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FOREWORD

The Scientific Papers contains 15 publications of the employees and PhD students of the Department of Economics and Computer Science. They are focused on issues related to data analysis and their use in management and economics. All texts are empirical and create both scientific and practical value.

In addition, the intention of the authors and the editor was also to place the considerations in the Priority Research Areas of the Silesian University of Technology. For this reason, in the particular articles you can find threads on:

- modern energy,
- sustainable development in industrial organizations,
- Industry 4.0,
- data mining and machine learning.

Izabela Jonek-Kowalska

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2023
ORGANIZATION AND MANAGEMENT SERIES NO. 171

CARBON FOOTPRINT IN NON-FINANCIAL REPORTING

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Purpose: The aim of the paper is to review the requirements of the non-financial reporting on climate change.
Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and Polish literature, legal acts relevant to the researched topic, and standards.
Findings: The evolution of the approach to non-financial reporting highlights the trend towards measurability, comparability of indicators.
Originality/value: The requirements of the new ESRS standard have been presented against the background of existing solutions.

Keywords: non-financial reporting, climate change, carbon footprint, ESRS.

Category of the paper: literature review.

1. Introduction

In recent years, the European Union has adopted a number of regulations aimed at supporting measures to promote sustainability and reduce the effects of climate change.

A standard for non-financial reporting has been established, which covers three areas – environmental, social and governance aspects – ESG. The evolution of the form in which non-financial information is presented, following the development of good practice and calculation standards, foreshadows the challenges that companies will face when the CSRD comes into force. In view of the criticism of the current presentation of non-financial information, characterised by a high degree of flexibility and the lack of a clear methodological framework (Szadziewska, Kujawski, 2022), it is important to note the potential of the new ESRS reporting framework to focus on the reliability and comparability of published information (Tylec, 2020).

2. Legal provisions

Among the legislative instruments that have successively made non-financial reporting mandatory are the Non-Financial Reporting Directive (NFRD), the EU Taxonomy Regulation (Regulation 2020/852) and the SFDR on the disclosure of information regarding sustainable investments (Regulation 2019/2088). While the first two have a direct impact on the reporting obligations of companies, the SFDR only applies to financial market participants. Nonetheless, its effect will be a greater demand from investors for non-financial information.

The directive 2014/95/EU NFRD ("Non-financial Reporting Directive") requires the disclosure of non-financial information by large public interest entities (PIEs)[1]:

- which employ over 500 people – in the case of average full-time employment per year, and
- whose total assets on the balance sheet at the end of the financial year exceed PLN 85 million or whose net revenue from the sale of goods and products for the financial year exceeds PLN 170 million.

These entities are obliged to include in their activity reports an additional statement on non-financial information, covering at least environmental, social and labour issues, compliance with human rights and anti-corruption and anti-bribery measures. Such statement should include the following information[2]:

1. a brief description of the entity's business model,
2. key non-financial performance indicators related to the entity's operations,
3. a description of the policies applied by the entity in relation to social, labour, environmental issues, respect for human rights and anti-corruption measures, as well as a description of the results of applying these policies,
4. a description of due diligence procedures - if the entity applies them under the policies referred to in point 3,
5. a description of significant risks associated with the activities of the entity that may have an adverse effect on the issues referred to in point 3, including risks associated with the entity's products or its interactions with the surrounding environment, including counterparties, and a description of the management of those risks.

[1] Article 49b of the Accounting Act of 29 September 1994 (Journal of Laws 1994, No. 121, item 591).
[2] Ibidem.

Requirements formulated in this way, which are mandatory from 2018 (2017 reports), provided considerable room for interpretation. The flexible approach to disclosure was mainly manifested in the implementation of the "comply or explain" rule. Non-disclosure of non-financial indicators is therefore allowed, provided it is adequately justified.

Regulation 2019/2088 SFDR (Sustainable Finance Disclosure Regulation) introduced sustainability-related disclosure rules for the financial services sector (e.g. insurance companies, investment companies and credit institutions that provide portfolio management services, financial advisors i.e. insurance brokers). Pursuant to the Regulation, the financial market participants are obliged to publish:

- information on their strategies for incorporating sustainability risks into their operations when making investment decisions; and
- due diligence strategy statement with regard to the adverse effects of investment decisions on sustainability factors, taking into account its size and the nature and scale of its activities and types of financial products.

Financial advisors disclose the above specified information in relation to the risks that are introduced in the investment or insurance advisory services they provide (Geerts et al., 2021).

The SFDR applies at the “entity level” (i.e. requiring financial companies to report how the organisation as a whole manages such risks) as well as at the “product level” (i.e. requiring companies to report how such risks affect their financial products). The SFDR also applies the “comply or explain” clause. Smaller companies with less than 500 employees can choose not to report due diligence processes. The regulation requires reporting of sustainability risks, even if the obliged entities do not offer ESG-related products. If an entity offers ESG-related products, the SFDR requires additional disclosures depending on how “green” the product is. The SFDR entered into force on 10 March 2021.

On 6 April 2022, the European Commission adopted a technical standard to the SFDR Regulation (hereinafter also “RTS”) clarifying the content, methods and presentation of information related to sustainability indicators, products promoting environmental and/or social aspects (Art. 8 SFDR) and products aiming at sustainable investments (Art. 9 SFDR).

The Corporate Sustainability Reporting Directive (CSRD) 2022/2464 requires companies to report annually. The reports must include data on their environmental, social, human rights, corporate governance impacts.

This directive entered into force on 1 January 2023 and will gradually oblige more entities to report (Table 1).

Table 1.
Reporting schedule according to the CSRD

Entities covered by the CSRD	Dates
Large public interest companies already covered by the NFRD and with more than 500 employees	Reporting in 2025 for 2024
Large companies that are not covered by the NFRD and have more than 250 employees and/or €40 million turnover and/or €20 million of total assets	Reporting in 2026 for 2025
SMEs, as well as other listed companies, small and non-complex institutions provided that they are large entities (listed or not) or small and medium-sized listed companies; captive insurance and captive reinsurance companies provided that they are large entities (listed or not) or small and medium-sized listed companies	Reporting in 2027 for 2026

Source: own elaboration.

The EU Taxonomy Regulation (hereinafter: taxonomy), which entered into force on 12 July 2020, reflects a common European classification system for environmentally sustainable activities. Basically, the taxonomy refers to the conditions that need to be met in order for an undertaking to be considered an environmentally sustainable activity. This is essential for investors to prevent "greenwashing" – that is, when financial products are advertised as sustainable without meeting sustainability criteria (Mustafa Khan, Mohd Ali, 2023). The taxonomy defines six environmental objectives and defines a business activity as sustainable if that activity contributes to at least two of these objectives without causing significant harm to any of the others.

3. Selected non-financial reporting standards

Non-financial information, known to be presented mostly, but not only, in Sustainability Reports, describes the company's performance regarding social, environmental, corporate governance, and human resources management issues, among others. It is an emerging topic that has gained increasing relevance in the perception of stakeholders about the information disclosed by the entity during its fiscal year (Eugénio et al., 2022).

A number of non-financial reporting systems can be identified that refer to environmental aspects and, in particular, to the impact on climate change (Loh et al., 2017). Table 2 presents selected standards.

Table 2.
Selected standards for reporting on environmental aspects

Name of standard	Overview	Framework	GHG emissions reporting
Global Reporting Initiative [GRI 301-308]	It refers to materials, energy, water, biodiversity, emissions, waste, value chain impacts.	Framework intended for private and public companies.	GRI 305 Scope 1-3 GHG Protocol
SASB Sustainability Accounting Standards Board [SASB]	Establishing disclosure standards for sustainability reporting, that facilitate the communication of information from companies to their investors.	Framework directed at investors.	According to GHG Protocol
Task Force on Climate-related Financial Disclosures [TCFD]	Promoting the integration of climate change disclosures and financial risks/ opportunities related to climate change into companies' risk management and strategic planning processes.	Initiative that targets banks, lenders, and insurance underwriters.	A set of voluntary, consistent disclosure recommendations that are intended to be used by companies to provide investors, lenders and insurers with reliable information about financial risks associated with climate impacts.
Carbon Disclosure Protocol [CDP]	Helps determine the environmental impact of the corporate activity of companies, through their questionnaire surveys.	Framework in the form of a disclosure system associated with the "Environment" dimension of ESG.	Different standards used to calculate the carbon footprint are acceptable.
European Sustainability Reporting Standards [ESRS E1-5]	They are an integral part of reporting under the CSRD.	To be used by organisations covered by the CSRD.	ESRS E1 Climate change According to GHG Protocol.

Source: Own elaboration based on: (Cruz, 2023).

GRI (Global Reporting Initiative) is an independent, international organisation based in Amsterdam that helps companies and other organisations take responsibility for their impact by providing a global common language to communicate that impact. GRI standards are currently an integral part of non-financial reporting used by many organisations.

The Task Force on Climate-related Financial Disclosures publication is an annual report on companies' disclosure of financial information related to climate impacts, in line with TCFD recommendations.

The TCFD recommendations, presented in 2015, were designed as a set of voluntary, consistent disclosure recommendations that are intended to be used by companies to provide investors, lenders and insurers with reliable information about financial risks associated with climate impacts. Work on the final form of the recommendations was completed in 2017, after extensive consultation. As a result, a set of recommendations has been developed to support transparent and reliable data reporting that allows for understanding the company's risks and opportunities in relation to the climate.

On 15 November 2022, EFRAG's Sustainability Reporting Board adopted a set of 12 final draft of the standards. Once submitted to the European Commission, they will be issued by the EC in the form of delegated acts by 30 June 2023.

4. Carbon footprint reporting according to ESRS E1

The organisation's impact on climate change as required by the CSRD will be reported according to the standard ESRS E1 - Climate change.

A draft made available on the EFRAG website sheds light on the strict reporting rules that will be mandatory from 2024. In addition, the entire "Climate change" standard will be mandatory for all entities, regardless of materiality assessment. The number of indicators that will be reported under this single standard is 84.

The standard includes the following main requirements:

E1-1 – Transition plan for climate change mitigation.

E1-2 – Policies related to climate change mitigation and adaptation.

E1-3 – Actions and resources in relation to climate change policies.

E1-4 – Targets related to climate change mitigation and adaptation.

E1-5 – Energy consumption and mix.

E1-6 – Gross Scopes 1, 2, 3 and Total GHG emissions.

E1-7 – GHG removals and GHG mitigation projects financed through carbon credits.

E1-8 – Internal carbon pricing.

E1-9 – Potential financial effects from material physical and transition risks and potential climate-related opportunities.

In terms of E1-1, the organisation describes its approach at a strategic and business model level to reducing its impact on climate change in relation to the 1.5 degrees Celsius target under the Paris Agreement. It is obliged to clarifying whether its targets are compatible with the goal of limiting global warming to 1.5 degrees Celsius. It should also describe the identified decarbonisation levers and the key actions planned regarding the product and service portfolio as well as the use of new technologies. A similar clarification should be applied to activities in the area of investment and transition financing. An organisation also addresses situations where the achievement of reduction targets may be at risk. A description of the alignment of the business to the Taxonomy Regulation and more broadly the plans for future alignment to the taxonomy (revenue, CapEx and CapEx plans) are also included where applicable.

The E1-2 disclosure refers to the identification, assessment and management of, and mitigation measures for, the significant impacts of climate change as well as the risks and opportunities associated with climate change mitigation. What needs to be described here is

whether and how the organisation's policies address areas such as: climate change mitigation, climate change adaptation, energy efficiency, renewable energy deployment and other.

Within E1-3, actions taken and planned to achieve climate-related policy goals are described. Reference should be made to the significant amounts of CapEx and OpEx that condition the implementation of the respective activities.

The aim of requirement E1-4 is to enable an understanding of the reduction targets that the organisation has set to support its mitigation and adaptation policies and to address the significant climate-related impacts, risks and opportunities. GHG reduction targets are disclosed here in absolute values (possibly also as intensity values). These objectives should relate to Scopes 1&2 and 3 for the defined organisational limits. GHG removals, carbon credits or avoided emissions should not be considered here. The base year and base year emissions are also disclosed. A new requirement, e.g. in relation to the GRI standard, is the need to update the base year for reduction targets from 2030 onwards every 5 years. The reduction targets should include at least targets for 2030 and, if available, for 2050. From 2030 onwards, target values are set after each successive five-year period. It is also determined whether the targets are scientifically justified and consistent with the goal of limiting global warming to 1.5°C. The organisation determines the expected decarbonisation levers and their overall quantitative contribution to achieving the reduction targets (e.g. energy or material efficiency and reduction in consumption, fuel switching, use of renewable energy, product and process withdrawal or substitution).

Within E1-5 the organisation provides information on energy consumption and the share of renewable energy in its overall energy mix. The disclosure includes the total energy consumption in MWh related to own operations, defined as follows:

a) total consumption of energy from non-renewable sources in high climate impact sectors (according to NACE for codes A-H), including:
   - fuel consumption from coal and coal products,
   - fuel consumption from oil and oil-related products,
   - fuel consumption from natural gas,
   - fuel consumption from other non-renewable sources,
   - consumption from nuclear products,
   - consumption of purchased or acquired electricity, heat, steam and cooling from non-renewable sources,
b) total consumption of energy from renewable sources, broken down by:
   - consumption of renewable fuels (including biomass, biogas, non-fossil fuel waste, renewable hydrogen, etc.),
   - consumption of purchased or acquired electricity, heat, steam and cooling from renewable sources,
   - consumption of self-generated non-fuel renewable energy.

Where applicable, the organisation disaggregates and separately discloses its own non-renewable and/or renewable energy production in MWh.

Moreover, the organisation should disclose information on the energy consumption (total energy consumption per net revenue) associated with activities in sectors with a high climate impact.

Under requirement E1-6, the organisation is required to disclose the gross emissions in Scopes 1, 2 and 3, as well as the total greenhouse gases emitted. When calculating emissions in these scopes, the requirements and guidance contained in the GHG Protocol and GRI 305 (which is also based on the GHG Protocol) should be taken into account, alternatively ISO 14064-1:2018. Including all greenhouse gases CO2, CH4, N2O, HFCs, PFCs, SF6, and NF3 is mandatory. Biogenic emissions are also disclosed, but separately. The latest GWP values published by the IPCC should be used. A description of the calculation methodology, the emission indicators used and the tools should also be disclosed.

Scope 1 includes direct emissions from the combustion of fuels in stationary installations, in mobile sources, diffuse emissions and those generated in production processes. Carbon absorption and emissions (CO_2, CH_4, N_2O) from direct land use and land use change are also disclosed separately.

Scope 2 includes indirect emissions related to the generation (by an external entity) of electricity, heat, cooling and steam purchased by the reporting organisation. Emissions within Scope 2 are reported using two methods: location-based and market-based.

Scope 3 includes emissions generated in the value chain. They can be a major factor in an organisation's climate impact. Calculations are performed in accordance with GHG Protocol requirements, and financial institutions should use the GHG Accounting and Reporting Standard for the Financial Industry from the Partnership for Carbon Accounting Financial (PCAF). Emissions should be calculated annually for the relevant Scope 3 categories. Scope 3 inventory should be updated every 3 years if any major changes occur.

In Scope 3, the organisation reports indirect Scope 3 GHG emissions from the consolidated accounting group (parent company and its subsidiaries); indirect Scope 3 GHG emissions from affiliates, joint ventures and unconsolidated subsidiaries where the reporting entity has the ability to control the operations and relationships (i.e. operational control); and Scope 1, 2 and 3 from affiliates, joint ventures, unconsolidated subsidiaries (investment entities) and joint contractual arrangements over which the entity does not have operational control and where these entities are part of the reporting organisation's value chain.

The manner in which the calculation results are presented in accordance with E1-6 according to the ESRS is shown in Figure 1. Compared to existing practice, e.g. according to GRI, this is a more elaborate form of presentation, taking into account the milestones and target years.

	Retrospective				Milestones and target years			
	Base year	Compa-rative	N	% N / N-1	2025	2030	2050	Annual % target / Base year
Scope 1 GHG emissions								
Gross Scope 1 GHG emissions (tCO_2eq)								
Percentage of Scope 1 GHG emissions from regulated emission trading schemes (%)								
Scope 2 GHG emissions								
Gross location-based Scope 2 GHG emissions (tCO_2eq)								
Gross market-based Scope 2 GHG emissions (tCO_2eq)								
Significant scope 3 GHG emissions*								
Total Gross indirect (Scope 3) GHG emissions (tCO_2eq)								
Purchased goods and services								
Optional sub-category: Cloud computing and data centre services								
Capital goods								
Fuel and energy-related activities								
Upstream leased assets								
Waste generated in operations								
Processing of sold products								
Use of sold products								
End-of-life treatment of sold-products								
Downstream leased assets								
Franchises								
Upstream transportation and distribution								
Downstream transportation and distribution								
Business travels								
Employee commuting								
Financial investments								
Total GHG emissions								
Total GHG emissions (location-based) (tCO_2eq)								
Total GHG emissions (market-based) (tCO_2eq)								

* Undertakings that choose to account for their Scope 3 emissions based on the indirect GHG emissions categories of ISO 14064-1:2018 (excluding indirect GHG emissions from imported energy) can present the information accordingly.

Figure 1. Manner of presentation of data concerning GHG emissions in Scope 1&2 and 3 according to ESRS.

Source: [Draft] ESRS E1 Climate change.

GHG intensity should also be determined based on net revenue. Manner of presentation of data according to ESRS is shown in Figure 2.

GHG intensity per net revenue	Comparative	N	% N / N-1
Total GHG emissions (location-based) per net revenue (tCO_2eq/Monetary unit)	-		

Figure 2. Manner of presentation of data concerning GHG intensity according to ESRS.

Source: [Draft] ESRS E1 Climate change.

When disclosing information concerning E1-7 on the removal and storage of greenhouse gases from own operations and value chain, the following should be described, among other things:

- greenhouse gases concerned,
- whether the removal and storage are biogenic, whether they result from land-use change (e.g. afforestation, reforestation, forest restoration, urban tree planting, agroforestry, building soil carbon, etc.), technological (e.g. direct capture from air) or hybrid (e.g. bioenergy with CO2 capture and storage) as well as technological details should be provided.

Manner of presentation of data concerning removals according to ESRS is shown in Figure 3.

Removals	Comparative	N	% N / N-1
GHG removal activity 1 (e.g.., forest restoration)	-		
GHG removal activity 2 (e.g.., direct air capture)	-		
...	-		
Total GHG removals from own operations (tCO_2eq)			
GHG removal activity 1 (e.g.., forest restoration)	-		
GHG removal activity 2 (e.g.., direct air capture)	-		
...	-		
Total GHG removals in the value chain (tCO_2eq)			
Reversals (tCO_2eq)			

Figure 3. Manner of presentation of data concerning GHG removals according to ESRS.

Source: [Draft] ESRS E1 Climate change.

Financing GHG reduction projects outside the company's value chain by purchasing carbon credits that meet high quality standards can be a useful contribution towards climate change mitigation. Disclosure on the use of carbon credits is made separately from GHG emissions (E1-6) and GHG reduction targets (E1-4). It also requires the company to demonstrate the extent of use and the quality criteria it applies to these emission units. The possible reporting format is shown in Figure 4.

Carbon credits cancelled in the reporting year	Comparative	N
Total (tCO_2eq)	-	
Share from removal projects (%)	-	
Share from reduction projects (%)	-	
Recognised quality standard 1 (%)		
Recognised quality standard 2 (%)	-	
Recognised quality standard 3 (%)	-	
...	-	
Share from projects within the EU (%)		
Share of carbon credits that qualify as corresponding adjustments (%)		

Figure 4. Manner of presentation of data concerning carbon credits according to ESRS.

Source: [Draft] ESRS E1 Climate change.

Internal carbon pricing systems are also disclosed, as well as significant physical and temporary climate-related risks that may affect the company's financial position (e.g. assets held, financially controlled assets and lease liabilities), performance (e.g. potential future

increases/decreases in net revenue and costs due to business interruption, increased supply prices resulting in a potential decrease in margins) and cash flows.

5. Conclusion

The evolution of the approach to non-financial reporting highlights the trend towards measurability, comparability of indicators.

At the same time, accountability for published information is increasing – reported non-financial data will be subject to mandatory auditing and the provision of false data will be subject to criminal and financial liability – including for board members.

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REAL-TIME DATA PROCESSING IN SIMULATION MODELS WITH 3D VISUALIZATION

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Purpose: The aim of this paper is to demonstrate how to integrate the FlexSim simulation environment with an R engine to enable use of the predictive algorithm results for real-time simulation run management.
Design/methodology/approach: Using a simple but easily generalizable simulation model representing a broad set of real-world solutions used in logistics and manufacturing, we outline how to combine FlexSim and the R language. In particular, we present the necessary settings of the objects that make up the simulation model, including event-initiating triggers, as well as the structure of a program written in R, together with the necessary instructions.
Findings: The case study showed that synchronous, i.e. real-time, communication between the simulation model and the R computing environment is possible and allows the simulation process to be controlled.
Research limitations/implications: The main limitation of the presented approach is the synchronization of file read and write operations, and this is an area for further investigation.
Practical implications: The solution proposed in this paper allows for the development and testing of simulations created in FlexSim using the results of optimization models or predictive algorithms developed using the R language, in real time – i.e. in the course of the simulation process. This approach can be used to simulate any process that is modeled using a discrete-event simulator, particularly in fields such as logistics or manufacturing.
Originality/value: The study can be of value to anyone involved in modeling and simulating real-world processes using FlexSim, for whom so far the problem has been to incorporate the output of algorithms obtained with other computing environments into the simulation run.

Keywords: FlexSim, discrete event simulation, prediction, R language.

Category of the paper: technical paper, case study.

1. Introduction

In times of ever growing necessity for the optimization of logistics and manufacturing processes, the use of simulation tools is becoming increasingly prominent. The search for process bottlenecks, workload analyses, or the capacity of corridors and pathways represent just a few of the concerns related to efficient management in the field of logistics. The selected computer simulation tools can provide support in these areas by providing new opportunities for testing organizational shifts and seeking optimal solutions without generating excessive costs. Simulation models can reduce costs by running experiments in a virtual environment without the need for expensive reorganization. The optimization modules enable the selection of appropriate model parameters for minimizing or maximizing the target function. Such optimization is possible by querying the solution space for a wide range of parameters, taking into account the constraints defined in the simulation model. For instance, in the field of logistics, it is possible to find optimal settings for minimizing the operator's path in the picking process for fast-moving goods (Pawlewski, 2018). Determining the surface area index for highway freight terminal facilities using the simulation tool in the FlexSim application was presented in the following studies (Chen, Hu, Xu, 2013). Whereas the studies of (Dallasega, Rojas, Rauch, Matt, 2017) used a flow chart process to compare traditional centralized manufacturing planning and control systems with modern 4.0 solutions involving decentralization and real-time planning and control. Another simulation model that shows the performance of autonomous vehicles with respect to the placement of charging points is presented in the studies by (Chen, Chen, Teng, 2021). Similarly, a case study in the paper by (Li et al., 2020) on AGVs with resource allocation in the field of manufacturing logistics was analyzed using a simulation model developed in the FlexSim environment. Furthermore, Yu & Nielsen (2020) emphasizes the use of computer simulation tools in the field of Industry 4.0 and the challenges associated with the implementation of this technology in simulations of factory operations and, in particular, the importance of using artificial intelligence – machine learning – in solutions of this sort.

The primary purpose of this study is to demonstrate a method of integrating a logistics and manufacturing process simulation environment with an R-based engine, enabling the implementation of algorithms for real-time prediction of selected parameters of a running simulation model.

As a discrete event simulator with 3D visualization, the authors of this dissertation chose the FlexSim environment. For the R environment, the engine 4.2.2 from the CRAN package repository was selected.

2. Simulation model in the FlexSim environment

The developed simulation model consists of five fixed resources and a simple flow logic. For the execution of the environment connection mechanism, a system that is unrelated to any real-world processes has been prepared. Nevertheless, this model can serve as a reference for more complex models, as the set-up and logic presented herein are often used for processes in the field of logistics or manufacturing. A core element of the model is the decision point that allows the selection of the target (destination) of the flow items, as is customary in real-life processes involving, e.g. storage. The consequence of classifying the freight units is the selection of a particular rack in the warehouse. Such solution is presented in the study by (Zhu et al., 2014). Likewise, a similar situation often occurs on production lines (Zomparelli, Petrillo, Salvo, Petrillo, 2018) and (Aljorephani Elmaraghy, 2016).

For a list of objects used in the model, see Figure 1.

