterizes only 18% of Poles. In Croatia and Iceland, such skills characterized 59% and 54% of people, respectively. Given that today's organizations need to store increasing amounts of data and subject it to analysis in order to operate more effectively in a turbulent environment and intensifying competition, the low level of skills in the above area is worrisome. As observation of management practice shows that the advanced use of spreadsheet software is only the first step on the road to using complex databases of various types. Economic processes are subject to datafication and networking. There is increasing and intensive use of data from various repositories (individual, institutional) and their integration is increasingly automatic (Śledziewska, Włoch, 2020).

Coding, enabling the storage of information in digital form, is one of the key skills of Economy 4.0. The results of own study, however, show a relatively low percentage of young Europeans with such skills. The Danes and Austrians are the leaders in this regard, with 21% and 20% of youths, respectively, having the ability to code in a programming language. In Poland, it is 14% of youths.

Compared to the countries surveyed, Poles fare significantly worse in terms of using the Internet *to communicate and cooperate*. In this case, Poland is ranked 23rd (Table 4). Again, the Finns and the Maltese are the leaders in this regard. The synthetic Hellwig indicator ($d_{i2}$) for Poland is 0.310, more than 2 times lower than for Finland.

Young Poles are good at using the Internet for personal, entertainment purposes, as evidenced by the fact that 91% declare participation in social networks and related skills – creating a user profile, posting messages or other posts on facebook, twitter, etc. The leader in this regard is Iceland, where 98% of young people declare such activity.

Attention is unfortunately drawn to the relatively poor use of the Internet's potential for educational purposes by Poles. Studies show that 55% of young people use online materials for learning. Poland is particularly far behind the leaders in this field – Iceland, Sweden, Finland, where 83%, 78%, 75% of young people, respectively, used online learning materials. The situation is similar for Poles' participation in online courses, with only 26% of young people declaring this. In this case, the leaders are the Dutch and the Maltese, where the percentage was 78% and 70%, respectively. Own study confirms the fact also perceived by other researchers (Głomb, Kniaź, 2019) that Poles are unable to use the vast educational resources of the web effectively. In order to intensify the possibilities of using the Internet for teaching purposes, an Integrated Education Platform was established in 2019. It contains more than 8,000 e-materials in the form of interactive tasks, teaching videos, virtual journeys, experiments, etc. The Platform's resources are constantly being expanded.

Relatively few Poles know how to take care of *privacy and personal data protection on the Internet* by taking appropriate measures in this regard. This is reflected in Poland's 21st position in the ranking compiled for this type of skills (Table 5). The largest number of youths representing the above skills was in Croatia and Estonia. For these countries, the synthetic Hellwig indicator ($d_{i3}$) was 0.871 and 0.843, respectively, while for Poland it reached 0.566.

The majority of Poles (89%) are aware that cookies can be used to track a person's movements on the Internet, however, less than half are able to prevent or limit their functioning on various mobile devices (41%). This compares with 96% and 62%, respectively, in Finland, where such people are most numerous.

The ability to track online activities is limited by relevant software. Its use is declared by 27% of young Poles, while in Norway, the leader in this regard, it is 49%.

The relatively low level of knowledge among young Europeans, including Poles, about the dangers of the Internet is reflected in the next three diagnostic characteristics adopted in own study.

The youths relatively rarely read privacy policy statements before providing personal information. This is confirmed by the arithmetic mean value for this characteristic for all countries surveyed, which is 37%. Such actions are taken by 34% of Poles. The most active in this regard are the Greeks, where 59% have read the above statements.

32 **Table 3.**
33 *Ranking of European*
34 *countries in terms of the*
35 *level of digital*
36 *competences in digital*
37 *content creation (I group*
38 *of characteristics*
39 *in Table 1)*

| No. | Name of the country | Synthetic Hellwig indicator $(di_1)$ |
|---|---|---|
| 1. | Finland | 0.781 |
| 2. | Malta | 0.725 |
| 3. | Spain | 0.703 |
| 4. | Iceland | 0.654 |
| 5. | France | 0.645 |
| 6. | Netherlands | 0.640 |
| 7. | Lithuania | 0.632 |
| 8. | Croatia | 0.608 |
| 9. | Latvia | 0.582 |
| 10. | Austria | 0.582 |
| 11. | Norway | 0.580 |
| 12. | Estonia | 0.568 |
| 13. | Switzerland | 0.568 |
| **14.** | **Poland** | **0.549** |
| 15. | Czech Republic | 0.538 |
| 16. | Italy | 0.473 |
| 17. | Greece | 0.470 |
| 18. | Serbia | 0.458 |
| 19. | Portugal | 0.448 |
| 20. | Luxembourg | 0.433 |
| 21. | Slovakia | 0.425 |
| 22. | Denmark | 0.411 |
| 23. | Sweden | 0.392 |
| 24. | Cyprus | 0.378 |
| 25. | Slovenia | 0.357 |
| 26. | Hungary | 0.355 |
| 27. | Belgium | 0.336 |
| 28. | Germany | 0.302 |
| 29. | Romania | 0.098 |
| 30. | Bulgaria | 0.091 |

40 Source: Own research.

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**Table 4.**
*Ranking of European countries in terms of the level of digital competence in the use of the Internet for communication and collaboration (II group of characteristics in Table 1)*

| No. | Name of the country | Synthetic Hellwig Indicator $(di_2)$ |
|---|---|---|
| 1. | Finland | 0.652 |
| 2. | Malta | 0.591 |
| 3. | Netherlands | 0.578 |
| 4. | Iceland | 0.564 |
| 5. | Estonia | 0.496 |
| 6. | Austria | 0.489 |
| 7. | Switzerland | 0.479 |
| 8. | Spain | 0.475 |
| 9. | Norway | 0.442 |
| 10. | Lithuania | 0.438 |
| 11. | Latvia | 0.434 |
| 12. | Hungary | 0.431 |
| 13. | Slovakia | 0.425 |
| 14. | Denmark | 0.408 |
| 15. | Czech Republic | 0.405 |
| 16. | Belgium | 0.404 |
| 17. | Portugal | 0.381 |
| 18. | Sweden | 0.370 |
| 19. | Slovenia | 0.362 |
| 20. | Italy | 0.334 |
| 21. | Luxembourg | 0.334 |
| 22. | Greece | 0.311 |
| **23.** | **Poland** | **0.310** |
| 24. | Croatia | 0.278 |
| 25. | Cyprus | 0.276 |
| 26. | Bulgaria | 0.264 |
| 27. | France | 0.191 |
| 28. | Serbia | 0.185 |
| 29. | Germany | 0.181 |
| 30. | Romania | 0.118 |

Source: Own research.