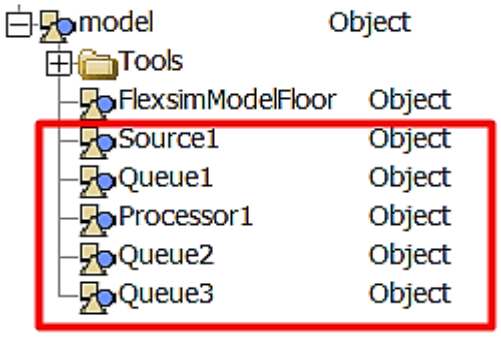
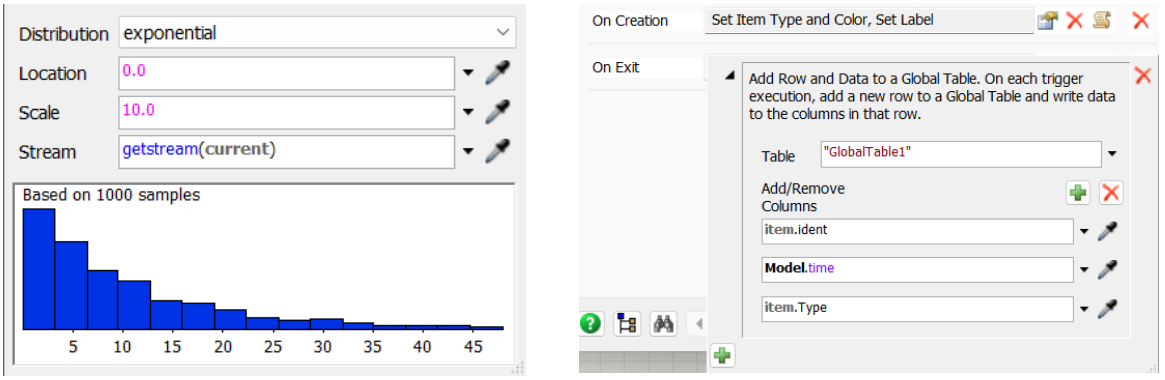


Figure 1. Highlighted list of objects used in the model.

Source: Own study.

The model uses three buffer fields from Queue1 to Queue3 with default settings. Furthermore, a single machine "Processor1" and a single data source were used for the "Inter-arrival time" setting and the default "exponential" distribution with default parameters, as shown in Figure 2.

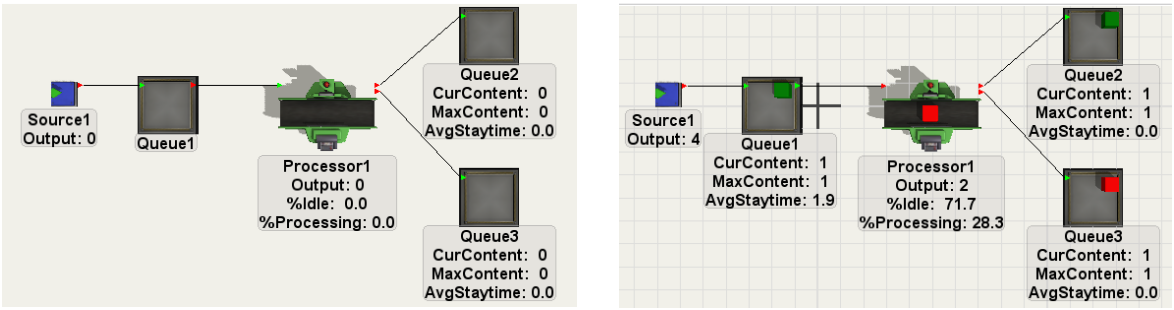


a) b)

Figure 2. The distribution parameters for the source of the model a) and the trigger settings for the source b).

Source: Own study.

Two triggers were placed on the source. The first one allows the creation of 2 different values for the default label "Type" randomized according to the "duniform" distribution. Moreover, each newly created flow item contains identifier information with a number based on the order in which the object was created, as well as information on the current time status in the model. The information is stored in a global table using a second trigger for the "On Exit" status of the source. The system is connected using the "Connect Object" directional connections. The connections are shown in Figure 3, with the finished simulation model.



a) b)

Figure 3. Simulation model: a) stop, b) start

Source: Own study

The object flow in the simulation model follows the figure from left to right. The predefined global table stores information about the identifier, type and time, and is saved to a csv file via the trigger at "Queue1". The data structure of the first global table can be seen in Table 1.

Table 1.

Structure of the simulation model output for a few selected flow items

Id	*time*	*decision*
0	*36.20*	*1*
1	*75.08*	*2*
2	*79.42*	*1*
3	*90.73*	*2*

Source: Own study

The table shows the data for the first 4 flow items. The decision column is a column that stores information about the type of object previously generated using the trigger. The output file generated in this manner is the input for the program running on the R engine.

The final and essential element of the model is the trigger that enables the import of the file processed by the R engine. This trigger is activated at the end of the machine process. Its task is to load the file in real time and execute a SQL query according to the object identifier. This will facilitate a decision on the choice of machine output port for the flow item towards queue 2 or 3. The input data structure of the simulation model is shown in Table 2.

Table 2.
Structure of the simulation model input for a few selected flow items

id	*pred*
0	*2*
1	*1*
2	*2*
3	*1*

Source: Own study

The identifier column remains the same. The *pred* column contains the new data determined by the R program that are linked to the flow element with the correct identifier. The structure of the trigger, based on which the decision related to the selection of the output port of the machine is made, is shown in Figure 4.

```
Object item = param(1);
Object current = ownerobject(c);
/***popup:GlobalTableLookupNew*/
/***tag:Description*//**Using Global Lookup Table ( tab )*/
Variant tableID = /**\nTable: *//***tag:TableName*//**/"tab"/**/;

Table table;
switch (tableID.type) {
    case VAR_TYPE_NODE: table = tableID; break;
    case VAR_TYPE_STRING: table = Table(tableID.as(string)); break;
    default:
        table = reftable(tableID.as(int));
    break;
}

Variant row = /**\nRow: *//***tag:row*//**/item.ident/**/;
Variant col = /**\nColumn: *//***tag:col*//**/2/**/;

double result = Table.query("SELECT pred FROM tab WHERE id == $1",row)[1][1];
return result;
```

Figure 4. Logic of the developed SendtoPort machine trigger in the simulation model
Source: Own study

The SQL query executed via the trigger returns a value from the second column of the input table for the row with the corresponding identifier.

The general structure of the proposed solution can be found in Figure 5.

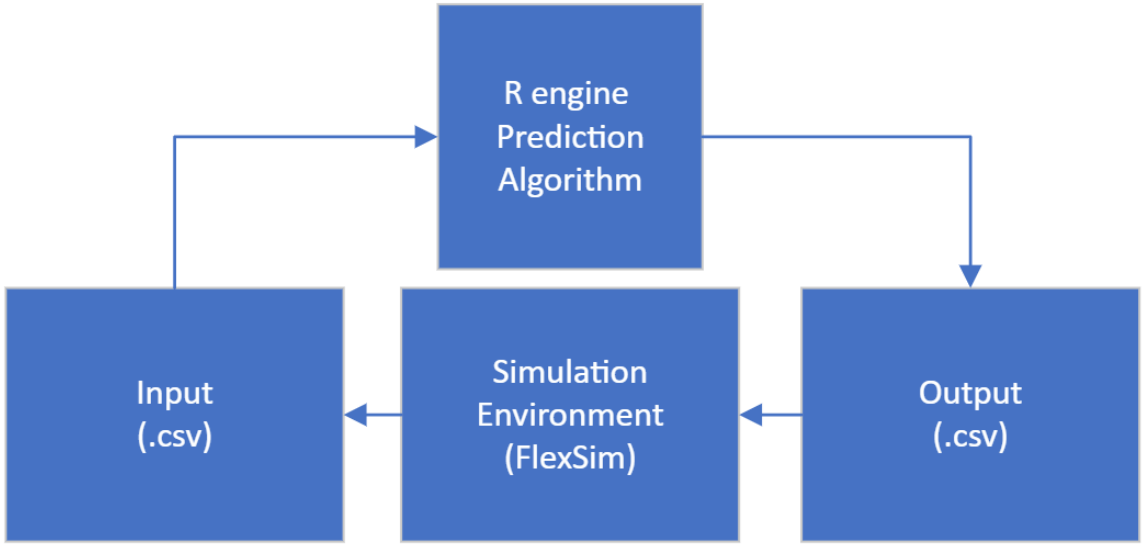


Figure 5. A model for the integration of the FlexSim environment and the R engine.
Source: Own study

3. The R-based program

A function in R that allows interaction with FlexSim and makes predictions based on simulation data must contain the following necessary elements:

1. Loading of object data generated during simulation.
2. Making prediction.
3. Saving the prediction to a csv file (each record saved should contain – in addition to the prediction value – the identifier of the relevant object).

Also, an optional, albeit useful solution is to display a current job status message (e.g. the number of objects for which a prediction has been made).

As the program is intended to run in real time, it is necessary to use an infinite loop that can be stopped manually. This kind of a solution requires exception handling mechanism so as to avoid aborting the loop in the event of any error (e.g. a file read error in a single iteration). The code for the loop used in the program is given in Figure 6.

```
while(TRUE){
    tryCatch({

        # 1 - read input file
        dat <- read.csv2(paste0(path, inFile))

        # 2 - make predictions, create dataframe
        df <- data.frame(id = dat$id,
                         pred = predict_sim(dat))

        # 3 - save dataframe with predictions
        write.csv2(df, paste0(path, outFile),
                   row.names = FALSE, quote = FALSE)

        # 4 - display message
        print(paste(Sys.time(),
                    "saving predictions for", nrow(df), "records")
              )

    }, error = function(err){
        # on error
        print(paste(Sys.time(), "error: ", err))

    }, finally = {
        # wait some time
        Sys.sleep(interv)

    }
    )
}
```

Figure 6. Code for the loop used in the program.

Source: Own study

An infinite loop is provided by the use of the *while* statement. This is immediately followed by the exception handling function (*tryCatch*). At every iteration, it attempts to execute a code consisting of four instructions: loading the data, making a prediction, saving the data and displaying a message about the number of records for which a prediction has been made. If any error occurs at this stage, the program proceeds to the *error* section, which displays an error message in this case. Whether or not an error occurs, the loop ends with the execution of a piece of code in the *finally* section – the use of the *Sys.sleep* function enables the loop to wait a certain amount of time before starting the next iteration. This is done to reduce the frequency of loading and writing files to disk.

The primary purpose of the integration of the FlexSim environment and the R language described in this study is to enable the use of machine learning algorithms. Therefore, the function making the prediction, which is referred to as *predict_sim* in the code presented in Figure 6, plays a key role in the program. This can be a function that returns predictions based on any machine learning algorithm (the example presented here applies specifically to a classification problem, but this does not prevent similar solutions from being used for a regression problem). The only condition is that the value returned by the function is a vector with predicted values for the individual flow items.

Additionally, the developed program uses global variables responsible for the path to the folder holding the simulation model and the file names. Furthermore, the loop described earlier is placed inside a function that resets the data file generated by the simulation model at the very start. Details of the program code are shown in Figure 7.

```
# path to project folder with FlexSim model
path <- "C:/Users/user_name/Documents/FlexSim 2023 Projects/"

# name of the input file (generated by FlexSim)
inFile <- "in.csv"

# name of the output file (read by FlexSim)
outFile <- "out.csv"


operate <- function(interv = 0.1){

    # reset input file
    write.csv2(data.frame(id = integer(),
                          time = double(),
                          decision = integer()),
               paste0(path, inFile), row.names = FALSE, quote = FALSE)

    while(TRUE){

        # code of loop

    }
}

# running the function
operate()
```

Figure 7. Detailed program code (without the loop code).

Source: Own study

4. Results

The solution presented here uses a simple prediction function that, based on information about the object type (contained in the *decision* column of the global table exported by the simulation model), makes a decision to redirect the object in question to the appropriate buffer field. For a type 1 object, this will be the Queue3 buffer field (the second machine output, so in this case the function will return a value of 2), while for a type 2 object it will be the first machine output (the function will return a value of 1, the object will be sent to the queue labeled Queue2). The code of the prediction function used is provided in Figure 8.

```
predict_sim <- function(dat){

    # for this test predictions are just switched decision values
    # but any ML prediction function can be incorporated here
    pred <- ifelse(dat$decision == 1, 2, 1)

    # vector of predictions is returned
    return(pred)
}
```

Figure 8. Code of the prediction function used.

Source: Own study

The first step involved running an R script with the function described in the previous section. Assuming the correct file paths are given and the function generates an empty input file at the start, the results are messages displayed at the frequency specified by the *interv* argument, which gives the time and number of processed records. As long as the simulation model is not launched, this number will be zero (Figure 9).

```
> operate()
[1] "2023-02-24 15:36:20 saving predictions for 0 records"
[1] "2023-02-24 15:36:20 saving predictions for 0 records"
[1] "2023-02-24 15:36:20 saving predictions for 0 records"
[1] "2023-02-24 15:36:20 saving predictions for 0 records"
[1] "2023-02-24 15:36:21 saving predictions for 0 records"
[1] "2023-02-24 15:36:21 saving predictions for 0 records"
[1] "2023-02-24 15:36:21 saving predictions for 0 records"
[1] "2023-02-24 15:36:21 saving predictions for 0 records"
[1] "2023-02-24 15:36:21 saving predictions for 0 records"
[1] "2023-02-24 15:36:21 saving predictions for 0 records"
[1] "2023-02-24 15:36:21 saving predictions for 0 records"
[1] "2023-02-24 15:36:21 saving predictions for 0 records"
[1] "2023-02-24 15:36:21 saving predictions for 0 records"
[1] "2023-02-24 15:36:22 saving predictions for 0 records"
```

Figure 9. Result of the program before starting the simulation.

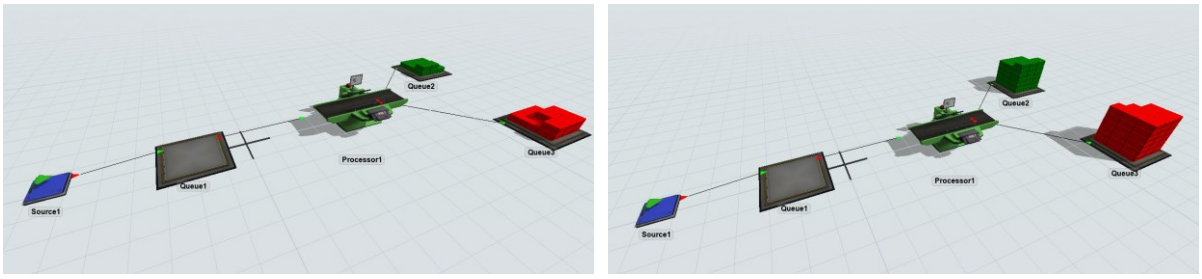
Source: Own study

After running the simulation model described in Section 2, the program will display the number of objects (records) for which a prediction has been made in successive iterations (Figure 10).

```
[1] "2023-02-24 15:42:20 saving predictions for 0 records"
[1] "2023-02-24 15:42:20 saving predictions for 1 records"
[1] "2023-02-24 15:42:20 saving predictions for 1 records"
[1] "2023-02-24 15:42:20 saving predictions for 1 records"
[1] "2023-02-24 15:42:20 saving predictions for 1 records"
[1] "2023-02-24 15:42:20 saving predictions for 1 records"
[1] "2023-02-24 15:42:20 saving predictions for 2 records"
[1] "2023-02-24 15:42:21 saving predictions for 2 records"
[1] "2023-02-24 15:42:21 saving predictions for 2 records"
[1] "2023-02-24 15:42:21 saving predictions for 2 records"
[1] "2023-02-24 15:42:21 saving predictions for 2 records"
[1] "2023-02-24 15:42:21 saving predictions for 4 records"
[1] "2023-02-24 15:42:21 saving predictions for 4 records"
[1] "2023-02-24 15:42:21 saving predictions for 4 records"
[1] "2023-02-24 15:42:21 saving predictions for 4 records"
[1] "2023-02-24 15:42:21 saving predictions for 4 records"
[1] "2023-02-24 15:42:21 saving predictions for 4 records"
[1] "2023-02-24 15:42:22 saving predictions for 4 records"
[1] "2023-02-24 15:42:22 saving predictions for 4 records"
[1] "2023-02-24 15:42:22 saving predictions for 4 records"
[1] "2023-02-24 15:42:22 saving predictions for 4 records"
[1] "2023-02-24 15:42:22 saving predictions for 5 records"
[1] "2023-02-24 15:42:22 saving predictions for 5 records"
[1] "2023-02-24 15:42:22 saving predictions for 5 records"
[1] "2023-02-24 15:42:22 saving predictions for 5 records"
[1] "2023-02-24 15:42:22 saving predictions for 7 records"
```

Figure 10. Initial execution of the program upon starting the simulation.
Source: Own study

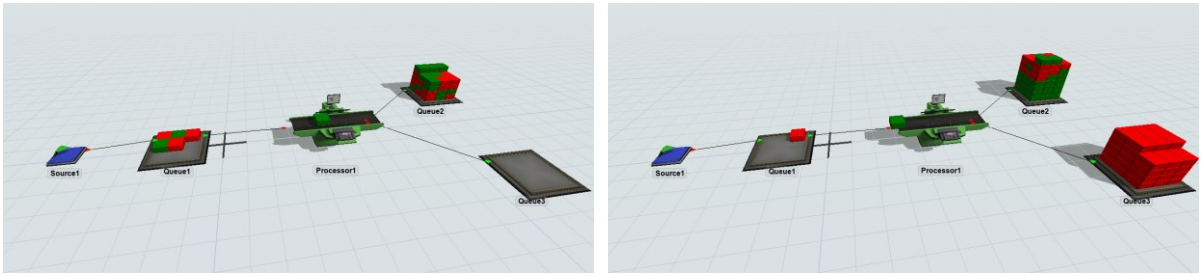
At the same time, the simulation model, or the Processor1 object to be more precise, will decide whether to send a given object to the first (Queue2) or second (Queue3) output, based on the predictions returned by the program. Figure 11 shows the simulation results after 25 and 100 processed objects, respectively, with the program running simultaneously. It shows that all green objects (type = 2) were passed to the first output, while all red objects (type = 1) were passed to the second output.



a) b)

Figure 11. Simulation results with the program running: a) after 25 objects, b) after 100 objects.
Source: Own study

Launching the simulation without a running program results in all objects being passed to output 1, regardless of their type (Figure 12a). Similarly, if the program is stopped during the simulation, all remaining objects generated during the simulation will be passed to output 1 (Figure 12b).



a) b)

Figure 12. Simulation results: a) without the program running, b) after the program was stopped.
Source: Own study

5. Summary

The example of an integration of a discrete event simulator enabling 3D visualization of real-world logistical processes with an R-based engine allowing the use of effects of machine learning, presented in this study, is part of a hybrid approach in modeling and simulation (von Rueden et al., 2020). It is a response to the increasing need to use computer simulations combined with modern optimization and prediction methods in the context of process automation and the concept of Industry 4.0 (Yu & Nielsen, 2020).

However, the solutions presented in the literature are mostly based on asynchronous communication between the simulation and optimization environments, where the results of prediction or optimization using historical data are either incorporated into the scheduling process before the simulation starts or are used to optimize processes post-simulation (Azab et al., 2021; Atalan et al., 2022). The integration proposal presented in this study is based on synchronous communication, where the simulation process continuously uses the output of the machine learning model and makes decisions based on it. A similar solution, using the FlexSim program and Python, was presented in (Leon et al. 2022), whereby the method of communication between environments was based on a client-server architecture. The solution proposed here involves communication by means of shared files, which in extreme cases (with an inappropriately selected simulation speed with respect to the loop delay in the program) can cause synchronization problems. This may offer an area for further research. However, the solution itself is relatively simple to implement and the results can be easily validated.

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NEGOTIATIONS AS AN IMPORTANT ELEMENT OF RESEARCH PROJECTS' COMMERCIALIZATION PROCESSES IN THE DOMAIN OF MINING MACHINES

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Purpose: As negotiations play an important role in commercialization processes of research projects' results, the Authors of the paper decided to share their knowledge and scientific experience with present and future negotiators. In the case of six research projects the multiple dimensions of negotiation processes such as the substantial, communication and emotional aspects are presented. The paper is ended with some guidelines which can facilitate negotiation processes, enabling to avoid mistakes, often made even by experienced negotiators.
Design/methodology/approach: The objectives were achieved in the result of an in-depth analysis of six innovative projects, realized at the KOMAG Institute. Based on these case-studies it was possible to formulate general character, taking into consideration holistic aspects of negotiation processes.
Findings: In the result of the research work the following findings and conclusions were formulated: the preparatory phase of negotiations should include a development of strategy and tactics, risk assessment and contingency planning; a significance of active questioning, testing, persuading, monitoring and documenting processes can be seen clearly in the result of conducted analyses; a correct negotiation process requires an ability of coordinating activities, a good communication and a flow of information; based on in-depth analysis of the six case-studies, it can be conducted that the "win-win" process of negotiations seems to be most successful.
Research limitations/implications: The Authors intend to continue their research work in future, taking into consideration the philosophy and psychology of the art of negotiating.
Practical implications: The research results, described in the paper, have pragmatic outcomes and applications for business.
Originality/value: The paper is addressed to all the present and future negotiators. Its special value results from a pragmatic approach of the Authors to negotiating processes. The findings are based on multi-year scientific experience of the Authors in a commercialization of innovation research projects' results. Negotiations seem to be relatively easy theoretically, however in practical everyday business life they are difficult, complicated and risky.

Keywords: negotiation, research project, innovation, commercialization, mining machines.

Category of the paper: case study, research paper.

1. Introduction and theoretical background

The word “Negotiations” seems to be easy in terms of its definition. Each need can be a subject of negotiations. When people exchange views, aiming at changing relationships between or among them, when they discuss their points of view, as a matter of fact they start negotiations. A crucial part of negotiations includes communication. A full description of the process of negotiations can be described within several disciplines of knowledge such as economy, law, sociology, IT, behavioural sciences, management etc. Many experts on negotiations believe that it is absolutely necessary to learn how to negotiate successfully taking advantage of the trials- and- mistakes method. However, it is not always true. A person, conducting negotiations for many years, might have made the same mistakes without having been aware of his/her weak points. Generally speaking, negotiations seem to be the least troublesome method of solving problems because they enable to determine the spheres of mutual understanding, leading to practical solutions and decisions. Successful negotiations require mutual trust of negotiators and their will of not only taking but also giving, which enables to reach a compromise in the results of bargaining, after having analyzed common interests of negotiating parties. It is convenient to start negotiations without any assumed limitations. Life experience proves that in the majority of cases the negotiating parties do not trust each other, so negotiations are not easy and nice. It should be highlighted that a good knowledge of human reactions, human behaviour and so called body language is extremely helpful. It is important to make certain assumptions at the very beginning of negotiations. It concerns both parties. However, the strategy and tactics of negotiations play a crucial role. It should be borne in mind that each of the negotiating parties has its own needs and expectations, so it is advantageous to take into consideration the needs of the other party. When such needs are ignored, there is a total victory and a total failure, really no chance for a win-win situation.

At present more and more businessmen are aware of efficient techniques of negotiations. In particular it concerns selling of licences and know- how for innovative products or services. It often happens that creators of innovative solutions are not experienced negotiators and they make mistakes which cause that they do not reach the expected success which they most certainly desire. A sales of a state-of-the-art technology requires a good presentation which enables to attract attention. A difficult to-be-understood technical jargon should be avoided unless the presentation is addressed to a group of technical specialists who can understand this jargon. It is worth giving some examples of users who implemented that technology and reached a market success.

As it had already been mentioned before, negotiations are difficult when each party wins, so it is important to know risks and basic principles. In real life a negotiator does not know what kind of strategy his opponent intends to apply. If negotiations are perceived as a kind of game,

then a sort of rivalry starts, which can lead to a success but also to a failure. A good negotiator aims at reaching an agreement and not his victory. Both parties should believe that they gained something. Summing up, it should be highlighted that negotiations are neither a game nor a sort of war, so they must not be oriented onto a devastation of the other party. Negotiations can be called a common egotism due to the fact that this process is conducted by both parties. If negotiations are treated as a form of collaboration, it is probable that they will lead to common understanding. However, there is always a kind of competition between parties, but it is an integrating process. It enables to compare one party's competence, knowledge and experience with the other party's qualifications and draw stimulating conclusions, enabling to detect some weak points in advance. It is most convenient to determine joint objectives and always emphasize similarities not differences, as one- party's total success is rarely long-lasting. A dominating position in negotiations does not give positive effects in comparison with a collaborative position. The partner should never feel cornered. Very few negotiations go smoothly and they differ from one another significantly. Experienced negotiators can reach an agreement very quickly. They do not waste time for a small talk or unimportant issues. After an initial exchange of pleasantries they concentrate on the subject- matter itself. Experienced negotiators never treat negotiations as a game as they are aware of the fact that it is indispensable to find lingua franca and avoid traps 'I take everything or nothing'. It should be borne in mind that experienced negotiators like to give hints, avoiding a straight- forward presentation of their intentions. However, sometimes negotiations get out of control. Real professionalists know when they should stop pushing the other party. The negotiator should realize when he is close to reaching the critical point. It is easy to forget this principle when emotions take over. If it is assumed that negotiating is a process demanding a collaboration, it is indispensable to search mutual benefits. As negotiations are a form of a human behaviour and not a game, they are efficient only when the case wins.

2. Literature review

The literature review, conducted by the Authors, was oriented onto a research problem consisting in a definition of negotiations, being an important element of commercialization process in the case of innovative projects. The subject- matter fits in the scope of "Production Engineering", because the issues under analysis belong to "Engineering of Innovations". It is worth mentioning that negotiations play an important role in commercialization processes and they can have a crucial impact on their successful management (Malec, Stańczak, 2020; Stańczak, 2020).

The role of human factor in negotiations should be highlighted (Nierenberg, 1981). Each negotiation is organized in three main steps: the initialization, the refinement of the job under negotiation and the closure (Sycara, Dai, 2010). The initialization step allows to define what has to be negotiated (Negotiation Object) and how (Negotiation Framework) (Duan, Dogru, Ozen, 2012). In the refinement step participants exchange proposals on the negotiation object, trying to satisfy their constraints (Hu, Deng, 2011). The closure concludes the negotiation. To handle the complex types of negotiation scenarios different components are proposed. They include: outsourcing jobs, block service and broker's activities (Creftan, Coutinko, Jardim- Goncalves, 2012). As it has already been mentioned, negotiation processes involve a substantive, communication and emotional dimensions (Filzmoser, Hippman, Vetschera, 2016). Business negotiations based on the bargaining model of game theory are presented in (Zhang, 2021). However, it is worth considering the cross-cultural-context in relation to negotiations across borders (Schoen, 2022). An interesting approach to an effect of new potential supplier on business to business negotiations performance is described in (Delina, Olejarova, Doucek, 2021). It is also worth considering methodological issues in negotiation research (Buelens, Van der Woestyne, Mestdagh, 2008). A description of the negotiation scorecard, being a tool in business and industrial marketing can be found in (Fleming, Hawes, 2017), whereas the impact of training on negotiators and organizations is presented in (Baber 2022). International business strategy is analyzed in (Asante-Asamani, Elahee, MacDonald, 2021). However, propositions, based on the international perspective in the scope of relational business negotiations, include a linear process that follows episodic or stage models. Business negotiations are geared towards a one-time transaction. They focus on a single negotiator or negotiations in a dyad. Aspects of business negotiations are conceptualized with the industrial marketing and purchasing (IMP) perspective (Eklinder-Frick, Age, 2020). While analyzing the literature on the subject-matter of negotiations, it is worth paying attention to negotiations for future studies in the domain of business negotiation (Agndal, Age, Eklinder-Erick, 2017). Bilateral contract negotiations, concerning delays in project outsourcing process, should be studied from the point of view of subcontractors' bargaining powers or the dynamic bargaining process in negotiations. Bilateral bargaining between the client and subcontractors reflects real-world negotiations. The research results, presented in the publication (Hou, Lu, Deng, Shen, 2021) uncovered how the coordination of project outsourcing is impacted by the contract form, bargaining power structure, precedence network topology, payment timing, external opportunities and negotiation protocols. For single-task projects the fixed-price contract can achieve system coordination only when the subcontractor possesses full bargaining power. Cost-sharing and time-based incentive contracts may not be effective for projects with parallel tasks. Projects with serial tasks can be coordinated only under extreme bargaining power structures. Some researchers (Curhan, Labuzova, Mehta, 2021) concentrate their studies on the subject of criticism which enhances creativity in negotiation. A cooperative social context allows criticism to be construed positively, spurring creativity without inciting intragroup

conflict and a corresponding reduction in creativity. In a cooperative context, instructions, encouraging criticism, yielded more creative ideas, whereas in a competitive context encouraging criticism yielded fewer ideas and they were less creative. In many cases under analysis negotiators' motivations and personalities played a significant role (Maslow, 1954).

A multi-agent based negotiation system for re-establishing enterprise interoperability in collaborative networked environments is described in (Kadar, Muntean, Cretan, Jardim-Goncalves, 2013). It proposes a system for promoting sustainable interoperability between enterprises involved in complex networked environments through multi- level negotiation, communication and information sharing. This solution is based on a multi-agent system architecture that applies rule-based negotiation at various organizational levels such as: business, ICT, workflows, data systems and people. On the grounds of the literature review a selection of the following research methods was chosen:

- analyses of national and international publications enabled to formulate a research problem which is described in the Introduction,
- a method of multiple case- study which was used for an analysis of six research projects, realized at the KOMAG Institute of Mining Technology,
- a heuristic method enabling to detect new facts and relationships among them.

3. Efficient negotiation processes in the case of innovative research projects

The KOMAG Institute of Mining Technology has realized scientific, research and technical projects of innovative character for over seventy years. The experience, gained over all those years, in particular in the scope of negotiation skills with other scientific but mainly industrial partners, is an extremely valuable and useful source of pragmatic information. Negotiations seem to be relatively easy theoretically, however in practical everyday business life they are difficult and complicated. A correct negotiation process requires an ability of coordinating activities, a good will of cooperation, a good communication and a flow of information. The reasons of difficulties in negotiations sometimes result from organizational problems at the institute or the company as well as an incorrect identification of business partners' expectations and needs. Based on the experience, gained at the KOMAG institute of Mining Technology, several types of projects can be distinguished (Fig. 1).

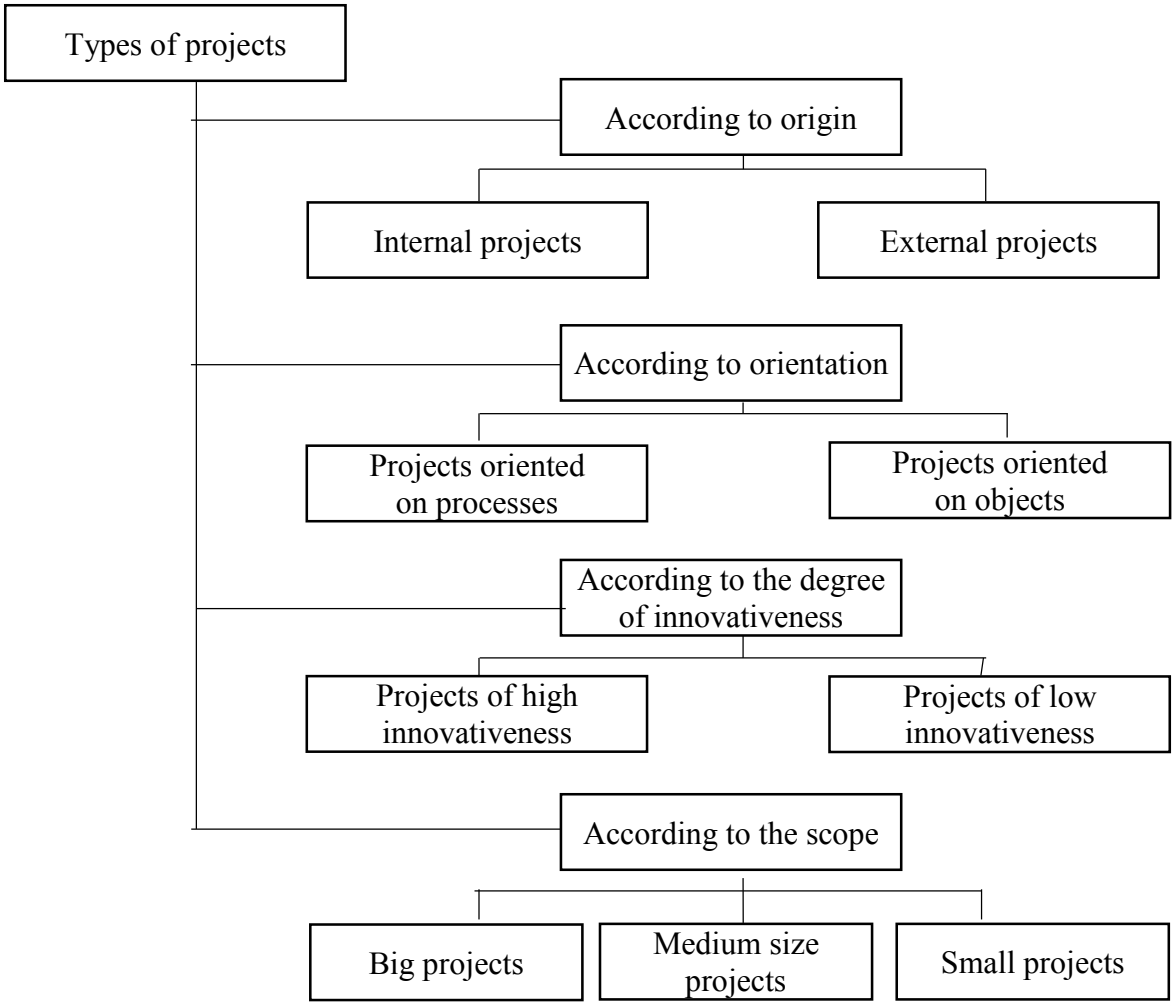

Figure 1. Types of scientific and research projects realized at the KOMAG Institute (Authors').

Examples of different types of projects:

1. An elaboration of technical documentation of machines or equipment.
2. An implementation of an innovative technical solution.
3. A development of a new computer system.
4. A construction of a laboratory.
5. An organization of a conference.

4. Analysis of negotiation processes - case studies

Within the research work the Authors investigated twenty five innovative projects, realized at the KOMAG Institute of Mining Technology, focusing on negotiation processes and negotiators' skills. From this set six different cases were chosen for an in-depth analysis enabling to formulate assessments of general character. The Authors concentrated on contracts and agreements taking into consideration the changes resulting from successful negotiations.

4.1. A longwall shearer external spraying system ensuring safe operation in the methane hazard conditions

It should be highlighted that the planned first user of the system, i.e. the Jastrzębska Coal Company, J.S.C. (Jastrzębska Spółka Węglowa S.A) since the very beginning has taken an active part in negotiating the conditions of the so called targeted project, including the technical requirements and the project financing. The scheduled work programme was mutually agreed and then contracts with producers were negotiated and signed. All the obligations of the parties were agreed upon, including the approval of the State Mining Authority (Wyższy Urząd Górniczy), who initiated the project aimed at improving safety in underground workings. The negotiations went smoothly due a full engagement of all the project stakeholders, i.e. KOMAG as an institute developing an innovative solution, the producers and the end users from the JSW mines. The first industrial implementation was planned at the Pniówek mine. Then a licence agreement with the producers was negotiated and signed.

4.2. System for an identification of powered roof support components

This innovative technical solution was developed by KOMAG in collaboration with the Silesian Technical University and the ELSTA company. Due to some obstacles experienced at the project initiation stage, negotiations of contacts with the project partners played a crucial role in a successful realization of the project objectives. The negotiations concentrated on the scheduled work programme and on financial issues. As in the targeted project application, the stakeholders were obliged to determine all the financial details in advance, several stages of negotiations turned out to be indispensable to find lingua franca and reach and agreement. During the project realization the contracts had to be renegotiated due to an availability of new generation identifiers and some corrective measures had to be taken. It should be highlighted that principles and conditions of paying and sharing royalties were negotiated among the parties at the very beginning, which enabled to avoid misunderstandings and conflicts during the project realization.

4.3. Small-size WMD-150 drill rig

The project was initiated by the industrial partner, the ZMUW- Mechanical Plant of Drilling Equipment, who carried out the market-survey which confirmed a demand for designing and manufacturing a drill rig for geological-and-exploratory drillings as well as for different-purpose bore-holes. In the result of negotiations a contract was formulated. It stipulated the financial conditions and obligations of the parties. The contract was subject to renegotiations due to a necessity of introducing some changes in the scope of financial conditions and the reduction of the project duration time caused by the end-user's requirements. In the result of negotiations two annexes, which enabled to manage the above mentioned changes, were signed. The third annex concerned an electronic version of technical documentation.

4.4. Research and development of solutions in the scope of using unconventional sources of energy

The project was oriented onto an innovative solution of a one-megawatt wind turbine. The producer was enthusiastic about the market potential of this product. The majority of negotiations concerned the technical specification. It was agreed orally that the initial design of the turbine will be elaborated at the KOMAG's cost and it was also agreed orally that further costs will be borne within the framework of the targeted project. KOMAG also developed a business plan which was approved by the industrial partner in the result of negotiations. When the first stage of the project at the KOMAG cost was finished, suddenly the industrial partner decided to withdraw from the consortium without any financial consequences. As there was no formal obligations in the written form, presenting the results of negotiations, KOMAG had no chance to reduce its financial losses. The negotiating party from KOMAG was a rather unexperienced one and he acted under a strong time pressure, so he did not demand any written confirmation of negotiation results which turned out to be a costly mistake.

4.5. Improvement of coal winning technology oriented onto a reduction of costs due to an application of mining prevention on the crossing of the longwall with roadway

The research project went smoothly at the very beginning. All the conditions seemed to be well negotiated and specified in detail. However, an incorrect flow of information among KOMAG researchers and the mine staff caused that there was an urgent need of renegotiating the contract. The negotiating parties did not take into account mining-and-geological conditions underground, which made a project realization impossible. A wrong assumption of these conditions made renegotiations pointless.

4.6. Intrinsically safe system of scattered structure for a control and supervision of machinery smart drives

The negotiations with the research partner, the ITR - Tele and Radiotechnical Institute (Instytut Tele i Radiotechniczny) were conducted in a professional and goal-oriented form. Then the application to the KBN - Committee for Scientific Research (Komitet Badań Naukowych) was submitted. When it was approved for financing a three-party contract was negotiated. During the negotiations the issue of product certification was omitted. In particular it concerned the ATEX Directive requirements. In fact there was no guarantee that the product will obtain indispensable certificates for an underground application where a gas explosion occurs. Based on this example, it can be seen that negotiations should cover all the issues which can have even a hypothetically negative impact on the project realization process. The mistakes made at the negotiation stage, concerning mainly the project scope, caused a failure of the whole project.

5. Characteristic features of negotiations presented in case- studies

Based on the in-depth analysis of the six case-studies, it can be concluded that a negotiation process is used to reach an agreement, compromise or settle differences between two or more parties. As all the parties want to achieve the best possible outcome for themselves and each other, "so win-win negotiations" seem to be most fruitful. They were used for a presentation of all the innovative projects described as the case-studies in the former paragraph. The five-step negotiation process is used at KOMAG in general. This process is reflected in the reports, minutes of meetings, contracts and agreements analyzed by the Authors. As some of them have the clause "confidential", they cannot be namely mentioned in this publication. There are two kinds of negotiation approaches:

- Win-win Negotiations (Interpretive Negotiation) are when both parties come to the negotiation table and leave feeling like they have won. They focus on integrative or value - creative bargaining processes and techniques which enable each party to learn what the other one wants.
- Hard bargaining (Distributive Negotiation) is when one or both parties take an extreme position, which often creates a win-lose solution. A win-lose scenario may seem beneficial if the deals skew in your favour, but others will not want to do business with you. If such an approach is used, you might win one negotiation but lose in the long run.

The five-step negotiating process is as follows:

1. Preparation is key to successful negotiations. It is indispensable to identify most realistic outcomes. It is important to determine the best alternative to a negotiated agreement.
2. Exchange of information about your initial position with the other negotiating party is the second step. You should avoid creating the environment of aggression and pressure. Active listening skills are vital for understanding how your counterpart sees the situation during this stage. That way, it is possible to reach an agreement that benefits everybody. Key negotiation skills, needed to successfully complete this stage of negotiation process, include questioning and active listening.
3. Clarification enables both parties to justify their claims. This stage is an opportunity for one party to provide the other one with any documentation that helps support its position.
4. Bargaining is a critical component of the negotiation process because it begins a give-and-take action. Both parties have a chance to suggest different offers.
5. Commitment is the final step in the negotiation process. It formalizes the agreement reached in the previous stage. Regardless of the outcome, both parties should thank each other. It should be borne in mind that negotiations are all about creating and maintaining long-term relationships.

The five-step negotiation process is graphically presented in Fig. 2.

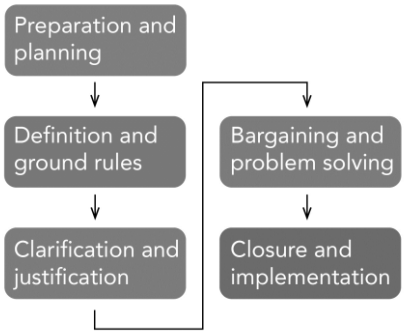

Figure 2. Guidelines enabling to conduct a successful negotiation process.

6. Role of human factor in negotiating

Negotiations are based on a collaboration between/among parties and it is crucial to bear in mind that negotiations are successful if they ensure that each party gains something. Knowledge about human behaviour is extremely useful. In general negotiations are oriented onto changing relations among negotiators who represent different characters, personalities and tempers. It should be borne in mind that one party's perception of facts is not always similar to the other party's one. Bad habits of negotiators can have a negative impact on the course of negotiations, including unpleasant gestures and mimics, however an instinct of the negotiator can be either a good or a bad advisor. Being aware of the above mentioned aspects of human behaviour, it is easier to predict the partner's reactions and to understand them. Fig. 3 presents influencing and negotiation skills. It is important to remember that special attention should be paid to personal influence and impact as well as to the psychology of persuasion.

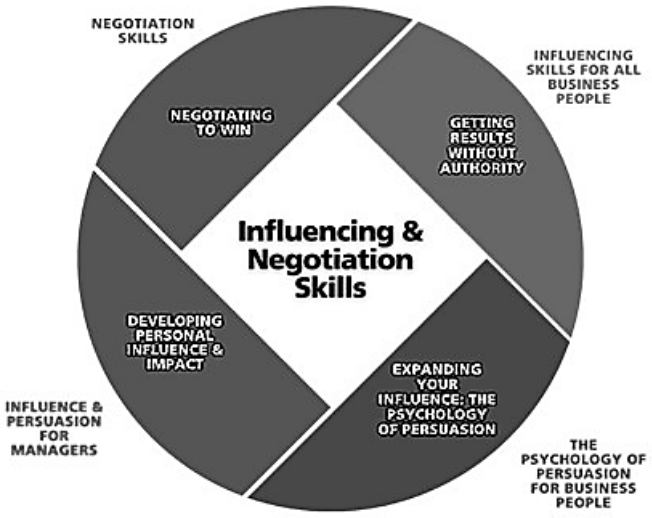

Figure 3. A graphical presentation of influencing and negotiation skills (https://mce.eu/open-programmes/influence-and-negotiation-skills/).

Experience of negotiators gives them abilities enabling to conduct successful negotiations, but it will not give sufficient knowledge about a wide range of available possibilities. Each person tends to assess the circumstances in the most advantageous way for him/her. Psychologists call this approach a rationalization of results which usually happens at the final part of negotiations. It is also worth mentioning a projection which consists in attributing own motivations to the opponent in negotiations, such as for example making biggest profits (Nierenberg 1981). It leads to a deformation of real facts and situations, when a liar believes that everybody is a liar. A dislocation should be mentioned as well, i.e. unjustified emotions during negotiations can be such a dislocation. Playing different roles in negotiations is also worth analyzing because it helps to avoid mistakes in the scope of intentions and objectives. Irrational fury can be an example of a behaviour which constructs a psychological barrier which is difficult to overcome. Open-minded negotiators are definitely more creative and goal-oriented. Summing up, it can be stated that human behaviour is not a fight between mind and heart but a combination of them both and of many other factors such as cultural environment and life experience. A trial of understanding human needs leads to successful negotiations, because people rationalize, conduct projections, dislocations and play their roles. They sometimes restrain their emotions and an experienced negotiator can guess what is going on.

7. Preparation for negotiations

A good negotiator should know how to control his own emotions. He should be patient in precise presenting his opinions which helps to avoid misunderstandings. It is helpful to conduct a research on your opponent trying to detect the other party's objectives in advance as well as his professional achievements. All these activities supply information enabling to foresee the opponent's strategy as well as his strong and weak points. Such an approach enables to establish certain assumptions which can be used during negotiations. It also saves time as both parties have a common understanding of facts and circumstances. It is indispensable to bear in mind that negotiations lead to satisfying both parties' needs.

8. Motivation in negotiations

Each negotiator aims at satisfying his/her needs. Prof. A. Maslow from the Brandeis University gives seven categories of needs which can be treated as basic factors of human behaviour **(**Maslow, 1954**)**:

1. Homeostatic needs (physiological).
2. Need of safety.
3. Need of love and affiliation.
4. Need of value.
5. Need of selfactualization (internal motivation oriented onto abilities).
6. Need of knowledge and understanding.
7. Aesthetic needs.

Homeostatic needs seem to dominate because they concern efforts of organism to maintain its normal, balanced condition. However, the need of value includes freedom and independence which also play a significant role in the process of negotiations. It is accompanied by competence and prestige. Gaining knowledge and life-time learning make a good and efficient negotiator. A deep knowledge about the needs, mentioned above, facilitates the process of efficient negotiations based on mutual collaboration.

In fact there are three levels of negotiations:

– Interhuman level - negotiations between two persons.
– Interorganizational level - negotiations between/among organizations.
– International level - negotiations between/among states.

There are different approaches used by negotiators:

– Negotiator is oriented onto satisfying his own needs.
– Negotiator allows his opponent to act towards meeting his needs.
– Negotiator acts towards meeting his own as well as the opponent's needs.
– Negotiator acts against his needs.
– Negotiator acts against the opponent's needs.
– Negotiator acts against his own and the opponent's needs.

The more alternative methods are used, the more chances for being successful, as the negotiator can then use different possibilities to reach his objectives. Open-minded negotiators are flexible as regards a selection of new methods.

9. Recognition of needs in negotiating

Different methods and techniques can be used for a recognition of the negotiator's opponent's needs. This step is connected with communication. A good negotiator watches his opponent's behaviour very carefully (manners, gestures, repeated expressions) which helps him to learn about objectives and hidden needs. Obviously the simplest way of getting information is asking questions such as: "What do you want to achieve during these negotiations?", "What do you expect?". It is crucial when such questions can be asked because it happens that

the obtained answers lead to nowhere. Questions are a sort of serious weapons during the negotiating process, so they should be asked carefully, because they stimulate the opponent to think critically about our proposal. General questions e.g. "Why have you said that?" make the opponent feel cornered and he will probably start looking for excuses. Careful questions, asked in a sensible way, attract attention and direct the discussion towards concrete information, making the opponent draw conclusions which are welcome by us. Apart from questions also statements can play a significant role in the negotiating process, because they enable to control it. It is recommended to avoid emotional statements which can impede negotiations. Threats and offensive words are unacceptable. It is worth concentrating on the meaning of the opponent's words and listen carefully to his statements so that to understand hidden meanings and hints. Listening is as important as speaking. A good negotiator must be open-minded and he should avoid prejudices and an advance formulation of conclusions. Non-verbal communication should also be highlighted. Gestures are extremely significant. Tension can cause contractions of muscles in the face, insincere smile and red spots, as well as body movements. Coughing can be a sign of nervousness or it can indicate that the opponent tells lies. When a person, sitting at table during negotiations, leans towards it, it means that he expresses extra interest and when he moves backward he shows a reduced interest. It is difficult to assess non-verbal communication as it is related to both the subconsciousness and emotions. Cultural differences have an impact on using and interpreting gestures. The main conclusion resulting from the information, presented above, is that a good negotiator aims at recognizing his opponent's needs, motivations and objectives. It can be done by asking questions, watching his gestures and other forms of non-verbal communication, being aware of the fact that he can be under emotional stress and that cultural differences may occur.

10. Negotiating techniques

After having prepared for negotiations, it is necessary to develop strategy and tactics of negotiations. The strategy "when" as well as "how and where" is indispensable as it facilitates time management. Each strategy can be divided into eight elements: anticipation/expectation, surprise, fait accompli, withdrawal, apparent withdrawal, reversal, restriction, misleading.