**Table 5.**
*Ranking of European countries in terms of the level of digital competence in terms of online privacy and data protection (III group of characteristics in Table 1)*

| No. | Name of the country | Synthetic Hellwig indicator $(di_3)$ |
|---|---|---|
| 1. | Croatia | 0.871 |
| 2. | Estonia | 0.843 |
| 3. | Spain | 0.828 |
| 4. | Denmark | 0.811 |
| 5. | France | 0.801 |
| 6. | Greece | 0.797 |
| 7. | Latvia | 0.788 |
| 8. | Czech Republic | 0.761 |
| 9. | Italy | 0.741 |
| 10. | Lithuania | 0.740 |
| 11. | Belgium | 0.728 |
| 12. | Germany | 0.724 |
| 13. | Malta | 0.696 |
| 14. | Luxembourg | 0.683 |
| 15. | Netherlands | 0.680 |
| 16. | Hungary | 0.672 |
| 17. | Bulgaria | 0.669 |
| 18. | Cyprus | 0.651 |
| 19. | Austria | 0.624 |
| 20. | Portugal | 0.586 |
| **21.** | **Poland** | **0.566** |
| 22. | Finland | 0.518 |
| 23. | Slovenia | 0.406 |
| 24. | Romania | 0.400 |
| 25. | Slovakia | 0.377 |
| 26. | Sweden | 0.340 |
| 27. | Iceland | 0.329 |
| 28. | Norway | 0.278 |
| 29. | Switzerland | 0.246 |
| 30. | Serbia | 0.133 |

Source: Own research.

Young people also rarely take steps to check whether the site they are using is secure. On average, 40% of Europeans do so. Only 28% of Poles are taking action in this direction. Against this backdrop, the Maltese definitely stand out, with 85% declaring such activites.

On the Internet, practically anyone can be the creator of information, rendering its users "inundated" with information of varying degrees of reliability and credibility (Witczak-Roszkowska, 2020). Being critical of them often gives rise to the need to check information in multiple sources. Are young people characterized by the ability to be critical of content presented online? Unfortunately, indirectly on the basis of another diagnostic characteristic adopted in the study, it can be concluded that the percentage of such people is low. Just over 36% of Europeans check the veracity of information or content found on online news sites or social media. Only 28% of young Poles undertake such activities. The Dutch – 59%, and Norwegians – 56%, are the most likely to check online content.

Nowadays, it is already a natural part of the daily functioning of young people to be present on various types of social networks, where they publish detailed accounts of their private and professional lives. Unfortunately, they often lose control over both the quantity and quality of the information provided there. By indulging in social exhibitionism online (Borzucka-Sitkiewicz, Leksy, 2017), they expose themselves to a number of risks. Actions to restrict access to profile and content on social networks reflect awareness and knowledge of these risks. They are taken up by more than half of young Europeans. In the case of Poland, it is 49% of youths. The Czechs take the most "prudent" approach to content presented online, with 76% declaring such actions.

## 5. Conclusion

Digital processes are transforming the labor market. It increasingly requires not only skills related to the use of devices, platforms and applications that have a variety of purposes, but also the creation of digital content and the critical evaluation of information presented online, distinguishing truth from falsehood, resisting the risks associated with functioning in the virtual space.

In light of the studies conducted, it is rightful to conclude that the relatively low level of digital competence of young Poles constitutes, in macroeconomic terms, a barrier to the effective and efficient implementation of modern technological solutions in economic practice and the development of the digital economy. On the other hand, at the microeconomic level, it exacerbates the risk of young people being excluded from the primary labor market that offers high-paying, secure jobs and career opportunities.

Poles are separated by a significant distance in the level of digital competence, especially compared to the leaders in this field, i.e. the Finns, the Maltese and the Dutch. There is optimism in the fact that young Poles, perform relatively well in the creation of digital content (14th in the ranking of skills of this type), which indicates their development potential in this area. Therefore, it is worth to take advantage of it and ensure the formation of more advanced skills of young people in this area, especially related to the use of spreadsheets, databases, programming. Poles fare less well in their ability to use the Internet for communication and collaboration (ranked 23rd) and to protect privacy and personal data online (ranked 21st). It therefore seems reasonable to give these two areas of digital competence special attention in the strategic and operational plans for digital education of the younger generation.

Closing the gap in the level of digital competences of young Poles in relation to leaders raises a number of challenges. Among them, an important place is occupied by the need to implement a plan for the development of digital competences, strategic in nature, where areas of digital competences that require particularly intensive action related to the need to eliminate and prevent competence gaps between labor demand and labor supply would be diagnosed. Gaps already revealed and potential ones, conditioned by the further development of the digital economy. So far, the development of digital competences is supported by two programs developed by the Ministry of Digitization, i.e. the Program for Integrated State Informatization for 2019-2022 and the Program for IT Talent Development for 2019-2029, but they are not strategic and comprehensive.

Raising students' digital competences is included in the basic directions for the implementation of the state's educational policy and in the core curriculum for general education in various subjects, especially information technology education and computer science. In particular, children and young people learn to use modern information and communication technologies. In this case, however, it would be important to note that these students represent the Z and Alpha generations, for whom the virtual world is as obvious and common an area of functioning as the real world. Hence, usually most of them acquire the ability to use information and communication technology, especially the computer, use basic programs and the Internet at home, often before they start formal education. In this context, it is worth considering diagnosing digital skills in children and adolescents and creating learning paths for digital competence with differentiated levels of proficiency. In this way it will be possible to avoid a situation where children and young people are being taught what they already know perfectly well. In addition, it would be possible to identify, at the very beginning of education, such children who have exceptional abilities in this area and offer them individualized digital competence training plans. This would prevent the waste of their talents.

It also seems important to draw attention to the fact that when it comes to children and adolescents, despite the fact that they are very active online, this activity is generally of a passive, entertaining nature (playing games, listening to music, using social networks). It seems reasonable, therefore, to give this activity a creative, analytical, educational character,

but this requires the formation of digital competence not only in classes like computer education or computer science, but in all other subjects, including those of a humanistic nature. This requires a reorganization of education in Polish schools, backed by significant support for teachers to acquire relevant skills. In this way, there is a growing opportunity to reduce the deficits in the digital competences of young Poles revealed, including in own study, in terms of taking a critical approach to content presented online and distinguishing true from false information, as well as countering the risks associated with functioning in the virtual space, including by protecting privacy and personal data online.