The basic forms of the "how are where" strategy are as follows: participation, accreditation, discreditation, cross-roads, allowing for expansion, randomization (bluff for bluff), random sample, salami (small steps by 'slices') and forks (how to determine the goal and hit it). The negotiating theory aimed at satisfying needs is presented in Fig. 4.

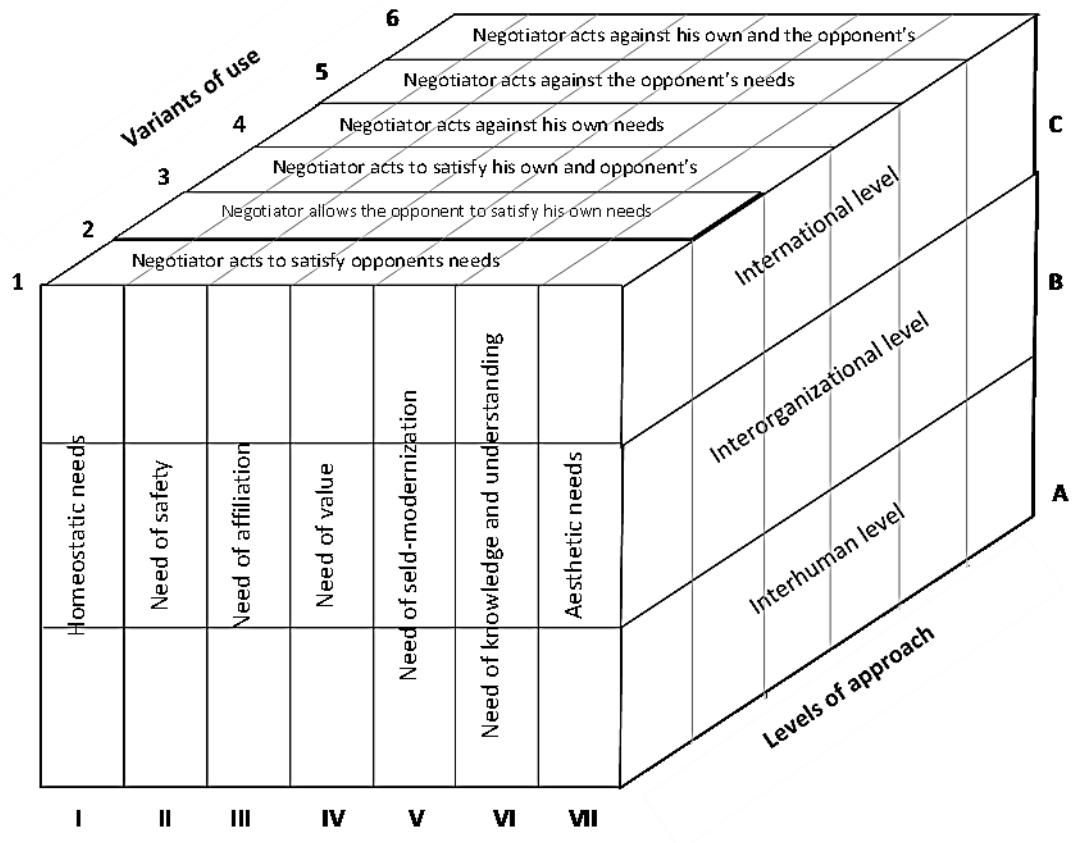

Figure 4. Structure and sequence of gambits in the framework of negotiating theory aimed at satisfying needs (Nierenberg 1981).

The schematic diagram shows a cube consisting of 126 cubes, whereas each of them represents a different gambit.

Summing up, it can be concluded that all the information, presented above, includes both the philosophy and psychology of the art of negotiating. Human behaviour was analyzed from the point of view not only of negotiations but also of basic needs. The theory of negotiations was oriented onto satisfying needs. Negotiating is a tool which can be efficiently used by a good negotiator who understands the principles of collaboration, bearing in mind that successful negotiations are a win-win event.

11. Multiple dimensions of negotiation process

According to the research results, presented in (Filmoser, Hippmann, Vetschera, 2016) negotiation processes are characterized by multiple dimensions. They involve a substantive, a communication and an emotional dimension. Research results, confirmed by the Authors of this publication after a thorough analysis of six case-studies indicate a strong linkage between communication and emotions, whereas connections to the substantive dimension are weaker. A negotiation process is viewed mainly as a sequence of offers and counteroffers based on

economic criteria like efficiency and utilities of parties. However, classification schemes for communication acts explain how communication context changes over time and influences the outcomes of negotiations, i.e. whether a negotiation reaches an agreement. The research, conducted recently, uncovered different emotional patterns in negotiations. In the case-studies, analyzed by the Authors, the negotiation processes were conducted in the unified framework as shown in Fig. 5. They were viewed as three parallel streams.

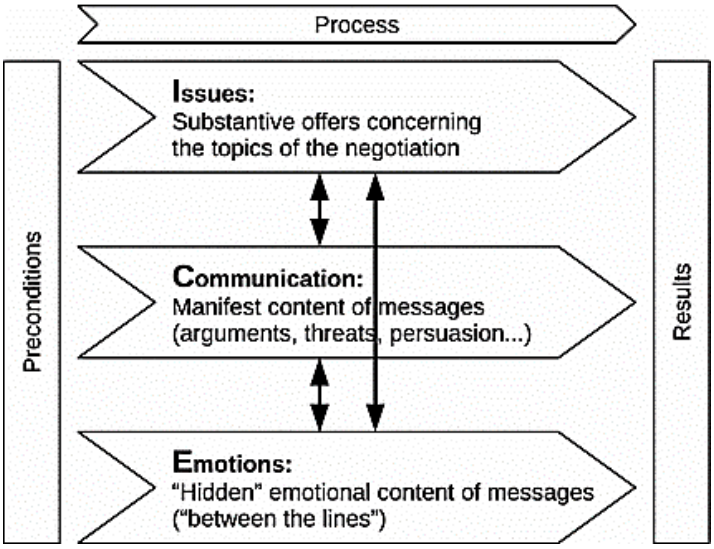

Figure 5. Issue-communication-emotions (ICE) framework for negotiation processes (Filzmoser, Hippman, Vetschera 2016).

Research on all three dimensions was concerned with their effects on outcomes. It is worth focusing on the process perspective as a common ground between dimensions. This requires a unified framework for negotiation processes which maps events in the different dimensions onto a common time scale.

Apart from presenting multiple dimensions of negotiation processes, the Authors decided to analyze a multi-agent based negotiation picture to get as much information as possible about an enterprise interoperability.

Sustainable interoperability between enterprises through a multi-level negotiation, communication and information sharing applies rule - based negotiation at various organizational levels such as: business, ICT, workflows, data systems and people. As it has been already shown in (Ray, Jones, 2006) a broad definition of interoperability refers to the ability of two or more systems to exchange information and use it. The lack of it disturbs the creation of new markets, networks and diminishes innovation and competitiveness of organizations. That is the reason why the KOMAG Institute has been trying to achieve interoperability in different fields of its scientific and technical activity. Multi-agent based negotiation system MAS plays a crucial role in e-negotiating processes (Kadar, Muntean, Cretan, Jardim-Goncalves, 2013), because in this case intelligent agents are able to assist humans in re-negotiation decisions taken at business level when breaking downs of interoperability occur. The negotiation abstract model, presented in Fig. 6., is designed with use

of the agent paradigm and the afferent tools. Agents can be regarded as computer systems (Wooldridge, Jennings, 1995). The model is an agent federation consisting of such agents as: autonomy, social ability, reactivity and pro- activeness.

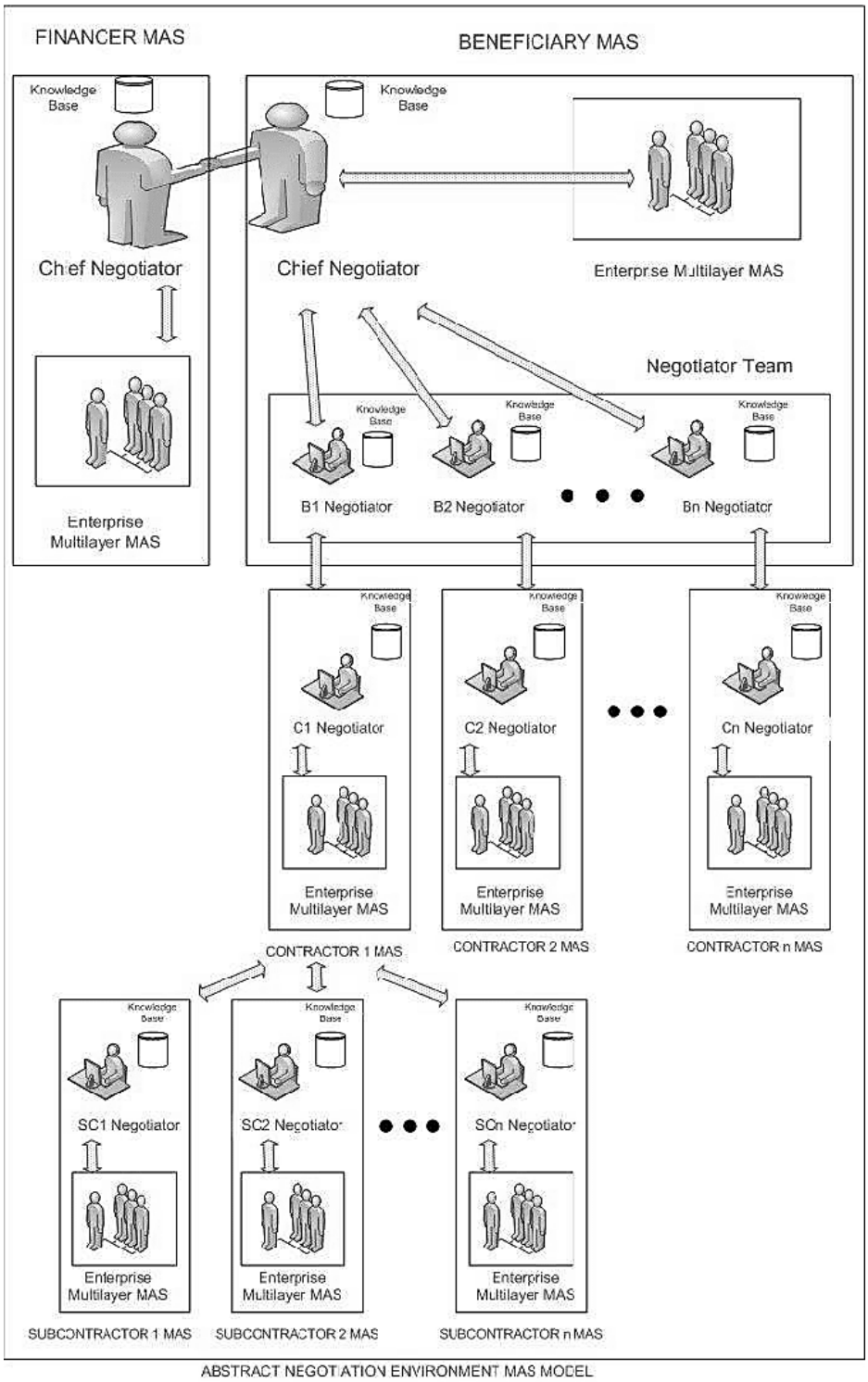

Figure 6. MAS for abstract negotiation model (Kadar, Muntean, Cretan, Jardim-Goncalves, 2013).

It should be borne in mind that group members interact with the agent acting as an intermediary. In this way the group is provided with a consistent interface. The most fundamental mechanism for managing inter-agent dependencies is negotiation, which

underpins attempts to cooperate. The architecture of the negotiation system offers mechanisms to support negotiations. This architecture is structured in four main layers: Chief negotiator, Negotiator Agent, Coordination Components and Middleware, as shown in Fig. 7.

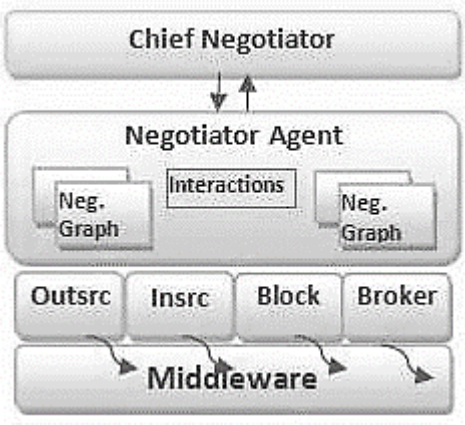

Figure 7. The architecture of the negotiation system (Hu, Deng, 2011).

Each negotiation is organized in three steps: initialization, refinement of the job under negotiation and closure (Hu, Deng, 2011). In the first layer Chief Negotiator handles all business decisions, the second layer is dedicated to the Negotiator Agent that assists the negotiations. In the third layer, Coordination Components coordination constraints are managed and the fourth layer, Middleware ensures the communication process being shared by all negotiation partners. The participants to a negotiation propose offers and each of them may accept or reject the offer received. A schematic example of negotiation process is shown in Fig. 8.

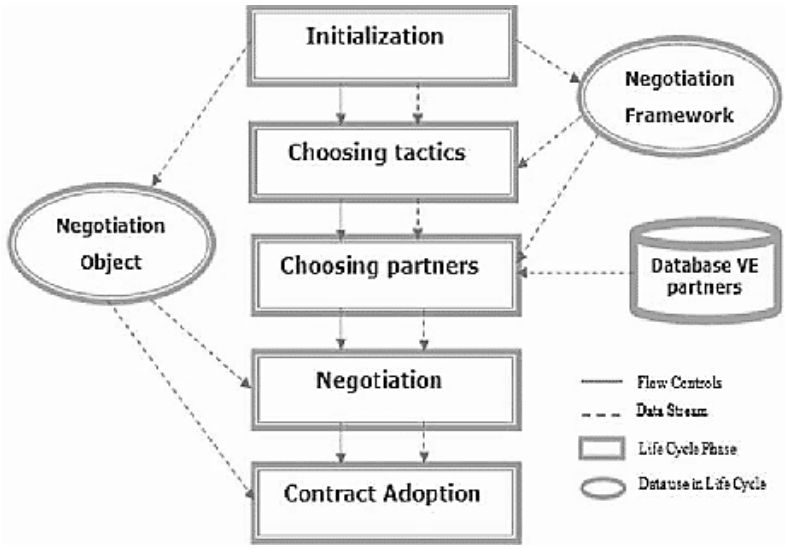

Figure 8. The structure of the negotiation process (Kadar, Muntean, Credan, Jardim-Goncalves, 2013).

The negotiation process is divided into five parts: Initialization, Choosing tactics, Choosing partners and Negotiation which enables the exchange of proposals.

The objective of the negotiation stage is to build a negotiation object whose attributes have been accepted by all partners. This object will be used to establish a contract. Contract Adoption is the final stage, in which the negotiation object has fixed values. In conclusion, the presented architecture enables to coordinate multi-phase negotiations on a multi-attribute object and among several participants. While presenting a negotiation model special attention should be paid to negotiation planning which enables to identify a set of activities which are undertaken by the negotiator to decide on the course of action to be pursued at the negotiating table. Setting long-term goals and identifying the ways of meeting them is the focus of strategic planning. Whereas tactical planning is oriented onto developing short- term steps to achieve the long-term goals. Finally, administrative planning includes making logistical and allocative arrangements for the negotiation. Negotiation planning consists in the systematic mapping of the different steps involved in the process of negotiation.

12. Summary and conclusions

The Authors concentrated their publication on the role of negotiations in commercialization processes of innovative research projects results. Their expertise is based on scientific and professional experience gained at the KOMAG Institute of Mining Technology. Six examples of research projects were chosen for highlighting crucial aspects of negotiation processes. As at present more and more businessmen are aware of efficient techniques of negotiations, it seems to be pragmatic to show their advantages and disadvantages. A good knowledge of human reactions, human behaviour and so called body language is extremely helpful. Special attention is paid to characteristic features of negotiations presented as the case-studies. Due to such an approach it has been possible to formulate some guidelines facilitating the negotiation process and enabling to avoid mistakes. The following conclusions can be drawn from the conducted analysis of the case-studies:

- The preparatory phase of the negotiating process includes strategy development, the preparation of negotiation strategy and tactics, the risk assessment and contingency planning.
- After the preparatory phase the negotiation starts. It includes active questioning for clarification, testing and probing, persuading and moving, closing, agreeing and documenting as well as deal monitoring at the very end.
- In the process of negotiation, conditioning calls for placing a starting point in the minds of the opponents are significant. Planning involves the consideration of the concerns related to the objectives which are to be achieved in the result of the negotiation process.

- A correct negotiation process requires an ability of coordinating activities, a good will of cooperation, a good communication and a flow of information.
- Based on the in-depth analysis of the six case-studies it can be concluded that the "win-win" negotiations seem to be most fruitful and successful.
- The five-step negotiating process is generally followed at the KOMAG Institute. It includes: preparation, exchange of information, clarification, bargaining and commitment.
- Recognition of needs in negotiation processes is extremely important. This step is connected with communication.
- It can be finally concluded that all the information, presented in the article, includes both the philosophy and psychology of the art of negotiating. The human factor should be analyzed not only from the perspective of the negotiation objectives but also from the point of view of basic needs, as in real life negotiations are oriented onto satisfying needs.

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THE ANALYSIS OF CSR REPORTING PRACTICES IN THE MINING SECTOR IN POLAND

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Purpose: The objective of this study is the analysis of reporting activities relating to the corporate social responsibility by mining companies in Poland.
Design/methodology/approach: The article is cognitive in its nature. The basic research methods include the subject literature analysis. Literature studies include the analysis of domestic and foreign literature. The empirical section used the study method known as content analysis which enabled to assess the scope of reported data and to compare it for different mining entities in Poland.
Findings: The conducted research provides an important conclusion for the management. The mining companies, due to their specific activity, including but not limited to their impact on the environment, should report their social activities in a clear way, compliant with international guidelines. In practice, however, it is not always like that and it requires further development in many areas. Thanks to the presented studies, the mining companies may compare their activities, improve them and look for new opportunities targeted at the Corporate Social Responsibility.
Research limitations/implications: The studies presented in this article may contribute to further empirical studies extended to other sectors or to international comparisons.
Practical implications: The practical implications of the conducted research make it possible to use them to improve the CSR reporting system in mining companies.
Originality/value: The study results point to the need to improve the CSR reporting system in mining companies.

Keywords: corporate social responsibility, mining sector, CSR reporting.

Category of the paper: General review, Research paper.

1. Introduction

One of the most important challenges of the Polish mining sector is to change the existing sector image. On the one hand, the activity of mining companies has an adverse impact on the natural environment, leading to changes in the water and waste management, causing

degradation of land, dust emissions and mining damage etc. The environmental impact of mining on the environment is indisputable and entails many effects which must be faced on a daily basis by the society, including but not limited to the immediate vicinity of mines. On the other hand, mining companies are important workplaces for the inhabitants of the region where they operate, stimulating business activity by demand for outsourced services, materials, energy, permanent equipment and building structures. What is more, they bring extra income to local government budgets where they operate. This is the mining fee and income tax share. They frequently pursue extended social policy not only towards their employees, but also to the whole community. Those are, for example, social and natural environment initiatives. Such activities, called Corporate Social Responsibility (CSR), become more and more popular (Gulko, Hyde, 2022). The companies undertaking CSR activities usually present their results in reports developed based on different standards. The studies discussed in this article are aimed at analyzing the scope of information covered by such reports developed by mining companies in Poland. This goal will enable to compare not only the CSR activities in that sector but the quality and scale of CSR reporting in mining companies as well. Based on the presented results, mining companies will be able to improve their operations and look for new opportunities targeted at the Corporate Social Responsibility. The solutions adopted in the mining sector will also be implementable in other sectors.

2. The notion of the Corporate Social Responsibility

The concept of the corporate social responsibility was started in late 19th century as a manifestation of the wealthy ones' charity and care for poorer members of the society (Carnegie, 2012). The contemporary perception of the corporate social responsibility was born in the United States, but later appeared in the United Kingdom as well (Bowen, 1953). It was termed the businessman's morality and ethical behavior towards stakeholders, meaning the whole society in a broader sense (Klimczak, 1999). Business responsibility towards the community where it operates was considered a compensation for any side effects of the open market development. Dynamically-growing companies were focused mostly on financial profits which could result in escalating such adverse phenomena as social inequality, unemployment, natural environment degradation etc. in the open market. Those factors led to a discussion concerning the corporate social responsibility and gave birth to the CSR notion. In Europe, the discussion on the corporate social responsibility was started only in 1995 when the group of European businessmen, including Jacques Dolores, the President of the Commission of the European Communities those days, presented their Manifesto of Enterprises (Rybak, 2004). The European Commission addressed the notion of the corporate social responsibility in the so-called Green Paper in 2001 (Green Paper, 2001). According to its

provisions, the CSR notion means companies' responsibility for their social impact. Although the companies are focused on earning profits, they should get involved in social and environmental issues as well, by included the CSR notion in their business strategies (Chen, Guo, Hu, 2023). The Green Paper presents the basic assumptions of the CSR concept, the required development directions, but without indicating specific solutions. Its follow-up is a 2002 document, termed the White Paper (White Paper: Communication on CSR, 2002). It presents the areas of further European Union activities relating to CSR. These are:

- the area of knowledge, education, sharing experience and best practice,
- CSR concept promotion,
- creation of a stakeholders' forum composed of representatives of governments, NGOs, entrepreneurs and trade unions (The European Multi-Stakeholder Forum on CSR, CSR EMS Forum),
- integration of the CSR concept with other EU activities.

As a result of further expansion of the CSR concept, in 2010 the International Organization for Standardization published ISO 26000 (Guidance on social responsibility) standard. This standard is to support different institutions when introducing the CSR notion in their operations. According to its provisions, the organization which implements CSR assumes responsibility for its operations and their impact on the environment and the community. Behavior of the organization, regardless of its size, should be ethical and transparent with respect to human rights, local community, environment, corporate governance, consumer aspects or employees' rights (Mbanyele, Muchenje, 2022).

According to the presented documents, CSR concept becomes more and more important in the contemporary world. At present, this area is supported by extensive scientific theory and numerous initiatives have been started. There are examples of best practice in that respect and stakeholders await broad information on the socially responsible operations of companies. This is why the role of CSR reporting grows.

3. CSR reporting guidelines

CSR activities' reporting may be carried out using different national, EU or international standards or based on internal company rules. One of the most popular standards is the Global Reporting Initiative (GRI) developed in 1997 in Boston by the Coalition for the Environmentally Responsible Economies and Tellus Institute. This is a global standard providing guidelines for reporting. Its original version was based on the so-called triple bottom line (TBL) relating to (Woźniak, 2019):

- the economic aspects,
- the environmental aspects,
- the social aspects.

The guidelines are constantly updated and complemented. The most recent set of GRI Standards has a modular structure and is composed of 36 individual standards divided into general, universal standards applying to every organization preparing a sustainable development report (3 standards) as well as theme-specific standards, including economic ones (6 standards), environmental ones (8 standards) and social ones (19 standards). Every organization decides on its own which GRI standards to indicate in its report.

Because of the specific activities of selected sectors, the GRI guidelines included sector-specific ones (GRI G4) referring to ten selected sectors, i.e.:

- Airports Operators.
- Electric Utilities.
- Food – Processing.
- Construction and Real Estate.
- Media.
- Mining and Metals.
- Event Organizers.
- Non-Government Organizations.
- Financial Services.
- Oil and Gas.

The guidelines for the above-mentioned sectors should be used to complement and not replace reporting according to GRI.

Due to the scope of studies presented in this article, solely the guidelines for the Mining and Metals sector, marked MM1-MM10/11, were used. They complement the basic version of the GRI report and address aspects which the mining sector should pay particular attention to. To complement the report for the specific nature of the Mining and Metals sector, the following indexes were added (GRI Standards, 2017):

- employment practice and decent work – this index covers the number of strikes and work breaks lasting more than one week,
- respecting human rights – the number of operations carried out in the areas inhabited by indigenous peoples and adjacent areas,
- impact on the local community – number and description of disputes over the ownership of land and the degree of using complaint mechanisms during dispute resolution,
- impact on small craftsman activity – number of operating companies connected with mining,

- displacements – areas where displacements were carried out, number of displaced households,
- planned liquidation – number of operations subject to the liquidation plans,
- responsibility for material management – programs and progress when creating material management,
- biodiversity – land area which was destroyed, damaged or reclaimed, including the number of areas requiring management plans,
- emissions, wastewater and waste – the total amount of input, rock, mining operating waste, sludge, slurry and related risk.

The development of CSR reports is highly important for the mining sector because of the scale of impact exerted by it on the environment, employment and economic development of the region. However, it is worth adding that the quality of reporting is also crucial. The company should report activities with real impact on the environment, based on actual numbers. It should consider the fact that the earliest readers of CSR reports include lawyers and shareholders. In practice, the reporting entity sometimes resigns from reporting certain indexes, e.g. when the achieved results are inferior to the previous ones. It may happen that companies do not disclose disadvantageous information as they do not want to show their worst side. However, many reports published worldwide include numerous examples of failed achievements as well. According to the experts, such an approach, i.e. confessing to failures, contributes to building a good image and trust in the company. Nonetheless, it should be ensured that the adverse results do not appear too often and that they are always accompanied by a remedy plan.

Summing up the GRI reporting rules in the mining sector, the most important ones include (Isacowitz et al., 2022; Bachowski, 2016):

- sharing best practices and standards in the operations carried out,
- ensuring transparency and fair competition,
- building a market position in the competitive environment,
- stressing the significance for the region by new workplaces, small business development, community involvement schemes, sponsoring etc.

The disadvantages of this reporting method include:

- the failure to include much sensitive information.

CSR reporting translates into building good relationships with the community and also helps to promote the company as the best practice implementer (Górecki, 2010). Unfortunately, few Polish mining companies publish their CSR operations.

4. Research results

When studying the verification of the CSR reporting method, the scale of CSR reporting among Polish mining companies was analyzed. The reports were verified for the guidelines included in GRI and GRI Mining and Metals as at 2021. Hard-coal mining was considered which is represented by the following entities in Poland:

- Polska Grupa Górnicza SA – PGG SA (0.0000026%, i.e. 1 share held by the Treasury, 20.42% of shares held by PGNiG Termika S.A., 18.30% of shares held by WĘGLOKOKS SA, 15.32% of shares held by PGE Górnictwo i Energetyka Konwencjonalna SA, 15.32% of shares held by Energa Kogeneracja Sp. z o.o. (on 15.02.2021 acquired by ECARB Sp. z o.o.), 15.32% of shares held by Towarzystwo Finansowe SILESIA Sp. z o.o., 7.66% of shares held by Polski Fundusz Rozwoju SA and 7.66% of shares held by ENEA SA).
- Jastrzębska Spółka Węglowa S.A. – JSW SA (55.17% of shares held by the Treasury).
- TAURON Wydobycie SA (100% of shares held by TAURON Polska Energia SA, a listed company).
- Lubelski Węgiel Bogdanka SA – LWB SA (65.99% of shares held by ENEA SA, a listed company).
- Węglokoks Kraj Sp. z. o.o. (100% of shares held by Węglokoks SA).
- Przedsiębiorstwo Górnicze Silesia sp. z o.o. (100% of shares held by a private owner).
- Zakład Górniczy SILTECH sp. z o.o. (100% of shares held by a private owner).
- Eko-Plus Sp. z o.o. (100% of shares held by a private owner).

The websites of the above-mentioned companies were used to verify if they publish CSR reports. The results are presented in Table 1.

Table 1.
Verification of the published CSR reports and their contents as per GRI

Company	CSR report
PGG SA	none (the report is made by the parent company PGE SA)
JSW SA	yes (includes GRI standards)
TAURON Wydobycie SA	none (the report is made by the parent company TAURON Polska Energia SA)
LWB SA	yes (includes GRI standards)
Węglokoks Kraj Sp. z. o.o.	none
Przedsiębiorstwo Górnicze Silesia sp. z o.o.	yes (no GRI standards)
Zakład Górniczy Siltech Sp. z o.o.	none
Eko-Plus Sp. z o.o.	none

Source: own work.

According to Table 1, only two mining companies publish CSR reports compliant with GRI standards. They are JSW SA and LWB SA. For the other companies, including PGG SA and TAURON Wydobycie SA, the reports are made on the level of the capital group which the

analyzed companies belong to. However, the reports are not included in further analysis as the mining activity is not the core operations for the capital groups PGE SA and TAURON Polska Energia SA. They are connected with the power engineering sector to a higher degree. Other mining companies operating on the Polish market were excluded from further analysis as they do not prepare CSR reports or prepare reports not compliant with the GRI standards which prevents comparisons of the basic indexes. Given the above limitations, two study entities, i.e. JSW SA and LWB SA, are considered for further comparative analysis. The core operations of both companies are coal mining. The analysis referred to CSR reports published by those companies. The studied period is 2021 which results from the date of the most recent report publication on the analyzed companies' websites (as at the analysis date, the reports for 2022 were not available). The analysis referred to the most important areas of corporate social responsibility reporting. The comparison referred to activities targeted at employees (development opportunities, compliance with OH&S rules, benefits for the employed ones). Then, the analysis covered an extensive part of reports relating to activities aimed at maintaining good relationships with the community and stakeholders (foundations and sponsoring was included). The last analyzed area referred to the natural environment, including remedies and measures compensating the mining activity impact on the environment. In every area, common properties/measures undertaken within the social responsibility were listed and compared based on the reports by the two analyzed companies. The comparison is included in Table 2 where "+" (plus) confirms that the property/measure was included in the report, while "-" (minus) indicates the absence of the information in the report.

Table 2.
Comparison of the CSR report of JSW SA and LWB SA

Property/measure included in the CSR report	LWB SA	JSW SA
AREA: EMPLOYMENT		
Human rights and counteracting discrimination	+	+
Significance of OH&S training	+	-
Training, qualification development opportunities	+	+
Modern developmental programs	+	+
Benefits	+	-
AREA: COMMUNITY AND STAKEHOLDERS		
Development of a virtual tour and learning history	+	+
Dialog with stakeholders	+	+
Care for health	+	+
Mining activity impact and rectification of undesirable effects	+	+
Learning and education, cooperating with schools and universities, internships, scholarships	+	+
Post-mining land development	+	+
Company development – new workplaces	-	+
Foundations	+	+
Local investments in community issues and charity	+	+
Sports support	+	+
Support for environmentally-friendly activities	+	+
Subsidiaries' activity for the community	-	+
Stakeholders' identification and involvement description	+	+

Cont. table 2.

Aspects discussed by stakeholders and the company's response	+	+
Cooperation and opinion exchange between customers	+	+
Dialog with trade unions	+	+
AREA: NATURAL ENVIRONMENT		
Post-mining land reclaiming	+	+
Continuous environmental impact monitoring	+	+
Failures and violations of environment protection regulations	+	+
Circular economy investments	+	+
Reduced consumption of energy and other resources in Company processes	+	+
Economical coal exploitation	+	+
Effective use of methane and other by-products of the mining process	-	+
Recipients' education relating to the awareness and environment protection and sustainable development	+	+
Biodiversity	+	+
Emissions, wastewater and waste	+	+
Programs and progress when creating material management	+	+

Source: Own study based on: The integrated report for 2021 of GK LW Bogdanka called "Stable Development in a Difficult Environment – Right Before the Armed Conflict in the Ukraine" (Stabilny rozwój w niełatwym otoczeniu – w przeddzień konfliktu zbrojnego na Ukrainie), https://ri.lw.com.pl/pobierz/445/raport-zintegrowany-2021-pdf and the integrated report for 2021 of JSW SA, https://www.jsw.pl/raportroczny-2021#Start.

In the employment area, both companies describe their activities related to employee relations broadly, following GRI guidelines. LWB SA indicated its measures relating to employee rights protection and workshops to counteract discrimination. LWB SA enables all its employees to access a broad range of different training or courses, stressing possible post-graduate course attendance. The company ensures innovative development programs. To cater for its employees, LWB SA keeps extending the benefits contributing to employees' health and wellbeing. Those benefits include sports opportunities (Multisport membership), contributions to holiday leaves, trips or entrance tickets to cultural events. It organizes team-building meetings and picnics, offers special assistance grants, housing loans or subsidies for pre-paid medical care package. In the employment area of JSW SA report, it is stressed that the company's priority is to respect human rights and to prevent mobbing and discrimination. Many training sessions were organized to that effect. The company follows a Code of Ethics. Moreover, the company tries to ensure the competence development opportunity to its employees by means of training, language courses or post-graduate courses. In its report, JSW SA does not reveal any employee benefits. The company ensures that it follows OH&S regulations and cares for its employees' life and health continuously but it does not mention any type and number of related training.

In the area relating to the impact on the community, including but not limited to stakeholders, both companies undertake similar measures. In LWB SA's report, there is no information on new workplaces created as a result of the company's developmental activities. In its report, LWB SA does not refer to the subsidiaries' activity for the community.

The natural environment area refers to reporting data on the mining operations' impact on the natural environment, but also to reporting undertaken environmental protection measures. LWB SA presents itself as an environmentally-efficient mine. The company policy and environmental management are focused on three important aspects, including:

- respect for natural resources,
- minimized adverse impact of the mining activity on the environment,
- effective waste management,
- responsible sale management, taking care of raw material composition and being a role-model for customers.

It is similar for JSW SA. The report of that company also indicates significant care for the natural environment. Both those reports prove care about local biodiversity and post-mining area reclaiming. In both cases, the company operations' environmental impact and attempted rectification of any mining land modifications which were not avoided were observed. It was stressed that the care for the environment entails ongoing monitoring and inspection of the raw material quality and amount of emissions to the air. Attention should be paid to the continuous search for innovative solutions relating to complete raw material use. LWB and JSW stress circular economy adoption for water management. What is more, JSW believes in the crucial role of salt production from mine water and of attempts at using methane or hydrogen. LWB SA does not share this initiative. Moreover, the reports reveal attempts at minimized energy consumption and appropriate waste management. As a result of the measures, much waste does not go to slag heaps but is used e.g. to reclaim degraded areas. Different environmental projects and campaigns are initiated.

Comparing the two reports, it should be stressed that they are accurate and high quality, meeting all GRI guidelines. They are comparable in terms of most indexes. The LWB SA report is more detailed than the JSW SA one.

5. Summary

The Corporate Social Responsibility (CSR) is a voluntary focus of the entity's operations considering the overall community and environmental benefits and emphasizing the significance of stakeholders' relations. CSR can be introduced in the company's policy by a broad range of tools adapted to the selected activity directions. The companies present those activities in annual reports. One of the most popular regulation in this respect is the international reporting standards of the Global Reporting Initiative. They are further enriched with guidelines for specific sectors, including but not limited to the mining sector. Reporting translates into building good relations with the environment and taking the leading position in the sector, and also helps to assess and promote the company as the best practice implementer.

The studies presented in this work were based on the comparative analysis of CSR reports of two selected mining companies. Those were the only two entities in the selected group to publish CSR reports compliant with GRI standards. For both companies, the concept of the Corporate Social Responsibility is rooted in the mission and vision which proves conscious building of lasting company value as well as social and sustainable value. According to the reports, the entities are highly active in the discussed areas. The main problems and indexes reflecting important economic and social impact of the companies, together with their environmental impact, were described in the reports and presented in the broader sustainable development context. Both companies keep attempting at improving employee relations, initiate innovative development-oriented activities, care about human rights and prevent discrimination, corruption and other undesired conduct. The LWB SA report stresses the broad range of OH&S training to improve work safety and describes numerous benefits and facilities for employees. JSW SA report does not contain such information. In the area relating to the community and stakeholders, both companies emphasize their contribution to the local development. The scope of their measures is comparable. They support education, organize many projects, competitions and internships, cooperate with learners and fund scholarships. It is similar for the environment. Both companies attempt at reducing the adverse environmental impact of mining operations. Particular attention is deserved by the activities relating to the effective waste management, post-mining land reclaiming and care for biodiversity.

Summing up, it should be stressed that the activities presented in the reports by the two analyzed mining companies are crucial for employees, community and natural environment. The activity focus of both companies is highly similar and the CSR reporting practice is an opportunity for them to show the public that mining operations can follow the Corporate Social Responsibility rules.

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STUDY ON THE CONDITION OF SELECTED MICRO-ENTERPRISES IN THE SILESIAN VOIVODESHIP IN THE SECOND HALF OF 2022

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Purpose: The aim of the paper is to examine the impact of the economic situation in 2022 on the condition of micro-enterprises in the Silesian Voivodeship.
Design/methodology/approach: A research sample of 150 micro-enterprises from the Silesian Voivodeship was selected. Research methods such as interview and survey were used. A questionnaire was used as the tool. A complete set of responses was obtained from 132 micro-enterprises.
Findings: It was found that entrepreneurs respond in different ways to the difficult situation their micro-enterprises faced after the pandemic and during the following months of 2022. This depends on a number of factors, such as number of years the company has been on the market, the degree of specialisation in the domain handled, flexibility in re-branding, ability to obtain external financial and non-financial support, etc. These factors mean that the condition of the micro-enterprises studied is not homogeneous.
Research limitations/implications: Due to the small research sample, the study results cannot be generalised and treated as a picture of the condition of all companies in the Silesian Voivodeship. Further studies, based on a larger research sample, would provide a more comprehensive picture.
Originality/value: The negative impact of the 2019 global pandemic has greatly affected micro-enterprises. The military conflict in Ukraine in early 2022 has destabilised global markets. Rising inflation in Poland became even more pronounced after the outbreak of war. Many micro-enterprises faced a difficult situation. It is important to gain knowledge about the impact of constraints related to the economic situation on the operation of micro-enterprises in order to develop mechanisms to mitigate negative effects on entrepreneurship based on micro-enterprises.

Keywords: micro-enterprises.

Category of the paper: Research paper.

1. Introduction

The negative impact of the 2019 global pandemic has greatly affected micro-enterprises. The military conflict in Ukraine in early 2022 has destabilised global markets, disrupted existing supply chains and hampered investments (Machniewski, 2023). Rising inflation in Poland became even more pronounced after the outbreak of war. The challenging situation faced by many micro-enterprises during the pandemic worsened in the following months of 2022.

The article is an attempt to determine the condition of selected micro-enterprises in early 2023. Micro-enterprises registered in the Silesian Voivodeship were studied.

2. Specificity of micro-enterprises

The most numerous group of enterprises in Poland are micro-enterprises - entities employing up to 9 people and with annual net revenues of up to EUR 2 million. In Poland, they account for 96% of all companies and have a significant impact on GDP (Figure 1) (Poland in figures, 2022).

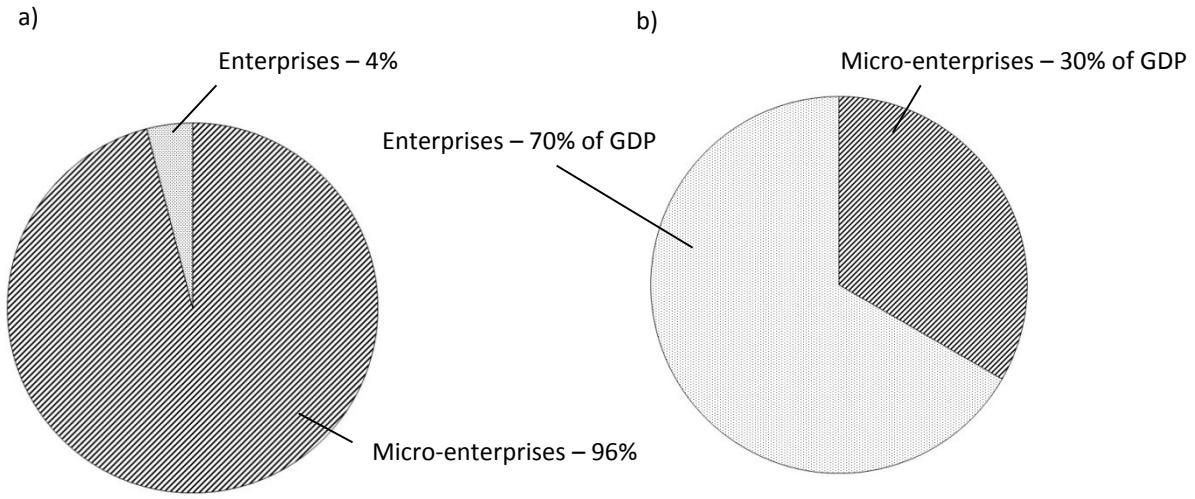


Figure 1. Micro-enterprises in the Polish market: share of micro-enterprises in relation to enterprises in general (a), share of micro-enterprises in GDP generation (b).

Own elaboration based on Poland in figures, 2022.

Micro-enterprises are often one-person enterprises (Smolarek, 2015; Safin, 2002). Micro-companies, with both advantages (considerable flexibility) and disadvantages (financing mainly from own resources) (Daszkiewicz, 2004; Dylkiewicz, 2008; Klimek, 2015; Nehring, 2012) are an important factor in the development of the economy, first and foremost at local level, then at regional and national level. A plan for the development of the micro-enterprise in

a broader time horizon significantly increases the entity's chances of staying in the market and possibly increasing the company's footprint (Oniszczuk-Jarząbek, Gutowski, 2008). In the Silesian Voivodeship the activities of micro-entrepreneurs are mainly concentrated in the following areas: industry-related activities, construction, trade and repair of vehicles, transport and storage, and professional, scientific and technical activities (GUS, 2022). The figure shows the percentage of micro-enterprises in these sectors.

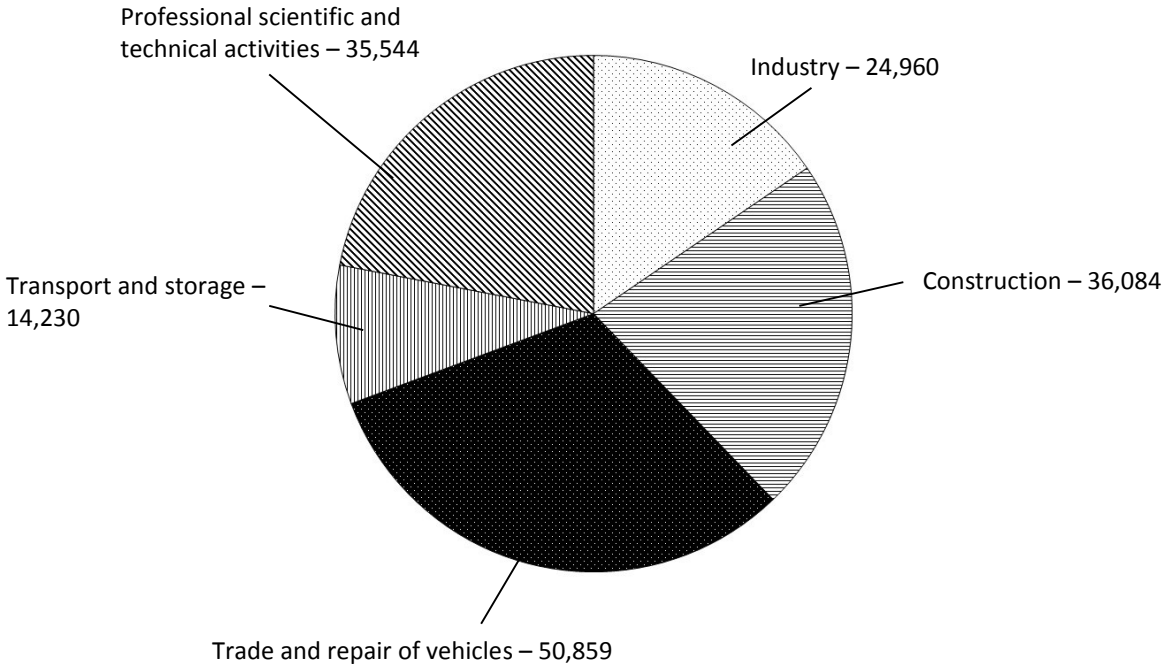


Figure 2. Share of micro-enterprises from the Silesian Voivodeship in some of the most popular business areas.

Own elaboration based on GUS, 2022.

3. Micro-enterprises in the post-pandemic period and in 2022

After a period of pandemic that forced some entrepreneurs to suspend their operations, some have been able to resume activity. However, this activity was burdened with uncertainty about the survival of the business. This concern was mainly related to the effects that rising inflation entailed (Kazimierski, 2022). Since October 2021, over a 12-month period, producer inflation has risen so much that at the end of this period producers were paying around 23% more than at the start. This fact translated into the price of the product. In September 2022 the producer inflation index stopped at just under 25%. One month later it dropped to 23%.

Other factors that have made it difficult for micro-entrepreneurs to exist are: interest rate rises and higher costs due to increases in electricity and gas prices (Leśniak, 2023; Lewandowski, 2022). Higher employment costs, associated with increased employee compensation, were not insignificant for micro-enterprises with more than one employee.

The biggest stimulus to micro-enterprise development is external funding, while the biggest barrier to growth is delayed payments, lost contracts and the inability to plan activities freely. Many businesses operate on the basis of collaboration with micro-entrepreneurs. For the development of micro-companies, or just their survival in the market, such coexistence is extremely important. Depriving a micro-enterprise of the possibility to cooperate with larger enterprises, coupled with the micro-enterprise's low liquidity, poses a considerable threat to such an enterprise. The relatively lower earnings of micro-entrepreneurs than of employees in companies with more than nine employees make it more difficult for micro-entrepreneurs to survive in difficult times. Figure 3 shows a comparison of earnings of micro-entrepreneurs with those of employees in other businesses between 2015 and 2021.

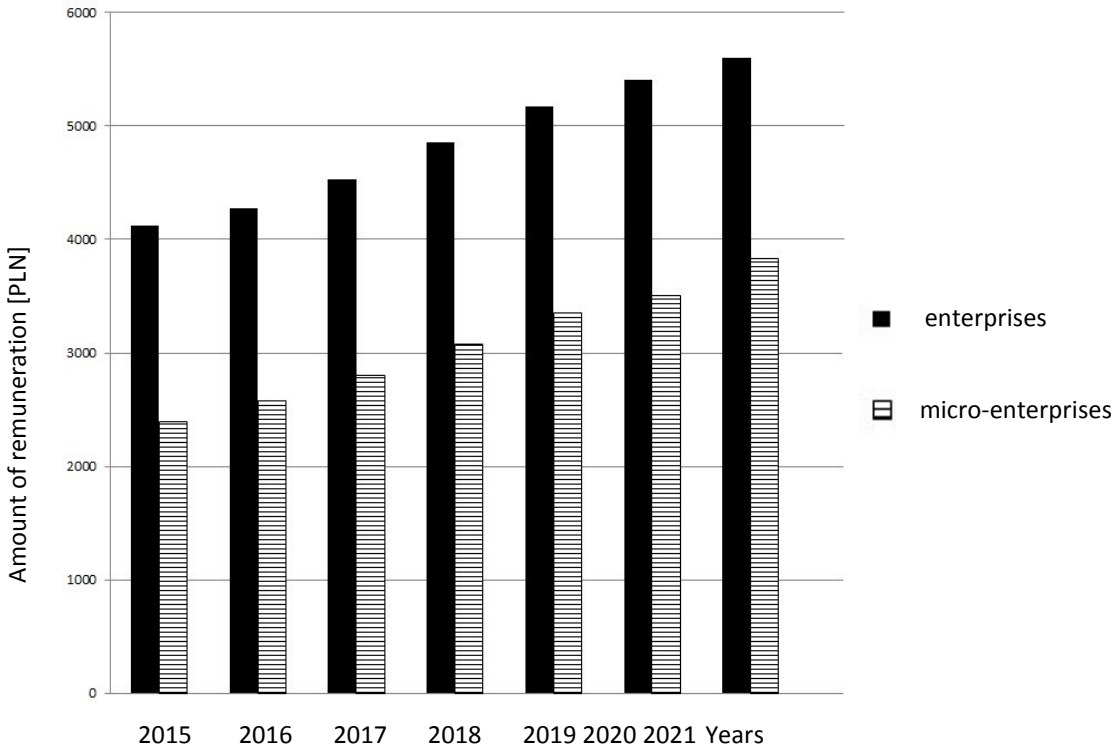


Figure 3. Comparison of remuneration amounts for employees of micro-enterprises with enterprises with more than ten employees between 2015 and 2021.

Own elaboration based on GUS, 2022.

4. Research sample, methods and tools

The idea was to survey 150 micro-enterprises registered in the Silesian Voivodeship. The selected enterprises operate in two of the three economic sectors: manufacturing and services. No micro-enterprises represent the agricultural sector in this study. Complete answers were obtained from 132 micro-enterprises.