In the context of the discussed issues, it is worth recommending the following activities undertaken within the educational systems of countries with a high level of digital competences of young people:

1. Development of cooperation between schools and universities, enterprises, especially those creating and using digital technology, public administration bodies (promoting good practices, joint implementation of projects, internships for students and teachers).

2. Using the potential of business entities to improve teachers' digital competences, especially those more advanced in coding and programming.

3. Emphasizing the use of digital work tools by students and teachers as part of the team implementation of interdisciplinary projects, including cooperation in the network.

4. Developing digital competences with particular emphasis on the ability to analyze and critically evaluate information provided on the web.

5. Emphasis on education in the field of safe use of digital technologies.

To a large extent, it will depend on the scale and type of measures currently being taken to develop the digital competences of young Poles, whether they will be the "elite" of the labor market creating digital innovations or merely passive users of these innovations.

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# THE MARKET AND QUALITY PERSPECTIVE OF CSR AND CRISIS MANAGEMENT – A LITERATURE REVIEW

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**Purpose:** The study provides a concise overview of the CSR concept in the literature regarding two market's aspects – quality and marketing. The aim of the study is to analyse to what extent a CSR maps to crisis management phases.

**Design/methodology/approach**: The article entails a literature review of 352 articles published in the years 2006-2021 supported by machine learning.

**Findings:** 15 thematic groups were identified. It is impossible to point to unambiguous thematic trends in relation to the topics in the analysed articles. CSR as a field includes three main elements (economic, environmental, social), but this concept can be considered in many areas and a wide range of organizational activities, which was shown in the article in individual thematic groups.

**Research limitations/implications**: As every literature review serves as a snapshot of a particular period, the results of the study are limited. Future research may also concern the qualitative research (e.g., case-studies in individual companies) and quantitative research (e.g., focusing on specific aspects and/or dedicated samples).

**Practical implications:** The CSR implementation is not a single and short-term organization's project, but an element of a long-term strategy and market trends. It is an important practical information for all organizations undertaking activities in corporate social responsibility.

**Social implications:** The results of the presented research help the reader to see a broader perspective of CSR activities. Microeconomic activities within the CSR triad influence the macroeconomic scale - the global increase in awareness of business responsibility towards society.

**Originality/value:** This is the first paper containing the literature review results on CSR considering the aspects of quality and marketing. The crisis management perspective was also considered as an issue related to the intensity of organizational activities in CSR.

**Keywords:** CSR, crisis, quality, marketing, text-mining.

**Category of the paper:** Literature review.

## 1. Introduction

Business activities are focused primarily on the economic aspect; a company generates revenue by serving customers who pay for the value delivered by a company. Customers base their purchase decisions on the perceived value that relates to perceived quality of the offering and the costs associated with the purchase. However, customers have been increasingly paying attention to the quality of products as well as to environmental and social issues. Responding to rising public awareness (Deloitte, 2021; Lai, 2021), companies started implementing responsible practices (e.g., CSR). According to research by Dentsu and Microsoft, 91% of consumers pay attention to brands which demonstrate sustainability commitments and 59% of them are willing to resign from shopping brands that does not implement sustainable practices (Dentsu, 2021). In response to the market trends and consumer expectations there is a growing number of companies which have been underlying their social goal statements (Global Reporting Initiative, 2022).

Consumers' expectations affect the activities of the organization in two ways. First, it is necessary to offer products of appropriate quality, and second, it is important to undertake and communicate socially responsible activities. The successful implementation of activities rests on organizational capability to function in an uninterrupted, continuous manner. From the beginning of 2020, the literature shows a noticeable increase in focusing on business continuity and organizational resilience (Hillmann, 2020), organization's stakeholders and the previously unnoticed macroeconomic dimension – coopetition in various fields of functioning in relation to the current competition, regardless of the market under consideration (e.g., consumer markets or business markets). Concepts of organizational resilience and business continuity relate to crisis and crisis management. Crisis is a situation that disrupts the activities of the organisation's day-to-day operations. In fact, "crisis by nature is an unprecedented event which does not give us much time to prepare in advance" (Bhaduri, 2019, p. 538). The emergence of a crisis triggers a need to do "something" that would allow a swift "as-soon-as-possible" (ASAP) return to so-called "business-as-usual" (BAU) level. Crisis management (CM) concerns individual organizations and for this reason range of applicable activities may differ between them depending on the adopted criteria for defining "crisis" (Khodarahmi, 2009). The most widely used crisis management model indicates three stages: the pre-crisis period, the crisis management, and the post-crisis stage (Parnell, Crandall, 2017). Crisis management activities in an organization often relate to the application of predictable mitigation strategies during the pre-crisis stage and are not correlated with BCM activities which should be launched during a crisis phase (Bowers et al., 2017). Taking actions to strengthen the organization's resilience to crises and preparing response actions is very important from the perspective of functioning on the market. It was clearly exemplified by the COVID-19 crisis – the worst shrink of the global economy in the 2020 year since the 1930s

Great Depression (Chan, 2020) that caused millions of Americans to apply for unemployment benefits in April 2020 (Mutikani, 2020).

The importance of CSR is also influenced by the stage of crisis management phase (pre/crisis/after) of the company itself (e.g., the need to recall a defective product) or the market (e.g., financial crisis of 2008 or COVID-19). Consumers' expectations influence the activities of organizations, and these in turn, are exposed to various crises. The necessity to consider many aspects of the functioning of the organization, in particular social responsibility, makes organizations undertake activities in CSR. Thus, it deems the analyses of CSR activities in relation to the crisis management phases, the intensity of the occurrence of various aspects of CSR (i.e., the "economy-environment-society" triad) and their connection to the issues of quality and marketing a highly relevant undertaking.

The article consists of three parts. The first shows technical aspects of conducted literature review. Second part presents the data-mining process aimed at searching for relationships and trends in the literature between the analysed issues and the analysis of the obtained data. The third part is related to the interpretation of the obtained results from text-mining and followed by conclusions.