Research methods included interview and survey. A questionnaire was used as a tool. It included questions on the issues listed below. Due to the limited volume of the article, the issues have been consolidated into 10 questions. Due to the limited volume, issues related to subjective feelings about the quality of life of entrepreneurs and their families were marginalised in this study in favour of measurable factors related to the operation of the business.

Below are the subject areas to which the questions were related:

1. How long has the micro-enterprise been in the market (up to 5 years, 6-10 years, more than 11 up to 20 years, more than 20 years)?
2. What is the main scope of the enterprise's activity (local, regional, national, international)?
3. Has the entrepreneur been forced to suspend business in the last four years due to the difficulties associated with a global pandemic?
4. During the pandemic and in 2022, has the entrepreneur used external funding sources (EU funding, government funding, other)?
5. Has the entrepreneur used non-financial methods of support (training, professional advice) during the pandemic and in 2022?
6. What are the main nuisances for running a micro-enterprise during a period of high inflation:
   - high prices of goods, materials and products,
   - high prices for energy utilities,
   - high fuel prices,
   - necessity to increase the remuneration of the employees of the micro-enterprise,
   - less interest from customers who cannot afford the products/services on offer in the current period,
   - lack of cooperation possibilities with previous entities/customers,
   - payments received late?

   Rate the impact on a five-point scale.
7. Is the enterprise currently applying measures to improve its competitiveness; if so, which ones?
   - increasing the quality of products/services offered,
   - expanding the range of products/services,

- advertising and marketing activities,
- offering promotions,
- setting lower prices than competitors,
- looking for and implementing other distribution channels than those used so far,
- introducing technological innovations,
- other.

8. Has the entrepreneur undertaken activities and work that generate an income which is alternative to the micro-enterprise?

The questions were closed-ended and the surveyed entrepreneur chose the applicable options for each question from the available list of possible answers. In several cases, where the adverse impact of a specific factor had to be assessed, the choice was made within a five-point scale (0 - no impact, 1 - weak, 2 - medium, 3 - strong, 4 - very strong).

5. Overview of research results

The aim of the study of micro-enterprises was to determine their condition after the coronavirus pandemic, and in 2022, when the negative effects of the military conflict in Ukraine were also strongly reflected in the Polish economy.

Among the entities surveyed, service micro-enterprises predominate (58%). The second group consists of companies engaged in manufacturing and processing (42%). A graphical presentation of the periods of operation (in years) of the surveyed enterprises in the market is shown in Figure 4.

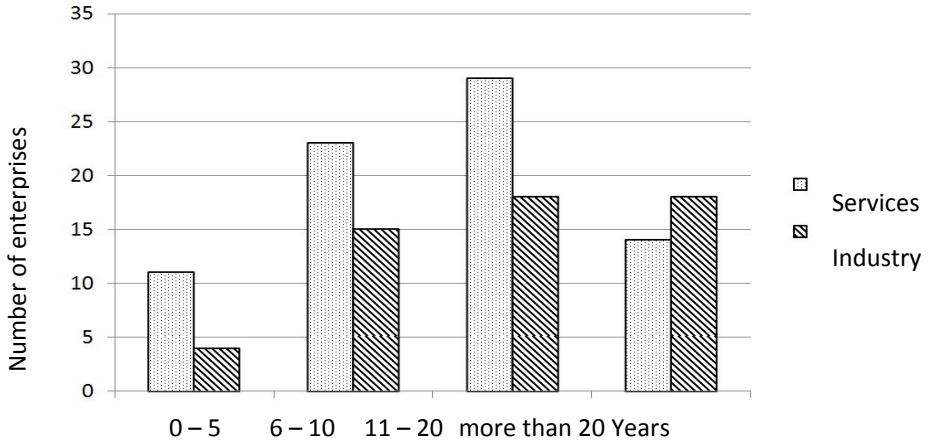


Figure 4. Length of operation in the market of the surveyed entities.
Own elaboration.

The range of impact of their companies, as perceived by entrepreneurs, is as follows: six entrepreneurs strongly believe that their business permanently goes beyond the country. Main recipients are Czechs and Ukrainians. Fifteen enterprises declared the country as their dominant area, while stipulating that going beyond borders with their products/services is not uncommon. However, the majority (one hundred and eleven micro-enterprises) are entrepreneurs operating regionally or locally. In their case, a clear assignment to a local or regional category was often not a clear-cut matter and the final division into these categories (regional reach - forty-nine, local - sixty-two entrepreneurs) is very indicative. Graphically, the range of impact of the surveyed enterprises is shown in Figure 5.

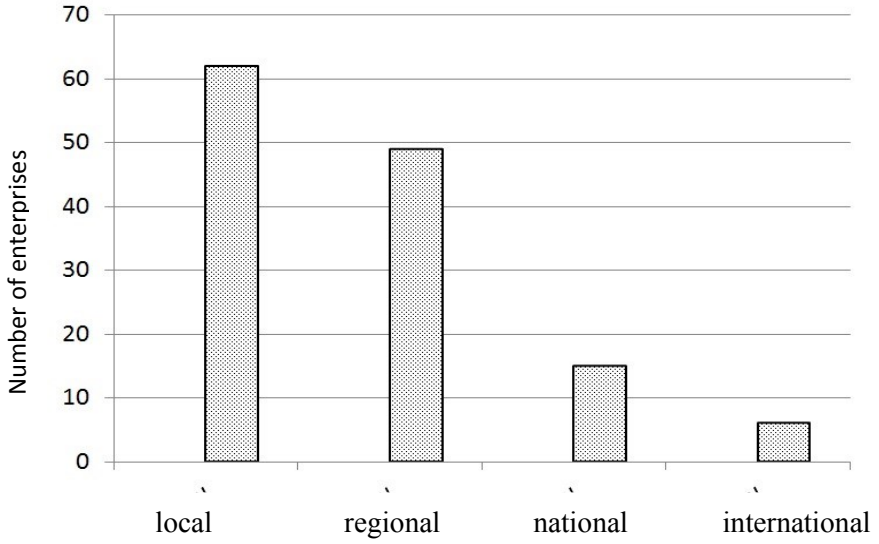


Figure 5. Primary reach of micro-enterprises surveyed.
Own elaboration.

None of the micro-enterprises surveyed have suspended operations since the coronavirus pandemic began in 2019, while those that ceased operations during the pandemic (Michalski, 2022) were not considered in the survey.

A certain impediment to working out the position of a micro-enterprise in the market is financing from own resources (Smolarek, Dzieńdziora, 2011; Siuta-Tokarska, 2008). During the period studied, only thirty companies used external sources of funding. The others declared that their activities are financed from their own resources. Two entities are supported by a bank loan. However, it should be noted that the loan was granted prior to the studied period. The use of the loan was recorded by these two enterprises in the survey under the item "other external resources." Eleven entities used non-financial external support in the form of training. Eighteen micro-enterprises were interested in professional advice, eleven of which were the same companies that took part in the training.

Non-financial support was mainly used by service entrepreneurs. Among those interested in the training, there were three representatives of enterprises that have been operating for 1-5 years, five entrepreneurs whose companies have been operating for 5-10 years and two that have been operating for 10-20 years. From the manufacturing sector, only one entrepreneur was interested in this type of support, whose micro-enterprise has been in the market for 5-10 years. Professional advice was used by fifteen service companies (four operating for 1-5 years, five operating for 5-10 years, three operating for 10-20 years, and one operating for more than 20 years) and three manufacturing companies (one operating for 1-5 years, two operating for 10-20 years).

The issues discussed are shown in Figure 6.

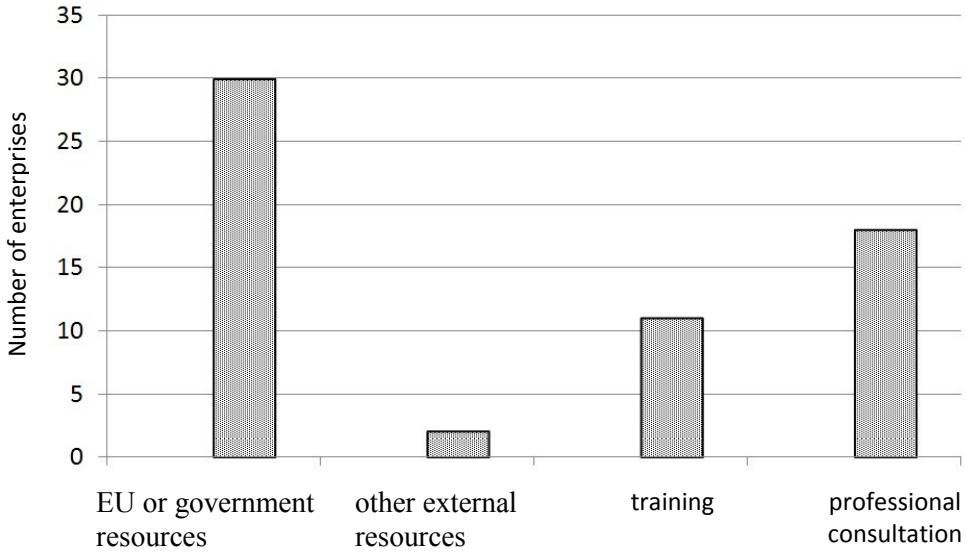


Figure 6. Use of financial and non-financial external support in the period 2019-2022.
Own elaboration.

The issue of the negative impact of certain factors on running a business is presented in Figure 7. Most of the factors mentioned, according to entrepreneurs, have a very negative impact on the operation of the enterprise. Due to high goods/material prices, high prices of energy utilities and fuels, entrepreneurs were forced to suspend purchases and avoid investments in the long term. They focused on necessary expenses and activities generating a quick income. Around 75% of respondents indicated that, on a five-point scale of negative impact, high prices have a negative impact at severity of 4 (sixty-four entrepreneurs), and at severity of 3 (forty-seven respondents). Other responses indicate the impact of severity of 2, 1 and no impact.

Eight of the micro-enterprises surveyed are one-man businesses, focusing on performing IT and software development services. As indicated by the owners of these micro-enterprises, most of the proposed factors did not significantly, or even at all, affect the operation of the enterprise. In the case of the factor related to the necessity to increase the remuneration of

micro-enterprise employees, the "no impact" option is represented by forty-four entrepreneurs. The fact that thirty-four companies are one-man micro-enterprises, which are not affected by the problem of raising the remuneration of co-workers, contributes to this choice. However, these enterprises are characterised by low liquidity. Thus, payments received late are felt strongly. This fact is reflected in the chart: a very strong impact (severity of 4) of late payment on the condition of the entity was declared by forty-three entrepreneurs.

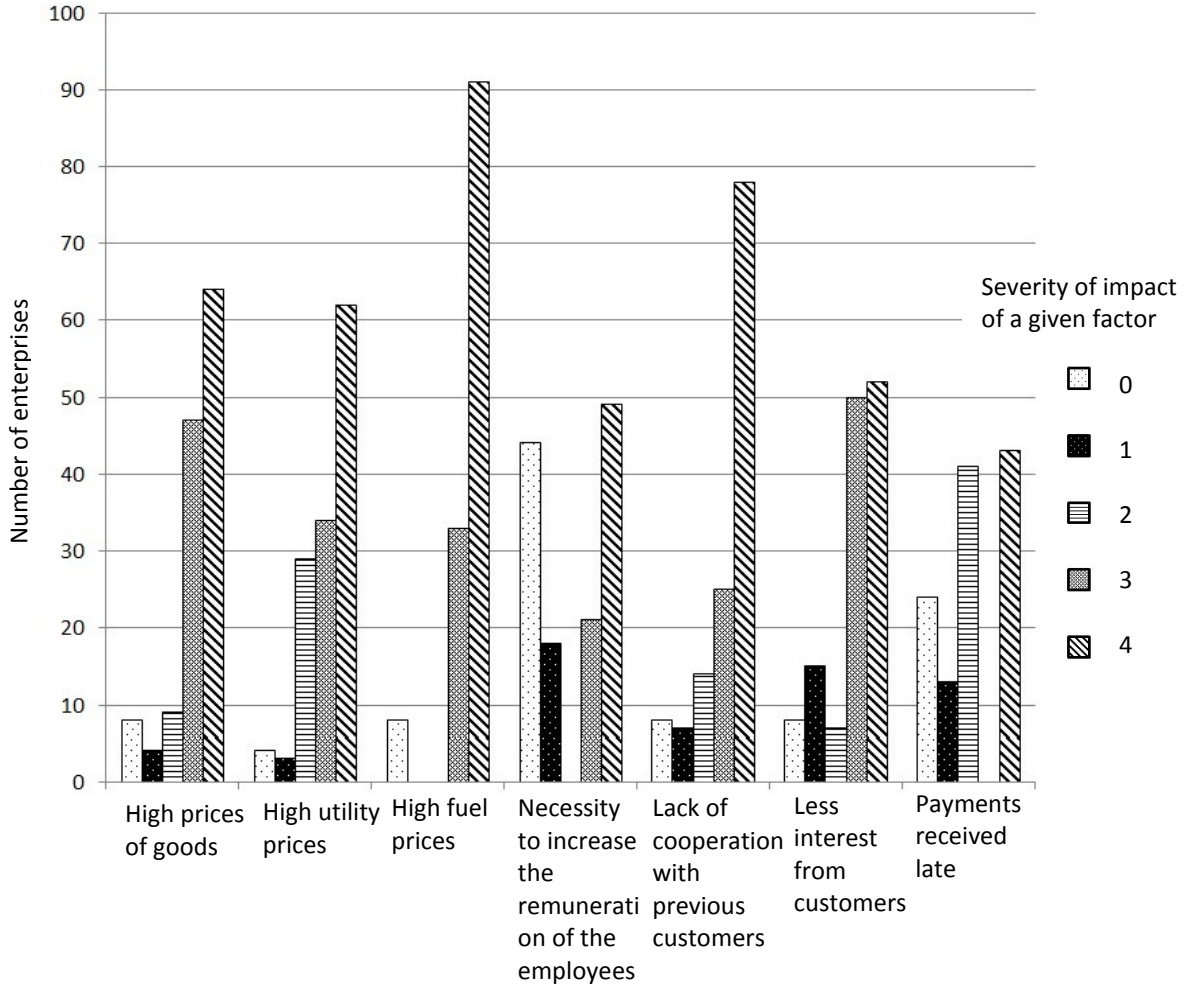


Figure 7. Negative impact of specific factors on the operation of the micro-enterprise.
Own elaboration.

More than a hundred respondents over the course of 2022 noted a clear decrease in the number of orders received, which they regard as an unfavourable factor of high severity (4 - fifty-two entrepreneurs, 3 - fifty owners), hindering the smooth operation of their business. 15% of service providers and 7% of companies with a manufacturing profile had been cooperating continuously with small and medium-sized enterprises for several years, being their subcontractor. The SMEs' own problems have forced some entrepreneurs in this area to suspend cooperation with the surveyed micro-entrepreneurs. Thus, in an indirect way, 29 micro-

enterprises lost some of their existing contractors in 2022. The problem of losing partners and customers who continuously cooperated with micro-enterprises until 2022 is considered by respondents as an unfavourable factor with an impact severity of 4 (seventy-eight owners), and with an impact severity of 3 (twenty-five respondents). Another fourteen micro-entrepreneurs rate the severity of the impact of this factor at 2, for seven it is a problem of low importance - 1, while for eight respondents this issue is not important.

A peculiar problem with running a micro-enterprise is the sudden loss of a complete set of employees who have been working for the entrepreneur for a long time. Examples include four service providers operating in the market for 10-20 years (three micro-enterprises) and more than 20 years (one), employing workers from Ukraine. After the outbreak of war in Ukraine, they voluntarily went to their country to fight the aggressor. Micro-enterprise owners thus faced the loss of a specialised and companionate group of workers.

Delays in receiving payments are perceived as very unfavourable by forty-three respondents. Among them were the aforementioned companies with low liquidity, for which such a delay is a significant problem in staying in the market.

The figure below (Figure 8) shows the structure of the choices and actions taken by entrepreneurs to increase their competitiveness.

Each of the listed activities has been undertaken by entrepreneurs, although the degree of involvement in each category indicates that many do not pursue any activities. Thirty entrepreneurs declared increasing the quality of products/services offered. Fifty-seven entrepreneurs expanded the range of products/services. Twenty-seven owners opted for advertising and marketing activities. Promotions were used by seventy entrepreneurs. An example of a company using this form of customer incentive is a company offering photography services – making copies, prints, scanning negatives.

The entrepreneur has introduced a discount for those ordering the service via the website.

This approach, implemented out of necessity during the pandemic, is now working partially. This is because the increased prices for services (which are a reaction of the entrepreneur to the high costs, mainly of electricity) have caused many regular customers to gradually give up their orders within a few months of 2022, if the orders were not necessary.

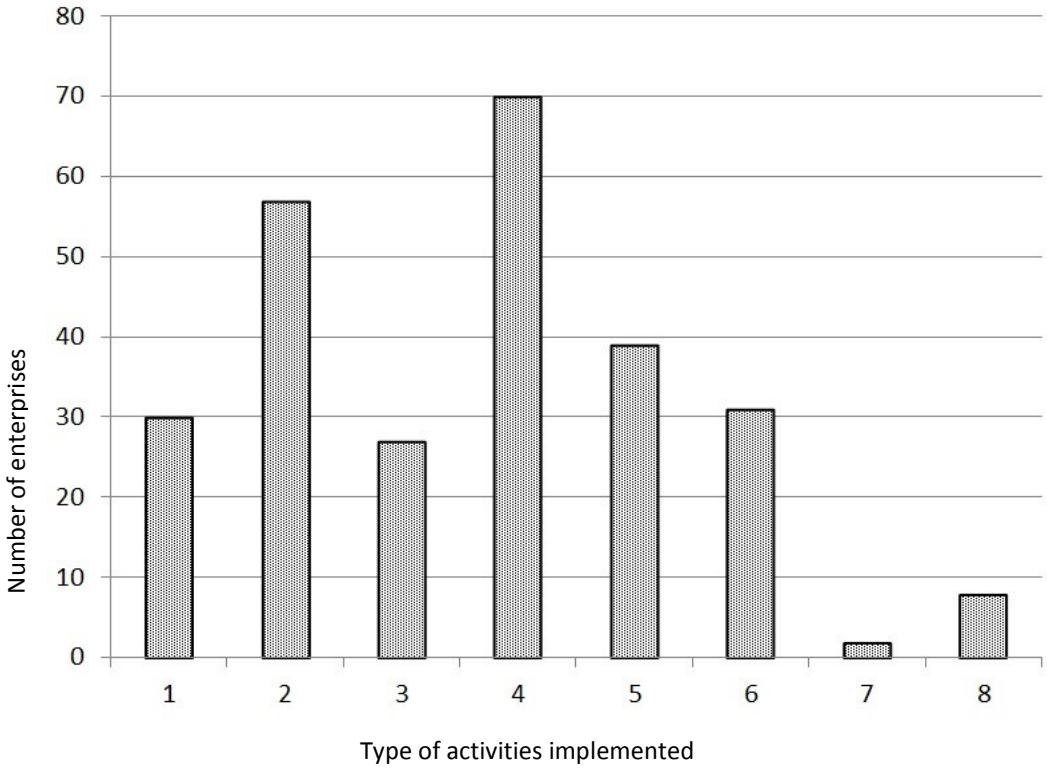
Thirty-nine micro-enterprises adopted the strategy of setting lower prices than the competition. This was done by entrepreneurs who had sufficiently high financial reserves to be able to offer products/services at barely profitable prices for a certain period of time.

Thirty-one entrepreneurs tried new ways to reach customers. They indicated that these were methods developed during the lockdown period, and which work well in the current situation.

Technological innovation were implemented by two entrepreneurs. Eight micro-enterprises owners selected the “other” option. An example of this is outlined below.

One entrepreneur, who has been running an architecture company for more than ten years, pointed out the following practice: when the quality of their service is at the highest level and they are not able to make any improvements, and they cannot afford to reduce the price of the

service, they extend the scope of work within the price agreed with the client for the design (e.g. of a single-family house), and as a bonus, they provide the client with, for example, a garden design or plot plan. As they claimed, they are not an isolated case in doing so and entrepreneurs they know who are engaged in the same activity follow similar practices. In the survey, they put their measures under the heading "other".



Key: 1 – increasing the quality of products/services offered, 2 – expanding the range of products/services, 3 – advertising and marketing activities, 4 – offering promotions, 5 – setting lower prices than competitors, 6 – looking for and implementing other distribution channels, 7 – introducing technological innovations, 8 – other.

Figure 8. Overview of activities implemented to increase the competitiveness of the micro-enterprise. Own elaboration.

The final question asked whether entrepreneurs were undertaking activities that provided them with an income which is alternative to the micro-enterprise in 2022. Among the respondents, only fourteen entrepreneurs were engaged in work that was not related to the activities of their micro-enterprise. The most numerous were entrepreneurs operating in their parent companies between 6 and 10 years (five manufacturing and three service companies). Among entrepreneurs operating up to five years there were two service and one manufacturing company that took up an alternative activity. Among micro-enterprises existing on the market for 11 - 20 years, two manufacturing companies were looking for additional income outside their company, and in the group of entities operating for more than twenty years, there was only one service entrepreneur. The issue discussed is presented in Figure 9.

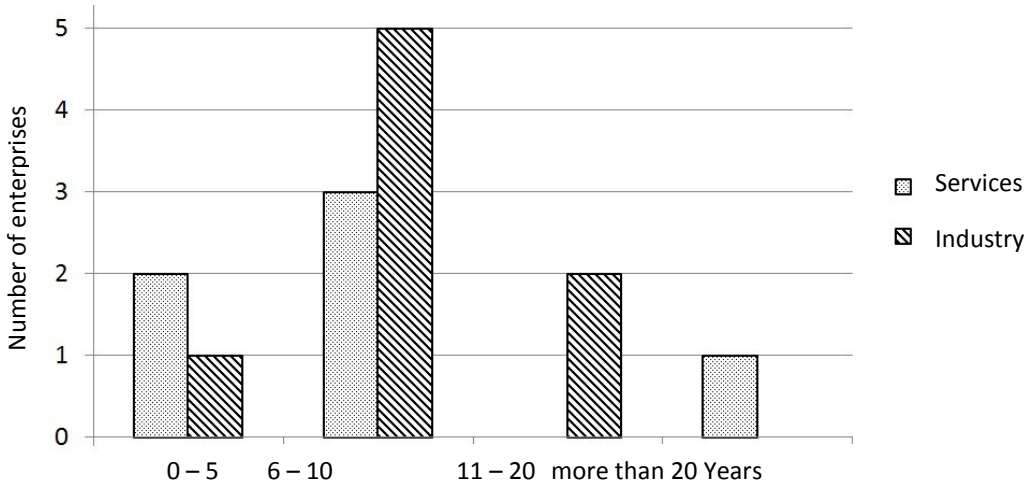


Figure 9. A breakdown of the number of micro-enterprises seeking alternative income in activities outside the parent company.

Own elaboration.

6. Summary

Due to the relatively small research sample, the obtained study results cannot be generalised and treated as a picture of the condition of all micro-enterprises in the Silesian Voivodeship. Further studies, based on a larger research sample, would provide a more comprehensive picture. However, the data collected so far allows us to conclude that entrepreneurs respond in different ways to the difficult situation their micro-enterprises faced after the pandemic and during the following months of 2022. This depends on a number of factors, such as the number of years the company has existed in the market, the degree of specialisation in the area served, flexibility in re-branding (which also depends on the number of employees in the company and their individual predisposition to accept change), or the ability to acquire external financial and non-financial support. These factors make the condition of the micro-enterprises studied not homogeneous.

Acknowledgements

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PRODUCTION MANAGEMENT AS ONE OF THE DIMENSIONS OF THE INDUSTRY 4.0 IMPLEMENTATION

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Objective: In the context of the Fourth Industrial Revolution (Industry 4.0), one of the more frequently discussed topics in the literature is the issue of maturity and readiness to implement Industry 4.0 solutions. The purpose of this article is to collect the dimensions of the implementation of modern technological solutions and to present the developed research tool for the functional area of the enterprise, which is "production management". The presented results are part of a broader research.
Methodology: The research methods consist of a multiple and extensive literature review of maturity models and models of readiness of organizations to implement the concept of Industry 4.0. Based on the review of literature sources, a set of functional areas and dimensions of implementation was collected. Using this data, a proposal for a research tool was developed to systematize the levels of sophistication of the dimensions in specific functional areas of the organization.
Conclusions: The result of the study is a proposal for a research tool for the "production management" area, which will be used to conduct the planned pilot study. This element is the next step in the development of the final research tool verifying the dimensions of Industry 4.0 implementation in the presented functional areas of manufacturing enterprises.
Limitations/indications: Functional areas in manufacturing organizations may vary depending on the specifics of the enterprise. Likewise, the dimensions of Industry 4.0 implementation gathered from literature studies do not represent a closed set. Further studies detailing these aspects are advisable. It is also necessary to carry out a pilot study, based on which it will be possible to correct or confirm the effectiveness of the tool.
Practical implications: The developed survey tool will provide the opportunity to conduct a comprehensive survey in manufacturing enterprises and at the same time can be used when performing self-assessment of the organization at the time of making decisions related to the implementation of modern technologies.
Originality/substantive value: The developed research tool will quickly and effectively allow decision-makers in enterprises to identify the current situation of their organizations, determine the target state and identify competency, technical, and organizational gaps. As part of their own research, it will allow the authors to conduct a pilot study in manufacturing enterprises.