## 2. Methodology

The main element shown in purpose of that article is to identify types of CSR activities in the context of product quality and marketing activities with perspective of crisis management. SCOPUS database has been selected to identify relevant studies as the most inclusive database. Some studies have selected a wide range of databases (including e.g., Web of Science, EBSCO) to identify relevant articles, but the selection for this article was based on three assumptions. Scopus is larger than Web of Science, provides high coverage from non-Western countries, and has a high percentage (99.1%) of titles shared with Web of Science (WoS). Further, a recent study by Singh et al. (2021) emphasizes the close matching of the largest databases in the scientific area of our research. In conclusion, we consider Scopus to be sufficient for a literature search to meet the objectives of our study.

In the Scopus database, a simultaneous search focusing on Title, Abstract and Keywords has been conducted (Vrontis & Christofi, 2021). The following thematic search strings to identify relevant articles have been included: a) "CSR" OR "quality" OR "marketing" OR "crisis" OR "management"; b) "corporate" OR "social" OR "responsibility" OR "crisis management"; c) "CSR" OR "b2b" OR "b2c" OR compan* OR firm* OR supplier* OR organization*.

Due to the wide coverage of the CSR topic, strict inclusion criteria for the articles have been implemented (Kushwah et al., 2019): (a) studies in published in English, (b) full-text journal article, (c) directly related with at least two of the keywords (i.e., CSR and any of the remaining), (d) Scopus Q1 or Q2 ranking. Ultimately, 352 articles have been sourced and analysed.

## 2.1. The method

To analyse the body of the literature, we use the methodology based on an active learning algorithm. This means that the algorithm is "allowed to choose the training data from which it learns" (Settles, 2009, p. 10). An active learner allows handling data that comes without any assigned characteristics of a defined outcome (i.e., unlabelled data). Some authors raise the question of a researcher bias in literature review (Wawak et al., 2020) and suggest using active learners may mitigate possible risk.

Machine learning is applicable to various tasks in all stages of a literature review process to alleviate the research burden, improve productivity (Bekhuis, Demner-Fushman 2010; O'Mara-Eves et al., 2015), and automate literature screening and categorization (Miwa et al., 2014). Within this field, text mining, and specifically so-called topic modelling, have recently gained momentum due to important benefits offered to researchers:

- speed: text mining helps in completing the reviewing process faster (Moro et al., 2019),
- flexibility: the procedures for text mining allow for tuning numerous parameters and handling various types of unstructured information (Wawak et al., 2020; Moro et al., 2019),
- scope: text mining allows to easily handle large collections of texts (Wawak et al., 2020; Zaki, McColl-Kennedy, 2020),
- objectivity: text mining and autonomous topic extraction reduces researcher bias (Wawak et al., 2020; Zaki, McColl-Kennedy, 2020).

Recently, much more emphasis has been put on applying novel review methodologies in management sciences (Miwa et al., 2014). For example, Wawak, Rogala, and Dahlgaard-Park (2020) used a text mining approach to identify research trends in quality management studies in yeas 2000-2019. The authors analysed 4,833 papers using TF-IDF and hierarchical clustering algorithm (HDBSCAN). As a result, they identified the evolution of 45 topics in scholarly literature. There has been also a noticeable interest in text mining in the service literature (Villarroel Ordenes, Zhang, 2019), though it is mainly applied to customer generated content (Situmeang et al., 2020; Villarroel Ordenes, Zhang, 2019).

Since CSR presents a broad domain of scholarly output, we apply the machine learning model to distil main topics and their evolution. We use time adjusted Latent Dirichlet Allocation (LDA) model. LDA is a hierarchical Bayesian model (Blei et al., 2003), an unsupervised learning method which was found to boost the performance of active learning algorithm without

applying manual annotation to documents (Miwa et al., 2014). In LDA, the topic distribution of a document is generated stochastically, assuming a Dirichlet distribution (prior and posterior). A stochastic model that assumes a generation process by a probability distribution is collectively called a generative topic model.

## 2.2.  Approach

We followed the approach described by Kitanaka et al. (2021). The authors developed and validated the topic modelling in an academic setting by comparing the results of an autonomous reader with a traditional literature review. The content of selected papers was extracted in Content ExtRactor and MINEr (Tkaczyk et al., 2015). The resulted XML files were parsed and processed using Python scripts developed by the authors.

The quality of a topic, as measured by coherence, can be thought of as how easy it is for people to understand a topic emerging from the words. Or, in layman's terms, that the words within a topic are consistent and people can tell what the topic is just by looking at it. Therefore, we chose coherence as an indicator of the model fit (Wawak et al., 2020). In the simulated runs of our LDA model, the maximum coherence score was achieved in K = 15 topics.

In the LDA model, a topic is represented by a combination of phrases and their respective weights (Kitanaka et al., 2021). Thus, each document can be described by probability of belonging to a given topics: $w_n = P(d \mid T)$, where d is a document and T is a topic.

# 3.  Results

Each of the 15 identified topics has been named after careful investigation of the most prevalent terms that formed the topic. Also, the articles with the highest topic weights (i.e., belonging mainly to a given topic) have been considered. The 15 topics identified in the analysis corroborate the notion of sparse scholarly discussion about CSR (see Table 1 in the Appendix). The prevalence of topics in the observation window (2006-2021) provides important insights for the analysis. First, the mapping of individual topics depending on the phase of crisis management allows to note that in the pre-crisis and post-crisis phase, the publications relate mainly to: "6. CSR: ethical and institutional perspective", "11. CSR: impact on financial performance", and "13. CSR: internal perspective". In the crisis phase, the analysis points predominantly "1. CSR: international aspects" and "4. CSR: reporting". It is worth paying attention to two issues: the fluctuation of the thematic intensity over the years and the possibility of identifying the thematic conjunction for these groups.

Firstly, in all three thematic groups there is a large fluctuation in the intensity of the title issues in articles over the years. When analysing the intensity peaks, there is a thematic link with the phases of crisis management:

- "6. CSR: ethical and institutional perspective". Most articles on these issues were published in the pre-crisis phase (2006-2007, before the financial crisis) and in 2011 (after the crisis). In subsequent years, the topic is not displayed in publications.

- "4. CSR: reporting". An intensive publication summit for the issues of reporting CSR activities falls on the years 2008-2009 (the period of the financial crisis), then suddenly the subject appeared in 2014 and since then there has been a noticeable decline in the coverage of this subject in scientific publications.

- "11. CSR: impact on financial performance". An interesting aspect is a similar fluctuation of publication intensity in this group compared to the previous one. From the research and analytical point of view, the topic was heavily exploited in the pre-crisis times (2008-2019) and noticeable in 2014. Reporting of activities in the field of CSR concerns mainly the "impact" (in the cause-effect relationship "company-market") and "financial performance" (in the reverse "market-company" perspective)

Secondly, when analysing the three groups through the prism of the other topics as well, it is worth noting that all have both a micro and macroeconomic dimension. However, when analysing the issues discussed in individual articles in detail, there is a visible outline of the CSR concept regarding the source of these actions – the actual impact of the macroscale within in the CSR triad ("economy-environment-society") or following only the economic motive in the microscale. In this spirit, the issues refer to criticism of corporate social responsibility theory which indicates that social and commercial goals are coincident. These issues were highlighted in articles grouped in "1. CSR: international aspects". Interestingly, an all parameters, the highest thematic average is for this group for the publication in 2010.

The global financial crisis of that period was reflected in publications asking about the motives for undertaking socially responsible activities in the light of the impact of banking on the lives of people, companies, and the functioning of the states.

The analysis also identified three thematic groups which publication saturation is low and not related to the crisis management stage ("10. CSR in developing economies", "14. CSR: macroeconomic perspective", and "15. CSR: other aspects"). Interestingly, a significant negative correlation can be observed between topics "7. CSR: marketing strategy and capabilities" and "5. CSR: Sustainable development of an organization" as well as between "11. CSR: impact on financial performance" and "8. CSR: the influence on attitudes and intentions". On the contrary, the positive correlation exists between "3. CSR: organizations and networks" and "1. CSR: international aspects" as well as between "8. CSR: the influence on attitudes and intentions" and "6. CSR: ethical and institutional perspective".

The most prevalent thematic topic in the analysed articles (Table 2) includes contributions that encompass broader ethical and institutional perspective ("6. CSR: ethical and institutional perspective", average prevalence 12,8%). For example, Wittneben et al. (2012) discuss the climate change and call for tangible CSR actions in this regard. Banerjee (2018) moves this further by discussing the negative social and environmental impact of mining industry (Banerjee, 2018). Girschik et al. (2020) highlights the fact that CSR is (unfortunately) used mostly as promotional strategy while Christensen and colleagues (2020) take a bold step in the discussion on hypocrisy in the CSR-related communication and discuss the long-term negative outcomes. Reporting CSR activities has an impact on improving trust and competitiveness of an organization. These issues ("4. CSR: reporting", 12,5%) constitute the second strong thematic trend. At the micro level this pertains to the trust of customers and suppliers, while at the macro level trust relates to all stakeholders. As an illustrative discussion, Egels-Zandén (2009) identified the need to complement the discrete campaign model with a continuous bargaining model of stakeholder pressure". Dagiliene et al. (2014) highlighted the role of transparency in improving trust and competitiveness of an organization whereas Habek and Wolniak (2015) called for increased governmental guidance in shaping sustainability reporting practices. Similarly, Tang and Demeritt (2018) showed the importance of mandatory carbon reporting to explore wider debates about CSR's non-financial reporting. After analysing CSR related information in the annual reports, Pelikánová (2019) concluded that employee matters and adherence to international standards are used as a public declaration to society more than the data on environmental protection, while social matters and research and development are played down. The third most prevalent topic ("11. CSR: impact on financial performance", 11,1%) gains prominence in periods directly before and after a crisis. The articles in this topic concentrate on the impact of CSR on the financial performance. For example, Lin et al. (2017) and Cho et al. (2019) use CSR expenditures to predict the performance while Kim and colleagues (2018) analyse the role of CSR in company valuation. Xiang and colleagues (2020) provide evidence of the role of investors' attentiveness in boosting CSR adoption. Finally, Bae et al. (2021) show that CSR has a potential to preserve shareholder value through stakeholders' engagement. The overview of all identified topics is provided in Table 3.

## 4. Discussion and conclusions

The purpose of the research and article was to identify the type of CSR activities in the scholarly literature and their intensity depending on the crisis management phases. In the event of a disruption, organizations make decisions aimed at ensuring business continuity, scaled from the full scope of activities to the so-called key products (depending on the type, scale, and duration of the crisis). Two aspects can be indicated here. The first one concerns the

microeconomic issue, which is clearly visible in the literature as equating crisis management with crisis communication in relation to incidents in individual organizations. These activities may result, for example, from product quality inconsistencies and are aimed at protecting the reputation and perception of the product brand. The second aspect concerns the macroeconomic issue, in crisis situations relating to a larger number of companies (territorially, by industry). In this case, crisis management activities involve issues of a social nature, with the economy falling into the 2nd plan for socialization (e.g., financial crisis 2009). The quality management serves as the basis for the organization's activities due to their orientation towards creating an offer that meets various requirements (technical, legal, customer). Marketing relates to the appropriate communication of this offer, and on the other hand, to obtain information about customer purchasing factors and the attempt to create them.

We identified 15 thematic groups in our literature review. We find no direct relations between searched elements and subjects in published articles. CSR, as a domain, contains three main elements (economic, environmental, social) but this concept can be considered in many areas and a wide variety of organisational activities. This was also identified in the previous bibliometric study on CRS in international business. Zhao and colleagues (2018) analysed contributions published in twelve leading international business journals over three decades (1996-2015) and identified five trending themes: business ethics, integration of stakeholder management, the evolution of the CSR concept, the political and social demands of CSR, and the financial implications of CSR.

For a company, the engagement in CSR activities should be always evaluated in relation to company performance. If CSR activities are driven by external (i.e., stakeholders') expectations, employees are less engaged and, as a result, so are the customers. This, in turn, brings more scepticism (Vanhamme, Grobben, 2009). Crisis Management in connection with CSR appears by far the most common in the context of communication in crisis situations, and in relation to one organization and situations that can negatively affect the perception of the brand by customers and the sales implications. Clearly, CSR can help organizations become more resilient to the negative impact of crises by spreading its positive values on stakeholders and the business itself (Yelkikalan, Köse, 2011). The relationship between customer sympathy and the application of CSR during crises could help organizations in obtaining a greater understanding about the customers (Tsarenko,Tojib, 2015). Importantly, CSR could be an effective crisis management tool, but only when the CSR initiatives are well aligned with the cause of the crisis (Azwar 2017; Sheikh, Beise-Zee, 2011).