Keywords: Industry 4.0, dimensions of Industry 4.0 implementation, maturity, readiness.

Category: Results of literature findings.

Introduction

Changing political, legal, social, environmental, economic and technological conditions directly affect the way organizations are managed. Dynamics in technological development, combined with the guidelines of Agenda 20230 (A/RES/70/1 Transforming Our World: The 2030 Agenda for Sustainable Development, 2030) for sustainable development presents companies with new challenges. As defined by (Stock, Seliger, 2016) Industry 4.0 is a stage just in the direction of sustainable industrial value creation and its main goal is to connect the real physical world with the digital factory and thus create a Smart Factory (Grabowska, 2021). The Smart Factory provides flexible and adaptive production processes, problem solving and immediate responses to changes and complexity in planning processes.

This paper aims to present and discuss one of the dimensions of the implementation of technological solutions included in the broader issue of Industry 4.0, namely "production management." This study is a continuation of previous literature studies that dealt with the implementation of Industry 4.0 in manufacturing organizations (Michna et al., 2021; Michna, Kruszewska, 2020, 2021, 2022a, 2022b, 2022c) and to address the research gap on tools tailored to the specifics of small and medium-sized organizations, the vast majority of which are still at initial levels of maturity/readiness to implement Industry 4.0 technology solutions (Amaral, Peças, 2021; Schuh et al., 2021). The result of the analysis presented here is the next step in the development of the final research tool to verify the overarching research hypothesis: "It is possible to rank the identified implementation barriers and drivers of Industry 4.0 implementation in terms of the strength of impact on the various dimensions of Industry 4.0 implementation in small and medium-sized manufacturing companies in the automotive industry".

The research discussed in this dissertation was carried out in accordance with the scheme presented in Figure 1, which also includes the summaries used within the framework of this study. The dissertation begins with the definition of functional areas in manufacturing organizations, developed on the basis of requirements collected in the international standard for quality management systems – PN-EN ISO 9001 issued in 2015. Literature research in the subject area of Industry 4.0, models of maturity and readiness for the implementation of modern technological solutions, resulted in the development of a map of the dimensions of implementation of Industry 4.0. Subsequently, the dimensions of implementation were allocated to individual functional areas of the enterprise, which is shown in Figure 2. The area of production management in technical and organizational terms was selected for detailed discussion. In this aspect, the literature was reexamined, this time with a special focus on the issues of organizational maturity related to the production area. The levels of maturity in the implementation of the various dimensions in the production management area were presented as a proposed research tool. Its design is based on the *VDMA Industry 4.0 Toolbox* solution

(Anderl, 2016; Rauen et al., 2016; Chong et al., 2018; Wang et al., 2018; Mohammad et al., 2019). Its main advantage is to visualize the steps – the levels of advancement of the organization in the implementation of a dimension in a specific area. For example: levels of advancement from 1–5, of the dimension "standardization" in the functional area "production management."

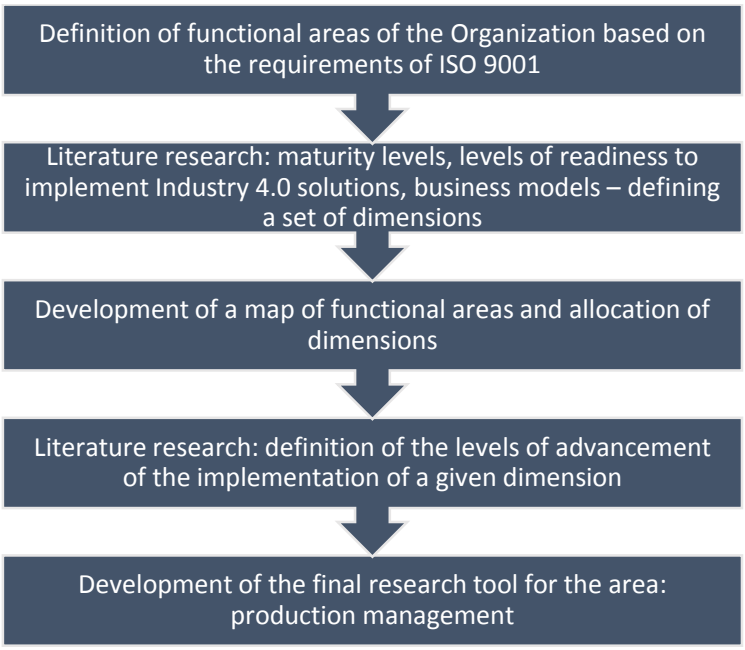


Figure 1. Study plan diagram. Source: Own elaboration.

Dimensions of implementation of Industry 4.0 in functional areas

The requirements for the operation of the organization are collected in the international standard PN-EN ISO 9001:2015 (ISO 9001, 2015). Starting from the location of the organization in the social, economic, legal, environmental, and technological space, through the establishment of the organization's structure, its processes, resources, responsibilities and authority, to operational activities, i.e. production or service delivery, logistics, change management and continuous improvement. Considering the standard's requirement to define the organization's internal processes, manufacturing companies use similar process divisions into: management processes (business management, human resources, quality management system, safety, environment, energy, etc.); core processes (sales, marketing, design, product development, production, logistics, customer service); and support processes (maintenance, IT, purchasing, quality control, finance and accounting). Figure 2 shows the most common processes in manufacturing organizations, which at the same time constitute the functional areas of companies. The nomenclature of the areas used and the division of responsibilities within these areas depends on the specifics, size, and internal decisions of individual enterprises.

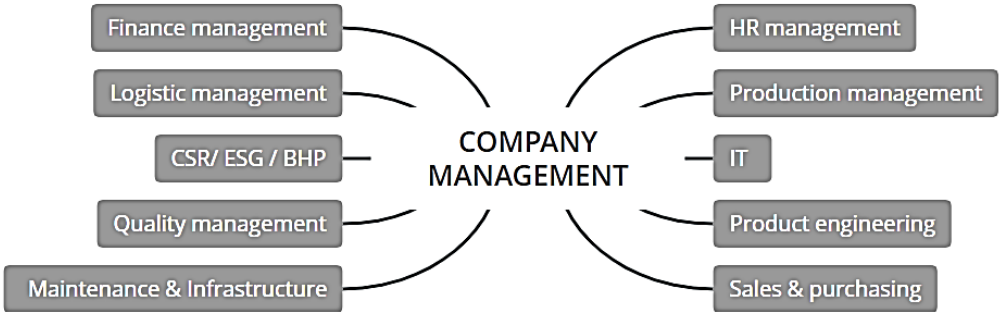


Figure 2. Processes – organizational areas in manufacturing enterprises.

Source: Own elaboration based on (Michna, Kruszewska, 2022c).

The "organization management" process is responsible for the development of business strategy, policies, goals, leadership, performance and development of the company. The "personnel management" process covers all aspects of employees: recruitment, development, training as well as termination. The "OHS" (health and safety) process is responsible for maintaining internal processes so that they are safe for all employees, while the "CSR - ESG" (*CSR – Corporate Social Responsibility, ESG – Environment, Social, Governance*) process focuses the organization's attention on aspects broader than just health and safety and namely elements related to the company's performance and its impact on the environment and society. The "financial management" or "finance and accounting" process deals with budgets, costs, income, assets, current accounts, etc., while the "purchasing" process is responsible for nominating and monitoring suppliers, purchasing components and materials and "sales" is responsible for acquiring new projects and new customers and, of course, selling products and services. The "IT" area includes all services related to IT equipment, installations, cyber security, applications, IT and communications connections and systems. The process most often referred to as "engineering or product design" but also as "product development" or "research and development" includes in its scope product creation, research, functionality verification and product innovation. Production technology and process development itself are usually allocated in the "production", "production management" or "technology" process. The "logistics management" process, on the other hand, is responsible for internal and external material flows, warehousing and shipping. "Quality management" has as its responsibility the supervision of quality systems that comply with industry standards or norms, planning and quality assurance of products and services, while the "maintenance" process deals with all infrastructure, machinery, and tools.

Literature research on maturity models of Industry 4.0 and models of readiness to implement the concept (Michna, Kruszewska, 2022c) resulted in a set of dimensions of Industry 4.0 implementation, which, when assigned to individual areas, form the map shown in Figure 3.

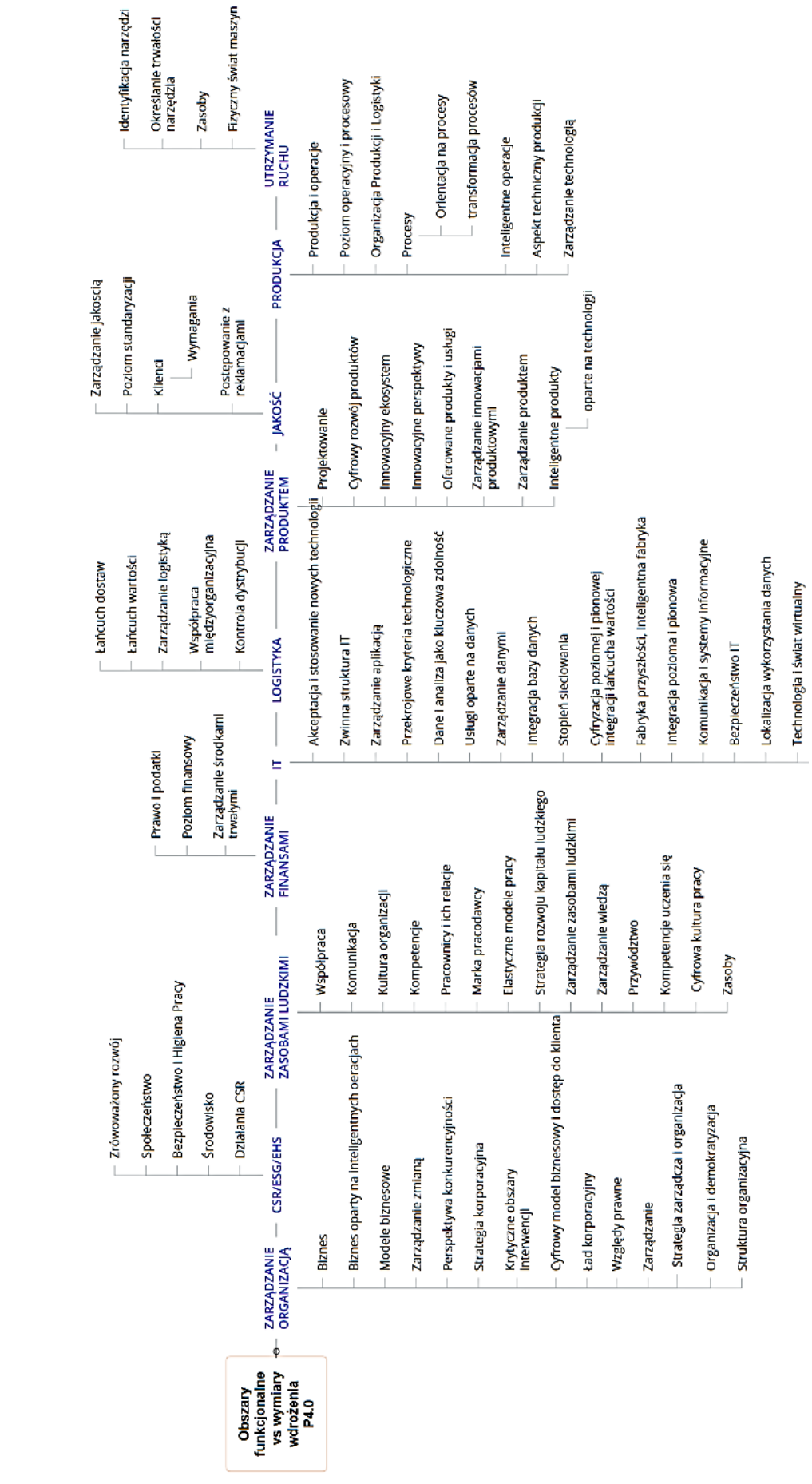


Figure 3. Map of dimensions of Industry 4.0 implementation by functional areas of the organization.
Source: Own elaboration based on (Michna, Kruszewska, 2022c).

In the functional area – "production management", the literature distinguishes such dimensions as production and operations, operational level and processes, production and logistics organization, process orientation, process transformation, intelligent operations, technical aspect of production, technology management. The literature research in terms of the individual requirements for a particular dimension detailed the names and scope of the selected dimensions the result of which is shown in Table 1.

Table 1.
Dimensions from literature sources and their adaptation

Dimensions – literature sources	Dimensions – adjusted description
Production and operations, Process level Production and logistics organization	Production management systems
Operational level	Data
Process orientation	Standardization, Data
Process transformation	M2M/Man2M communication (Machine-to-Machine & Man-to-Machine)
Technological aspect of production	Automation

Source: Own elaboration.

Production management as a dimension of Industry 4.0 implementation

Production management is a concept that combines many aspects, e.g., process management, personnel management, product management, technological aspect (including capabilities and limitations of manufacturing processes and machinery and equipment) and organizational aspect (norms, standards, customer and internal process requirements, visualization tools, work organization, methodologies such as lean management or continuous improvement). The element that binds all these aspects together is data. Data that is necessary for the correct development and planning of processes, data related to the status of the process, the status of the product, its quality, the status of machinery and equipment, their working efficiency, failure rate, etc. Obtaining accurate and real information about the state of the process is very important in the management and development of production systems (Rácz-Szabó et al., 2020). Data allows optimization and improvement of processes, facilitating making decisions and defining improvement actions. These actions include the implementation of Industry 4.0 solutions.

The first of the dimensions discussed in this study – "automation" with its level of implementation and use in the enterprise supports more efficient production, affects the reduction of waste, reduces resources and achieves repeatability of manufacturing processes (Zoubek et al., 2021). Starting with the initial automation of individual manufacturing processes or machining cells (Mittal et al., 2018), through linking machines into system infrastructures including their full control through automation (Agca et al., 2016) all the way to the

phenomenon that is the "lights-out factory" (Zoubek et al., 2021) or a factory in which processes can be carried out with the lights off thanks to automation and robotization. Table 2 shows the collected aspects of automation broken down from the basic level of implementation – 1 to the most advanced level – 5. The scope that goes into each level of sophistication was collected through literature research. The content of each level was linguistically adapted, capturing the translation from English, improving sentence style and optimization enabling future respondents to more easily understand the issue at hand.

Table 2.
Literature sources for the automation dimension

AREA: Production management; DIMENSION: Automation			
#	**Source**	**Source description**	**Adjusted description**
1	(Mittal et al., 2018)	"Single-station automated cells"	1. None or little implementation of automation of production processes – single automated workstations/machining nests. 2. Machines are not/cannot be controlled or managed through automation.
	(Zoubek et al., 2021)	"Lack of implementation in production processes"	
	(Agca et al., 2016)	"Machines cannot be controlled through automation"	
2	(Mittal et al., 2018)	"Automated assembly systems"	1. Basic level of automation of production processes with required participation of workers, e.g., automated assembly systems. 2. Partial connection of production equipment (machines, production lines) with information systems – basic digitization.
	(Zoubek et al., 2021)	"Partial connection of production equipment (machines, production lines) with information systems – basic digitization. Basic automation of production processes with the participation of workers"	
	(Agca et al., 2016)	"Few machines can be controlled through automation"	
3	(Mittal et al., 2018)	"Flexible production system"	1. Some machines and system infrastructure can be controlled through automation. Automated machines and production lines with human collaboration. Communication conducted online. 2. Flexible production system.
	(Zoubek et al., 2021)	"Automated machines and production lines with human collaboration. Communication conducted online"	
	(Agca et al., 2016)	"Some machines and system infrastructure can be controlled through automation"	
4	(Mittal et al., 2018)	"Computer-integrated production system"	1. Most machines and system infrastructure can be controlled through automation. Use of robots to replace workers – process supervision still required. 2. Computer-integrated production system. Machines and production lines autonomously connected.
	(Zoubek et al., 2021)	"Use of robots to replace workers – process supervision still required. Machines and production lines autonomously connected"	
	(Agca et al., 2016)	"Most machines and system infrastructure can be controlled through automation"	
5	(Mittal et al., 2018)	"Reconfigurable production system"	1. Machines and systems can be completely controlled through automation. Highest form of autonomous manufacturing company – fully robotic and autonomous machines; implementation of *"lights-out factory"*. 2. Reconfigurable production system.
	(Zoubek et al., 2021)	"Highest form of autonomous manufacturing company – fully robotic and autonomous machines; implementation of *"lights-out factory"*	
	(Agca et al., 2016)	"Machines and systems can be completely controlled through automation"	

Source: Own elaboration.

The effectiveness of organizations making digital transformation also depends on parallel management improvement, which is related to production management, but also to the management of the entire organization. Investing only in modern technologies without improving management can lead to the opposite of the intended results (Kryukov et al., 2022). Considering the possibilities within production management systems, we have a whole set of tools: from ERP (*Enterprise Resource Planning*) systems – enabling the management of production information at a strategic and financial level, through MES (*Manufacturing Execution System*) systems – systems for managing and monitoring production processes in real time, PPC (*Production Planning and Control*) systems – a tool that enables production planning and monitoring to ensure productivity and efficiency, up to the full compatibility of these systems and common communication and all this to ensure cost minimization and increase efficiency (Chong et al., 2018; Kryukov et al., 2022; Mohammad et al., 2019; Rauch et al., 2020).

Table 3 shows the set of individual levels of sophistication within Production Management Systems.

Table 3.
Literature sources for the production management systems

AREA: production management; DIMENSION: production management systems			
#	**Source**	**Source description**	**Adjusted description**
1	(Rauch et al., 2020)	"No ERP-class system"	1. IT systems are not used for the implementation of production processes or their basic tools are used: computer hardware, MS Office level software. No ERP-class system. 2. Lack of connection of production with other units of the organization.
	(Kryukov et al., 2022)	"IT systems are not used for the implementation of production processes or their basic IT tools are used: computer hardware, MS Office level software"	
	(Anderl, 2016; Rauen et al., 2016; Chong et al., 2018; Wang et al., 2018; Mohammad et al., 2019)	"Lack of networking of production with other business units"	
2	(Rauch et al., 2020)	"ERP system implemented"	1. Systems and services that exclude the presence of paper media are used to implement the production process. ERP-class system implemented – planning system. 2. Exchange of information with other organizational units is performed via mail/telecommunications.
	(Kryukov et al., 2022)	"Systems and services that exclude the presence of paper media are used to implement the process"	
	(Anderl, 2016; Rauen et al., 2016; Chong et al., 2018; Wang et al., 2018; Mohammad et al., 2019)	"Exchange of information via mail/telecommunications"	

Cont. table 3.

3	(Rauch et al., 2020)	"ERP and PPC system. Production planning and control system used to plan material requirements"	1. An automated system tailored to the company's processes and standards is used to implement the production process. Automated management systems are used. ERP and PPC production planning and control systems have been implemented. 2. Information is exchanged with other organizational units through the use of systems, using uniform data and established rules for their exchange.
	(Kryukov et al., 2022)	"This process is executed through an automated business management system. The automated system is tailored to the company's process. The implementation of the process using an automated system is reflected in the company's standards"	
	(Anderl, 2016; Rauen et al., 2016; Chong et al., 2018; Wang et al., 2018; Mohammad et al., 2019)	"Uniform data formats and rules for their exchange"	
4	(Rauch et al., 2020)	"MES or similar system implemented but not integrated with ERP"	1. An MES or similar system is used to implement the production process. However, it is not integrated with ERP. Data analysis is based on large data sets, reports are generated automatically and recommendations are available in real time. 2. Information exchange with other organizational units is carried out through the system, using uniform data and using interdepartmental data servers.
	(Kryukov et al., 2022)	"Automated process services are used to evaluate process implementation results. Activity analysis is based on big data analysis technologies that automatically generate reports and recommendations in real time. Changes to the automated system are planned"	
	(Anderl, 2016; Rauen et al., 2016; Chong et al., 2018; Wang et al., 2018; Mohammad et al., 2019)	"Uniform data formats and interdepartmental data servers"	
5	(Rauch et al., 2020)	"ERP and MES are integrated and communicate with each other"	1. An MES system fully integrated with ERP is used to implement the production process. Integration with external data sources of suppliers and buyers. Use of artificial intelligence systems for forecasting, diagnostics, and recommendations 2. Information exchange with other organizational units is carried out through fully networked and inter-branch IT solutions.
	(Kryukov et al., 2022)	"The efficiency of the company's process is greatly enhanced by automating it. Changing a company's processes is done by changing its automated implementations. Integration with external data sources of suppliers and buyers. Use of artificial intelligence systems for forecasting, diagnostics, and recommendations"	
	(Anderl, 2016; Rauen et al., 2016; Chong et al., 2018; Wang et al., 2018; Mohammad et al., 2019)	"Cross-divisional fully networked IT solutions"	

Source: Own elaboration.

In the area of manufacturing, the maturity of Industry 4.0 should be understood as full integration, in which not only all production equipment (sensors, machines, robots, conveyors, etc.) are connected and automatically exchange data and information with each other, but will also become self-aware and intelligent enough to predict events, control and manage the entire production system (Müller, 2019; Stawiarska et al., 2021). The generation of data, its further processing, storage, visualization, access, and its use in different areas of the organization (Chong et al., 2018; Colli et al., 2019; Grufman, Lyons, 2020) constitute another dimension shown in Table 4.

Table 4.
Literature sources for the data dimension

AREA: production management; DIMENSION: data			
#	**Source**	**Source description**	**Adjusted description**
1	(Stawiarska et al., 2021)	"Data from the components that make up the production system are not generated and processed"	1. The elements that make up the production system do not generate data – thus, data is not processed.
	(Colli et al., 2019)	"Lack of presence of digital data generating assets in the organization"	
	(Grufman, Lyons, 2020)	"No data for further use"	
	(Anderl, 2016; Rauen et al., 2016; Chong et al., 2018; Wang et al., 2018; Mohammad et al., 2019)	"Lack of data processing"	
2	(Stawiarska et al., 2021)	"Data from production systems are exclusively generated and stored"	1. The components that make up the production system exclusively generate and store data. Interfaces exist to access and visualize data for anyone who needs it. 2. Data shall be stored for documentation purposes, visualized and used as needed.
	(Colli et al., 2019)	"Digital processes are in place and working because assets generate digital data". "Interfaces exist to access and visualize data for anyone who needs it"	
	(Grufman, Lyons, 2020)	"Data is used for a few select purposes (greater transparency, etc.)"	
	(Anderl, 2016; Rauen et al., 2016; Chong et al., 2018; Wang et al., 2018; Mohammad et al., 2019)	"Data storage for record-keeping purposes"	
3	(Stawiarska et al., 2021)	"Data from production systems are analyzed to monitor production processes"	1. Data from production systems are generated, processed, and analyzed. Tools exist to process the data, correlate and analyze it, and communicate the results to the user. 2. Data is analyzed and used mainly for monitoring. "Some data is used to optimize production processes (maintenance, predictive actions, etc.)".
	(Colli et al., 2019)	"Tools exist to process the data, correlate and analyze the data and communicate the results to the user"	
	(Grufman, Lyons, 2020)	"Some data is used for process optimization (predictive maintenance, etc.)"	
	(Anderl, 2016; Rauen et al., 2016; Chong et al., 2018; Wang et al., 2018; Mohammad et al., 2019)	"Analyzing data to monitor the process"	
4	(Stawiarska et al., 2021)	"Data from production systems are analyzed and evaluated to plan and control production processes"	1. Data from production systems are generated, processed, analyzed and evaluated to plan and control production processes. There are resources/tools that can operate autonomously according to the information received after the analytical process. 2. Data is used in several areas to optimize, plan and control production processes.
	(Colli et al., 2019)	"There are assets or tools that can operate autonomously according to the information received after the analytical process"	
	(Grufman, Lyons, 2020)	"Data is used in several areas for optimization"	
	(Anderl, 2016; Rauen et al., 2016; Chong et al., 2018; Wang et al., 2018; Mohammad et al., 2019)	"Evaluation for process planning/control"	

Cont. table 4.