Social responsibility has a positive effect on crisis management within an organization as it can drive the development of responsible behaviour within organization, which will be an advantage during potential future crises (Banerjee, 2008). Social responsibility programs and activities can prevent this loss of reputation (Coombs, Frandsen, Holladay, Johansen, 2010). It can therefore be mentioned that CSR offers preventive shield, being not only a reactive tool used to reduce the negative effects of a crisis. According to Haigh and Dardis (2012),

responsible behaviour can support an organization to safely navigate and substantially improve its reputation during crisis (Idowu et al., 2017). CSR in the context of CM can be viewed from a micro and macro perspective. The first sphere concerns CSR activities undertaken in individual organizations because of the crisis. The thematic transition to the macro level is to focus on crisis management from an overall perspective, definition, and phases for CM activities. Crisis management consists of a set of factors used to combat crises to reduce the actual damage inflicted by a crisis (Coombs, 2006). Definition of crisis management (CM) may differ from country to country and organisation to organisation due to variations in level of turbulence in different situations in different corners of the globe (Eliasson, Kreuter, 2000). Therefore, cultural dimensions and legal aspects of each country need to be analysed for appropriate action plans (Khodarahmi, 2009).

The 2008 financial crisis was defined as a crisis of trust (Roth, 2009; Earle, 2009). The COVID-19 crisis (CC) could be seen as a social crisis of safety which also affected (of course to varying degrees) the activities of every organisation and every person in terms of basic needs – health and life, where the word "quality" (in relation to the fulfilment of requirements by products and services) has taken on a new glow. CSR policies in response to COVID-19 are created by organizations but are implemented by individual employees. The way employees perceive and react to CSR actions are key determinants of CSR's implementation and success (Aguinis et al., 2020; Ratten, 2020).

Crises are complex, multi-faceted, and ill-defined systems of highly interconnected problems. Profound ethical issues are among their prime components. Therefore, any attempt to manage them is unprofessional at best if it does not include ethical and moral standards. The link between ethics and crisis management, however, is seriously underdeveloped (Alpaslan, Mitroff, 2021). The quality of the results of business activities results from the appropriate quality of internal processes of the organization. Organizational activities are focused on the quality of the final product from the perspective of customer needs and product levels. These include technical and functional quality, but also emotional aspects related to the product itself, brand relationships and customer beliefs. Marketing activities in the organization take these aspects into account, identifying the needs and expectations of customers and transferring this knowledge to the processes of designing and creating an attractive market offering. These issues vary depending on the market in which a given organization operates (e.g., business markets versus consumer markets), as different criteria determine purchasing decisions. Decisions, however, are made by people based on their preferences (consumer markets) or consider the profile and culture of the organization (business markets). Market interactions make organizations the source of problems (e.g., environmental) and at the same time problem solvers (social responsibility). Individual economic entities consider CSR strategies and practices in different ways, which depends on many factors, starting from legal responsibility of producers for product safety and moving to a broader consideration of all aspects of social responsibility and optimization of activities in this area of management.

The intensity of activities in the "economy-environment-society" triad depends on internal factors in an organization (resources, awareness of managers, mission, and vision of the organization) in interaction with external factors (stakeholder expectations, type of market). Internal relationships between the components of CSR change in response to the volatility of the economic and social environment. The importance of social responsibility results from this two-way interaction – the impact of individual elements on the functioning of the organization and the impact of the organization on the environment. This applies to individual organizations (on a microeconomic scale) and on a macro scale, by including activities in an increasing number of companies on the market.

From the perspective of the analysed topics, publications on CSR show a lack of general and unequivocal trends in specific aspects – triad CSR "economy-environment-society". In the results of the analysis of the literature, there is a distinction between micro and macroeconomic level (group no. 14 "CSR: macroeconomic perspective"). These issues are analysed in individual articles in terms of microeconomics in individual organizations (group no. 10 "CSR in developing economies" with showing case-studies; group no. 15 "CSR: internal perspective") or macroeconomics from industries point of view (group no. 6 "CSR: ethical and institutional perspective"; group no. 7 "CSR in banking") or both (group no. 1 "CSR: international aspects"; group no. 2 "CSR: financial aspects and analysis"; group no. 5 "CSR: Sustainable development of an organization"; group np. 12 "CSR: agent-theoretic perspective", group np. 15 "CSR: other aspects").

Regarding the research objective, it is possible to synthetically summarize the obtained results of CSR publications in relation to individual assumed areas – crisis, quality, marketing. Corporate Social Responsibility activities are undertaken in individual organizations for various reasons, brand focus (group no. 7 "CSR: marketing strategy and capabilities"; group no. 8 "CSR: the influence on attitudes and intentions"), relations with stakeholders (group no. 3 "CSR: organizations and networks", group no. 4 "CSR: reporting") or focusing these actions on financial aspects (group no. 11 "CSR: impact on financial performance") concerns preventive actions. The unprecedented impact of Covid-19 crises induced a bottom-up flow of CSR activities that have become more collaborative and co-creative. This is a noteworthy change comparing to a typical strategy-led CSR engagement. The above issues may be undertaken at various stages of crisis management. Also, the marketing aspect of these activities is an individual matter in individual companies, and the issue of the relationship to the quality of products is not noticeable in the analysed materials.

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# Appendix

**Table 1.**

*CSR's topic proportions by year*

| Topic | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. CSR: international aspects | 4,5% | 1,9% | 0,0% | 6,2% | **48,0%** | 12,9% | 5,1% | 2,5% | 8,6% | 2,5% | 3,9% | 9,0% | 2,7% | 5,3% | 7,6% | 6,8% |
| 2. CSR: financial aspects and analysis | 0,0% | 0,0% | 0,0% | 14,6% | 0,0% | 0,3% | 2,0% | 0,0% | 0,1% | 5,1% | 3,9% | 0,1% | 8,4% | 3,9% | 4,6% | 0,0% |
| 3. CSR: organizations and networks | 16,9% | 0,8% | 0,0% | 3,0% | **29,5%** | 0,0% | 0,6% | 16,1% | 4,1% | 1,2% | 6,0% | 6,5% | 2,5% | 5,3% | 2,4% | 0,1% |
| 4. CSR: reporting | 4,8% | 10,1% | **28,5%** | **37,1%** | 1,3% | 14,4% | 3,0% | 6,1% | **32,0%** | 15,7% | 13,0% | 9,0% | 7,1% | 4,9% | 5,3% | 7,5% |
| 5. CSR: Sustainable development of an organization | 0,0% | 0,0% | 0,0% | 0,3% | 0,0% | 0,3% | 0,5% | 1,3% | 0,0% | 0,8% | 0,4% | 4,4% | 4,2% | **13,0%** | **15,0%** | 5,5% |
| 6. CSR: ethical and institutional perspective | **30,8%** | **42,7%** | 4,6% | 7,6% | 7,3% | **22,4%** | 17,1% | 7,0% | 8,2% | **10,3%** | 6,5% | **11,3%** | 7,0% | 7,8% | 7,0% | 6,7% |
| 7. CSR: marketing strategy and capabilities | 9,2% | **17,0%** | 12,7% | **19,2%** | 3,2% | 12,2% | **22,2%** | 11,3% | 2,1% | 7,4% | 10,7% | 5,7% | 5,4% | 2,1% | 2,7% | 7,0% |
| 8. CSR: the influence on attitudes and intentions | **24,1%** | 10,5% | 0,0% | 0,0% | 0,0% | **17,0%** | 0,3% | **17,8%** | 0,8% | 10,0% | 5,5% | 4,0% | 5,2% | 2,3% | 2,2% | 4,3% |
| 9. CSR in banking | 1,8% | **17,0%** | 0,5% | 0,4% | 0,0% | 0,6% | 9,0% | 9,1% | 12,5% | 7,6% | 8,5% | 11,1% | 7,4% | 3,1% | 3,7% | 4,1% |
| 10. CSR in developing economies | 2,1% | 0,0% | 1,4% | 1,6% | 0,0% | 0,2% | 0,0% | 8,6% | 3,2% | 9,2% | 6,3% | 6,0% | 7,8% | 4,1% | 2,3% | 5,0% |
| 11. CSR: impact on financial performance | 0,0% | 0,0% | **25,8%** | 0,4% | 2,6% | 9,3% | 12,0% | 0,0% | **21,8%** | 9,1% | 11,1% | 8,4% | **19,6%** | **22,4%** | **18,8%** | **17,0%** |
| 12. CSR: agent-theoretic perspective | 0,0% | 0,0% | 1,2% | 7,6% | 2,3% | 0,0% | 2,7% | 2,0% | 1,1% | 1,9% | 7,9% | 6,5% | **10,9%** | 8,3% | 4,5% | **23,2%** |
| 13. CSR: internal perspective | 5,7% | 0,0% | **25,3%** | 0,6% | 3,8% | 9,9% | **25,4%** | 17,3% | 3,3% | 4,0% | **14,8%** | **12,1%** | 7,7% | 5,1% | 8,7% | 3,2% |
| 14. CSR: macroeconomic perspective | 0,0% | 0,0% | 0,0% | 1,3% | 2,0% | 0,2% | 0,0% | 0,8% | 0,3% | 10,4% | 1,0% | 4,7% | 2,5% | 6,0% | 5,1% | 0,5% |
| 15. CSR: other aspects | 0,0% | 0,0% | 0,0% | 0,0% | 0,0% | 0,2% | 0,1% | 0,0% | 2,0% | 4,7% | 0,5% | 1,5% | 1,7% | 6,4% | 10,1% | 9,1% |
| **Crisis stage** | Before crisis | | | During crisis | | After crisis | | | Before crisis | | | | | | During crisis | |

Notes: Values for the most represented topics in given years are presented in bold.

Source: own calculation.

**Table 2.**

*Prevalence and variance of topics*

| Topic | Average prevalence | Topic variance |
|---|---|---|
| 1.  CSR: international aspects | 8.0% | 1.2432 |
| 2.  CSR: financial aspects and analysis | 2.7% | 0.1666 |
| 3.  CSR: organizations and networks | 5.9% | 0.6651 |
| 4.  CSR: reporting | 12.5% | 1.1688 |
| 5.  CSR: Sustainable development of an organization | 2.9% | 0.2224 |
| 6.  CSR: ethical and institutional perspective | 12.8% | 1.1238 |
| 7.  CSR: marketing strategy and capabilities | 9.4% | 0.3807 |
| 8.  CSR: the influence on attitudes and intentions | 6.5% | 0.5490 |
| 9.  CSR in banking | 6.0% | 0.2536 |
| 10. CSR in developing economies | 3.6% | 0.1018 |
| 11. CSR: impact on financial performance | 11.1% | 0.7975 |
| 12. CSR: agent-theoretic perspective | 5.0% | 0.3536 |
| 13. CSR: internal perspective | 9.2% | 0.6298 |
| 14. CSR: macroeconomic perspective | 2.2% | 0.0870 |
| 15. CSR: other aspects | 2.3% | 0.1166 |

Notes: Average prevalence for the total sample M = 6,7%.

Source: own calculation.

**Table 3.**

*Identified topics and representative articles*

| Topic | Characteristic |
|---|---|
| 1. CSR: international aspects | Articles in the group focus on criticism of CSR theory. Brueckner & Mamun (2010) present a long-running conflict between community members and their corporate neighbor and question the possibility of meeting local needs by the means of economic efficiency. Mihalic (2016) outlines the problem with practical meaning and implications of the "responsustable" tourism. Grigore and colleagues provide an explanation of how the contradictions of CSR are avoided in practice even when actors may be aware of them (Grigore et al., 2020). |
| 2. CSR: financial aspects and analysis | The articles in this group indicate the positive relation between CSR and financial results of companies. Flammer (2015) positions CSR as a competitive strategy. Adamska and Dabrowski (2016) note a positive relation between CSR and financial results of companies. Their findings confirm that investors in emerging markets take into account the information about changes in the level of CSR by responding positively to its growth and negatively to its decline. Guillamon-Saorin et al. (2018) show that higher commitment to CSR activities results in lower levels of inefficiencies, especially if the activities are environmentally oriented. Cao et al. (2019) note that competitive pressure positively affects the disclosure of environment-related activities by companies. |
| 3. CSR: organizations and networks | Micro-environment and macro-environment links (i.e., number and type of stakeholders) are important because they determine the scope of activities undertaken by an organisation due to CSR strategy. Navickas and Kontautiene (2013) find that an active development of socially responsible initiatives positively influences business innovations and increases competitiveness of a companies. Short et al. (2016) call for developing governance structures to mitigate reputational risks. González-Gomez and García-Santillán (2019) investigate the relations between intellectual property and international commerce. |
| 4. CSR: reporting | Reporting CSR activities has an impact on improving trust and competitiveness of an organization. Egels-Zandén (2009) identifies the need to complement the discrete campaign model with a continuous bargaining model of stakeholder pressure. Dagiliene et al. (2014) highlight the role of transparency in improving trust and competitiveness of an organization. Habek and Wolniak (2015) call for increased governmental guidance in shaping sustainability reporting practices. Tang and Demeritt (2018) show importance of mandatory carbon reporting to explore wider debates about CSR's non-financial reporting (Tang & Demeritt, 2018). |
| 5. CSR: Sustainable development of an organization | Benos et al. (2018) propose a comprehensive dashboard to enable a cooperative performance assessment and conclude that a cooperative organizational form is a resilient, and naturally sustainable one (Benos et al., 2018). Su and Yu (2019) discuss sustainable economic and environmental development in China and propose new policies to strengthen the sustainable development of new energy enterprises. Hernández-Perlines et al. (2020) analyse the sustainable growth in the agro-food cooperatives and find that whilst all dimensions of CSR are important and appropriate for the agro-food cooperatives, the environmental dimension affects the performance of agro-food cooperatives the most. Sánchez-Hernández & Maldonado-Briegas (2019) highlight that sustainable entrepreneurial culture programs in the public educational system positively affect students´ attitude to social responsibility, thus empowering them to change the world for a better future. |
| 6. CSR: ethical and institutional perspective | This topic includes contributions that encompass broader ethical and institutional perspective. For example, Wittneben et al. (2012) discuss the climate change and call for tangible CSR actions in this regard. Banerjee (2018) moves this further by discussing the negative social and environmental impact of mining industry. Girschik et al. (2020) highlights the fact that CSR is used mostly as promotional strategy and Christensen and colleagues (2020) discuss the long-term negative outcomes of hypocrisy in the CSR-related communication. |

Cont. table 3.

| 7. CSR: marketing strategy and capabilities | Lindgreen et al., 2012 analyse the development of a CSR brand and capabilities which are necessary to implement a CSR-related brand strategy. Similarly, Janiszewska (2013) discusses the complexity of consumer insights in place branding. Extending this concept, Scandelius and Cohen (2016) scrutinize the food and drink value chain. Based on a series of case studies, the authors concluded that strategic ambiguity in branding can form a solid base for improved collaboration and co-creation. This is also echoed in the article by Ingenbleek and Dentoni (2016) in which authors show how companies can expand their capabilities by adopting social learning perspective. |
|---|---|
| 8. CSR: the influence on attitudes and intentions | Social media is the important element in CSR communication process. Whelan and colleagues identify three dynamics in social media-augmented corporate–society relations, through utilizing the notion of 'citizenship arenas' (Whelan et al., 2013). The prevalence of social media in the CSR context is emphasised by Dunn and Harness (2018). The authors clearly evidence that companies rely on social media while communicating their CSR activities. Other authors show that the online communication of CSR drive positive word-of-mouth intentions (van Prooijen & Bartels, 2019). Plewa et al. (2015) fin that corporate volunteering can be an effective employee engagement initiative may influence consumer perceptions of CSR image and subsequent consumer behaviour. |
| 9. CSR in banking | Institutional reputation and market trust are crucial factors in the banking sector. The articles in this topic point to two CSR issues: (1) communicating actions, and (2) market's perception of the communication. Pérez & Bosque (2014) explore the role of corporate governance structure in shaping customer CSR expectations in the banking crisis context. In a comparative study, Ruiz et al. (2016) identify antecedents and consequences of bank reputation (Ruiz et al., 2016). Through the CSR prism, Rahman et al. (2017) investigate how the type of bank ownership can affect relationship lending to small and medium enterprises (SMEs). Alt and colleagues (2017) show bank's social responsiveness in communicating with costumers before the economic crisis. |
| 10. CSR in developing economies | Developing economies receive broad coverage in the CSR literature. Fayyaz and colleagues (2017) discuss the adoption of CSR by in industrial clusters. Perry et al. (2015) investigate the strategic balancing of ethical considerations (Perry et al., 2015). Haque and Azmat (2015) examine CSR in labour-intensive industries in Bangladesh. Tasavori and colleagues (2016) explore corporate social entrepreneurship in market entry strategies. |
| 11. CSR: impact on financial performance | The articles in Topic 11 concentrate on the impact of CSR on the financial performance. Lin et al. (2017) and Cho et al. (2019) use CSR expenditures to predict the performance. Kim and colleagues (2018) analyze the role of CSR in company valuation. Xiang and colleagues evidence the role of investors' attentiveness in boosting CSR adoption (Xiang et al., 2020). Finally, Bae et al. (2021) show that CSR has the potential to preserve shareholder value through stakeholders' engagement. |
| 12. CSR: agent-theoretic perspective | Agudo-Valiente and colleagues (2017) explore the role of managers believes in CSR and respective outcomes. Ferro-Soto et al. (2018) demonstrated how managerial efforts to improve sustainability affect business performance. Farooq and Salam (2021) identified the relationship between employee engagement, organizational pride, organizational identification (Farooq & Salam, 2021). |
| 13. CSR: internal perspective | Jordan et al. (2012) investigated the influence of company's crises response on brand perceptions and behavioral intentions. Shim and Yang (2016) claim that CSR offers leverage if a company has already good reputation, whereas implementing CSR as a remedy to bad reputation triggers the perception of hypocrisy. Consequently, CSR message framing invites negative sentiment in communication due to hypocrisy (Shim et al., 2017). Importantly, Ahn and Lee (2020) evidence that consumer participation in CSR activities reduces consumer scepticism. |
| 14. CSR: macroeconomic perspective | The papers in this topic discuss CSR on macro level. For example, Shen et al. (2015) debate the crisis of CSR in the textile industry, Chang et al. (2015) explore airline industry (Chang et al., 2015), Jabłoński and Jabłoński (2019) investigate water supply companies. |
| 15. CSR: other aspects | The last set of articles grouped paper which concern different aspects of CSR. This includes discussion on the core of CSR. For example, Abad-Segura et al. (2019) investigates the evolution of the relationship between CSR and sustainability. |

# REVIEWERS