5	(Stawiarska et al., 2021)	"Production systems are automatically planned and controlled"	1. Production systems are automatically planned and controlled. "Resources deployed throughout the supply chain can interact and reconfigure themselves to optimize performance" 2. Data is used for comprehensive process optimization.
	(Colli et al., 2019)	"Resources deployed throughout the supply chain can interact and reconfigure themselves to optimize performance"	
	(Grufman, Lyons, 2020)	"Data is used for comprehensive process optimization"	
	(Anderl, 2016; Rauen et al., 2016; Chong et al., 2018; Wang et al., 2018; Mohammad et al., 2019)	"Automatic scheduling/process control"	

Source: Own elaboration.

Table 5 contains a set of elements related to M2M (*Machine to Machine*) machine-to-machine and man-to-machine (Man2M) communication. Such components as infrastructure, machine integration, PLCs (*Programmable Logic Controller*), user interfaces, data processing capability, visualization and use of augmented reality, networking, Internet, industrial Ethernet interfaces that is, data communication standards in industrial automation that allow various devices to be connected over an Ethernet network (Stawiarska et al., 2021), field bus interfaces or data communication standards used to connect devices on a single bus (Mittal et al., 2018; Mohammad et al., 2019), interaction and cooperation between different systems within a single open ecosystem (open system interconnections) are aspects that need to be considered in the M2M or a Man2M communication dimension (Grufman, Lyons, 2020).

Table 5.
Literature sources for the M2M communication dimension

AREA: production management; DIMENSION: M2M communication			
#	**Source**	**Source description**	**Adjusted description**
1	(Grufman, Lyons, 2020)	"The infrastructure of machines and systems cannot be controlled by IT and lack of integration (M2M)". "No exchange of information between the user and the machine"	1. Machine-to-Machine communication No communication. There is no automatic communication between machines and production equipment. Infrastructure of machines and systems cannot be controlled by IT, no integration (M2M), Control by PLC. 2. Man-to-Machine communication No exchange of information between the user and the machine. No data exchange.
	(Mittal et al., 2018; Mohammad et al., 2019)	"No communication". "No exchange of information between the user and the machine"	
	(Stawiarska et al., 2021)	"There is no automatic communication between machines and production equipment". "There is no exchange of information or data in man-to-machine interaction"	
	(Amaral, Peças, 2021)	"PLC-controlled sensors and integrators."	

Cont. table 5.

2	(Grufman, Lyons, 2020)	"Some machines can be controlled by IT, are co-operative or have M2M communication capabilities"	1. Machine-to-Machine communication. PLCs are used, Field Bus Interfaces – connection of devices on a single bus. Devices (sensors, controllers, and IT systems) exchange information and data between each other. Some machines can be controlled by IT, are co-operative or have communication capability. Data processing capability. 2. Man-to-Machine communication. Use of local user interface. Only local exchange of data and information in man-to-machine interaction (e.g., only at a given production site).
	(Mittal et al., 2018; Mohammad et al., 2019)	"Field Bus Interfaces." "Use of local user interface"	
	(Stawiarska et al., 2021)	"Only local exchange of data and information in man-to-machine interaction (e.g., only at a given production site)". "Machines and equipment are equipped with PLCs"	
	(Amaral, Peças, 2021)	"Data processing capability"	
3	(Grufman, Lyons, 2020)	"The infrastructure of machines and systems can be controlled through IT and is partially integrated"	1. Machine-to-Machine communication. The infrastructure of machines and systems can be controlled through IT and is partially integrated. The devices communicate over an industrial Ethernet network. Machines can exchange information. 2. Man-to-Machine communication. Monitoring and control of production processes can be carried out centrally and locally.
	(Mittal et al., 2018; Mohammad et al., 2019)	"Industrial Ethernet interfaces." "Centralized/decentralized production, monitoring/control"	
	(Stawiarska et al., 2021)	"The devices communicate over an industrial Ethernet network." "Monitoring and control of production processes can be carried out centrally and locally"	
	(Amaral, Peças, 2021)	"Machines can exchange information"	
4	(Grufman, Lyons, 2020)	"Machine can be completely controlled by IT, is partially integrated (M2M) or co-operative"	1. Machine-to-Machine communication. The devices have Internet access, can be completely controlled by IT, are partially integrated or co-operative. Open-system interconnections (no need for modification or integration of systems). 2. Man-to-Machine communication. In man-to-machine interaction, mobile devices are used to exchange data and information – mobile user interface.
	(Mittal et al., 2018; Mohammad et al., 2019)	"Machines have Internet access." "Man2M – Using the mobile user interface"	
	(Stawiarska et al., 2021)	"Machines and devices have Internet access". "Mobile devices are used to exchange data and information in man-to-machine interaction"	
	(Amaral, Peças, 2021)	"Open system interconnections"	
5	(Grufman, Lyons, 2020)	"Machines and systems can be controlled almost entirely by IT and are fully integrated (M2M)"	1. Machine-to-Machine communication Machines and systems can be controlled almost entirely by IT, are fully integrated and communicate with each other through network services and M2M software. Use of systems to control open systems. 2. Man-to-Machine communication. Assistive software, augmented reality, etc., are used to exchange data and information.
	(Mittal et al., 2018; Mohammad et al., 2019)	"Internet service (M2M software)". "Man2M – augmented and assisted reality"	
	(Stawiarska et al., 2021)	"Machines and devices communicate with each other through network services, Machine to Machine (M2M) software". "Man-to-machine interaction uses assistive software, augmented reality, etc., to exchange data and information"	
	(Amaral, Peças, 2021)	"Open systems control system"	

Source: Own elaboration.

The last dimension selected for this study is "Standardization" – Table 6. This dimension includes issues related to the Lean Management concept, quality management and maintenance management. These three issues combine the requirements of maintaining work standards, meeting organizational and customer requirements and continuous process improvement. Concepts and tools such as MRO (*maintenance, repairs, and operations*) or, in short, a collection of various activities related to the upkeep and maintenance of machinery and equipment, as well as their repair and improvement, to ensure smooth and efficient operation (Zoubek et al., 2021), whether CMMS (*Computerized Maintenance Management System)* or, on the other hand, QMS (*Quality Management System*) (Kumar et al., 2020) along with a full range of standardized processes, just as the broad area of Lean Management (Maasouman, Demirli, 2015) are a representation of the elements included in the sophistication within the latter dimension.

Table 6.
Literature sources for the Standardization dimension. Source: Own elaboration.

AREA: production management; DIMENSION: standardization			
#	**Source**	**Source description**	**Adjusted description**
1	(Zoubek et al., 2021)	"Lack of MRO implementations (maintenance, repairs, and operations)". "Basic monitoring. Minimization of unnecessary movement and ease of transportation. Proper (including use of natural) lighting and ventilation."	1. UR – Basic monitoring of machinery and equipment, no MRO (maintenance, repairs, and operations) implementations. 2. Lack of Lean Management initiatives. 3. Quality 1.0 Self-Monitoring.
	(Maasouman, Demirli, 2015)	"Lack of Lean initiatives"	
	(Caballero et al., 2008)	"Information quality (IQ) management objectives have not been defined"	
	(Kumar et al., 2020)	"Quality 1.0 Self-Monitoring"	
2	(Zoubek et al., 2021)	"Small CMMS implementation, maintenance processes focused on functionality. A paperless maintenance management system"	1. Small CMMS implementation, maintenance processes focused on functionality. A paperless maintenance management system. 2. Lean Management principles are understood by the Organization. 3. Quality 2.0. Inspection/control/ assurance/standards. Repeatability of conducting internal processes.
	(Maasouman, Demirli, 2015)	"Lean initiatives have resulted in an understanding of Lean principles"	
	(Caballero et al., 2008)	"The information management system (IMP) has been defined and planned. The process is therefore repeatable"	
	(Kumar et al., 2020)	"Quality 2.0 Inspection/control/ assurance/military standards"	
3	(Zoubek et al., 2021)	"MRO implemented. Mainly through the use of CMMS and other business information systems"	1. MRO principles are implemented; CMMS or other business information systems are used. 2. Lean initiatives have led to the implementation of Lean Management principles. 3. Quality – management systems have been implemented.
	(Maasouman & Demirli, 2015)	"Lean initiatives have resulted in an implementation of lean principles"	
	(Caballero et al., 2008)	"IMP's integrated information management system is defined and aligned with IQ requirements. As a result, the process can be managed in accordance with the organizational policy on IQ".	

Cont. table 6.

4	(Zoubek et al., 2021)	"Level 3 + Implementation of artificial intelligence (AI), use of online sensors, dashboards"	1. Artificial intelligence, online sensors - Internet of Things - are being used in maintenance operations. 2. Lean initiatives lead to continuous improvement in the production area and to improve the lean tools and principles used. 3. Quality 3.0 Software is used to manage quality improvement and quality planning. Implemented management systems function and are constantly improved.
	(Maasouman, Demirli, 2015)	"Lean initiatives have resulted in the improvement of lean principles"	
	(Caballero et al., 2008)	"Information management processes are integrated, and plans for obtaining them are developed and automated. Thus, IMP can obtain repeatable and reliable data"	
	(Kumar et al., 2020)	"Quality 3.0 Software for quality management, improvement and planning"	
5	(Zoubek et al., 2021)	"Completely implemented in MRO. Big data and predictive maintenance as catalysts for performance improvement"	1. Completely implemented MRO. CMMS systems are used. Big data analytics are used for predictive action. Continuous efficiency improvements. 2. Lean initiatives lead to improvements in the production area and the consolidation of lean principles. Lean Management principles are built into the Organization Management System. 3. "Quality 4.0 – Continuous quality through real-time data and IoT."
	(Maasouman, Demirli, 2015)	"Lean initiatives have resulted in the stability of lean principles"	
	(Caballero et al., 2008)	"IMP optimization is managed quantitatively, and measures are used to improve its performance. Thus, the process is subject to continuous improvement"	
	(Kumar et al., 2020)	"Quality 4.0 Continuous quality through real-time data and IoT"	

The different levels in the tables above have been developed in such a way that it is possible to build a research tool. The target matrix is based on the "Toolbox" concept (Anderl, 2016; Rauen et al., 2016; Wang et al., 2018; Chong et al., 2018; Mohammad et al., 2019). Its design makes it possible to depict different elements and stages of development organized in a sequence from low level to high sophistication within a given dimension. The strength of this tool is the easy identification of progress and competence within the organization according to the selected areas and their dimensions (Anderl, 2016; Wang et al., 2018). Figure 4 shows an example of the "Toolbox' for the "business model" area and the "quality improvement" dimension (Wang et al., 2018). In this case, Level 1 is manual quality control, Level 2 is automatic quality control, Level 3 is real-time control through connection to monitoring sensors, Level 4 implies a knowledge-based process for detecting error patterns, and Level 5 is automatic intervention in the process. By rearranging the information in such a clear and obvious way, one can quickly recognize the severity of an issue.

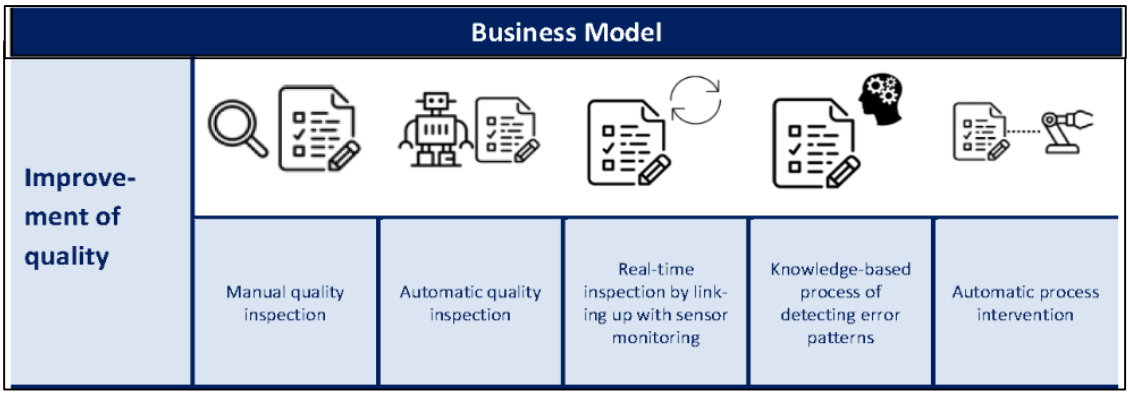
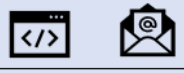


Figure 4. Example of Toolbox for a business model.

Source: Y. Wang, T. Tran, R. Anderl, Toolbox Approach for the Development of New Business Models in Industrie 4.0. WCECS 2018, II.

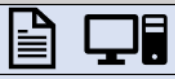
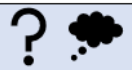
Based on all of the above data and the information collected, a matrix of levels of sophistication of dimensions within the "production management" area was developed. Here, Levels 1 through 5 also determine the sequence of sophistication within an issue. Tables 7-9 will present the final matrices along with the dimensions: automation, production management systems, data, M2M communication, standardization; and the levels developed based on the literature research conducted.

Table 7.
Level matrix: area – production management, dimensions – automation and production management systems

Area	Dimension	Level 1	Level 2	Level 3	Level 4	Level 5
PRODUCTION	AUTOMATIZATION					
		1. Lack of process automatization or little implementation of automation at the production area - single automated workstations / machining cells. 2. Machines are not / cannot be controlled through automation.	1. Basic degree of automation of production processes with required participation of employees, e.g. automated assembly systems. 2. Partial connection of production equipment (machines, production lines) with information systems - basic digitization.	1. Some machines and system infrastructure can be controlled through automation. Automated machines and production lines with human cooperation. Communication carried out online. 2. Flexible production system.	1. Most machines and system infrastructure can be controlled through automation. Use of robots to replace employees - process supervision still required. 2. Computer-integrated production system. Machines and production lines are autonomously connected.	1. Machines and systems can be completely controlled through automation. The highest form of autonomous manufacturing company - fully robotic and autonomous machines; implementation of a "lights-out factory." 2. Reconfigurable production system.
PRODUCTION	PRODUCTION MANAGEMENT SYSTEM					
		1. IT systems are not used for the implementation of production processes or their basic tools are used: computer hardware, MS Office level software. Lack of ERP-class systems. 2. No connection of production with other units of the organization.	1. Systems and services that exclude the presence of paper media are used to implement the production process. An ERP - planning system has been implemented. 2. Information exchange with other organizational units is carried out by mail / telecommunications.	1. An automated system tailored to the company's processes and standards is used to implement the production process. Automated management systems are used. ERP and PPC - production planning and control systems have been implemented. 2. Information exchange with other business units is carried out using the systems, using uniform data and established rules for their exchange.	1. An MES or similar system is used to implement the manufacturing process. However, it is not integrated with ERP. Data analysis is based on large data sets, reports are generated automatically and recommendations are available in real time. 2. Information exchange with other business units is done through the system, using uniform data and using interdepartmental data servers.	1. An MES system fully integrated with ERP is used to implement the manufacturing process. Integration with external data sources of suppliers and customers. Use of artificial intelligence systems for forecasting, diagnostics and recommendations. 2. Information exchange with other business units is carried out through fully networked and inter-branch IT solutions.

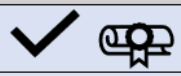
Source: Own elaboration.

Table 8.
Level matrix: area – production management, dimensions – data and M2M communication

Area	Dimension	Level 1	Level 2	Level 3	Level 4	Level 5
PRODUCTION	DATA	 1. The elements that make up the production system do not generate data - thus data is not processed.	 1. The components that make up a production system exclusively generate and store data. There are interfaces to access and visualize the data for anyone who needs it. 2. Data is stored for documentation purposes, visualized and used when needed.	 1. Data from production systems is generated, processed and analyzed. Tools exist to process the data, correlate and analyze it, and communicate the results to the user. 2. Data is analyzed and used mainly for monitoring purposes. Some data is used to optimize production processes (maintenance, predictive actions, etc.).	 1. Data from production systems are generated, processed, analyzed and evaluated to plan and control production processes. There are resources/tools that can operate autonomously according to the information received after the analytical process. 2. Data used in several areas to optimize, plan and control production processes.	 1. Production systems are automatically planned and controlled. "Resources deployed throughout the supply chain can interact and reconfigure themselves to optimize performance. 2. Data is used for end-to-end process optimization.
PRODUCTION	COMMUNICATION M2M	 1. Machine-to-machine communication. Lack of communication. There is no automatic communication between machines and production equipment. Infrastructure of machines and systems cannot be controlled by IT, No integration (M2M), Control by PLC. 2. Human-machine communication Lack of information exchange between user and machine. Lack of data exchange.	 1. Machine-to-Machine Communication. PLCs are used, Field Bus Interfaces-connection of all devices on a single bus. Devices (sensors, controllers and IT systems) exchange information and data between each other. Some machines can be controlled by IT, are co-operative or have communication capability. Data processing capability. 2. Human-Machine Communication. Use of local user interface. Only local exchange of data and information in human-machine interaction (e.g., only at a particular production site).	 1. Machine-to-Machine Communication. The infrastructure of machines and systems can be controlled via IT and is partially integrated. Machines communicate via an industrial Ethernet network. Machines can exchange information. 2. Human-Machine Communication. Monitoring and control of production processes can be carried out centrally and locally.	 1. Machine-to-Machine Communication. Devices have Internet access, can be completely controlled by IT, are partially integrated or co-operative. Open-system interconnections (without the need for modification or integration of systems). 2. Human-Machine Communication. Human-machine interaction uses mobile devices to exchange data and information - mobile user interface.	 1. Machine-to-Machine Communication Machines and systems can be controlled almost entirely by IT, are fully integrated and communicate with each other through network services, M2M software. System for controlling Open systems. 2. Human-Machine Communication. Assistive software, augmented reality, etc. are used to exchange data and information.

Source: Own elaboration.

Table 9.
Level matrix: area – production management, dimensions – standardization

Area	Dimension	Level 1	Level 2	Level 3	Level 4	Level 5
PRODUCTION	STADARDIZATION					
		1. UR - Basic monitoring of machinery and equipment, lack of MRO (maintenance, repair and operations) implementations. 2. Lack of Lean Management initiatives. 3. Quality 1.0 - Self-Monitoring,	1. Small CMMS implementation, maintenance processes focused on functionality. Paperless maintenance management system. 2. Lean Management principles are understood by the Organization. 3. Quality 2.0 Inspection / control / assurance / standards. Repeatability of running internal processes.	1. MRO principles are implemented; CMMS or other business information systems are used. 2. Lean initiatives have led to the implementation of Lean Management principles. 3. Quality - management systems have been implemented.	1. Artificial intelligence, online sensors - the Internet of Things - are being used in maintenance activities. 2. Lean initiatives lead to continuous improvement in the production area and improvement of the lean tools and principles used. 3. Quality 3.0 Software is used to manage quality improvement and quality planning. The implemented management systems are functioning and being improved.	1. MRO has been fully implemented. CMMS systems are being used. Big data analytics are used for predictive action. Continuous improvement in efficiency. 2. Lean initiatives are leading to improvements in the production area and the consolidation of lean principles. Lean Management principles are embedded in the Organization Management System. 3. Quality 4.0 - Continuous quality through real-time data and IoT- Internet of Things.

Source: Own elaboration.

Summary

Industry 4.0 solutions are intended to optimize and streamline processes, give the ability to manage them in real time and on the basis of real and available data, so that, as a result, production processes can be realized faster, production batches can be adapted more flexibly to changing customer requirements and the economic situation of the environment (Wang et al., 2018). Changes concerning the production area in terms of modern technological solutions are inevitable and ubiquitous. However, the variation depending on the size of the organization and the business sector means that the access, capabilities and use of Industry 4.0 solutions are not homogeneous (Amaral, Peças, 2021). Designed, based on detailed literature research, the tool illustrates the elements and stages of implementation of each dimension within the "Production Management" area. Designed for use in small and medium-sized enterprises, it fits into the aforementioned research gap. A further elaboration of the levels of implementation of Industry 4.0 solutions in the other functional areas of the organization listed above, along with their implementation dimensions, will provide the opportunity to conduct a comprehensive study. This tool can also be successfully used in the future when performing a self-assessment of the organization at the time of making decisions related to the implementation of modern technologies, while allowing the generation of new ideas. Given the limitations of this tool (number and selected functional areas, and selected dimensions), it is necessary to carry out a pilot study on the basis of which guidelines will be developed for its possible correction and improvement.

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ADAPTATION OF THE SCHOOL COMPUTER LAB TO THE CONDITIONS OF EDUCATING PERSONS WITH SPECIAL EDUCATIONAL NEEDS IN THE POLISH EDUCATIONAL SYSTEM – A CASE STUDY

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Purpose: The aim of the research was to develop a concept of adapting the working environment of a computer lab of a selected high school, to the individual developmental and educational needs and psychophysical capabilities of its students. The adaptation activities included the adaptation of the room and the equipment of the lab for conducting classes with young people with different educational needs.
Design/methodology/approach: Recognition in terms of the needs and opportunities of the young people was made on the basis of the experiences that the author of this article gained during independently conducted classes and through lesson observations. The study lasted 180 lesson periods. It covered only classes in the subject of computer science, which were held using the computer workstations of the school's computer lab. It was conducted in the 2021/22 school year on a representative sample of sixth class students for which the percentage of those with special educational needs (SEN) was at least 15%. The full spectrum of special education needs was achieved by including the following young people in the study: persons with vision impairment, hard-of-hearing students, students with mobility disability, particularly gifted students, students having learning difficulties and adaptation difficulties related to the change of educational environment, including previous education in Ukraine.
Findings: The author proposed that the modification of the educational process taking place in the computer lab of the selected school should include a change in organization by dedicating permanent workstations to selected students and improving the conditions for the implementation of education by retrofitting the lab with new teaching resources in the form of: additional screens and large scale projectors, dedicated software and by upgrading the lighting.
Research limitations/implications: It is advisable to re-diagnose the educational difficulties of the young people of the selected high school, carried out after the implementation of the proposed measures. This research will make it possible to confirm the effectiveness of the solutions applied and to identify new barriers that will accompany the next generation of the student community in the process of learning computer science.
Practical implications: The submitted proposal for change is a concept for the implementation of the authorization contained in the Education System Act, which obliges the teacher to undertake individualized pedagogical actions. This approach embodies the idea of making educational opportunities equal for young people and is an implementation of the principles of inclusive education.

Social implications: The targeting of adaptation measures is particularly important for those who have been diagnosed with developmental disorders and deviations or difficulties that make it impossible to meet the requirements of the general education core curriculum.
Originality/value: The approach presented in this article makes it possible to prevent secondary disorders of the emotional-motivational sphere of students.

Keywords: special educational needs, adaptation, computer lab.

Category of the paper: conceptual paper, case study.

1. Identification of the problem

The student body of the selected high school is characterized by diversity in terms of skills and psycho-physical predispositions related to the use of IT tools. In order to reveal the potential dormant in young people and to achieve harmony in their emotional development, it is required to provide various forms of student support during computer science lessons. In view of the above, the author of the study noted that it is required to adapt the interior architecture of the room in which the computer science lessons take place, and to prepare additional teaching resources that strengthen the activization of the interaction behaviors. These measures are particularly important for those who have been diagnosed with developmental disorders and deviations or difficulties that make it impossible to meet the requirements of the general education core curriculum. This approach embodies the idea of making educational opportunities equal for young people and is an implementation of the principles of inclusive education. It fosters the creation of a space around the student which integrates the school environment and shapes social awareness in terms of overcoming prejudice, discrimination, exclusion or segregation. It is the implementation of the authorization contained in Article 44b(8)(1) of the Act of 7 September 1991 on the educational system (Journal of Laws of 2020, item 1327, as amended), which was made more specific by the Regulation of the Minister of National Education of 22 February 2019 on the assessment, classification and promotion of pupils and students in public schools (Journal of Laws of 2019, item 373). It obliges the teacher to take individualized pedagogical measures that result from the diverse educational needs and psychophysical capabilities of students fulfilling schooling obligation during both compulsory and supplementary educational classes.

2. Genesis and dynamics of the phenomenon

As part of the professional work carried out by the author of the present study in a public high school, she was entrusted with tasks of conducting computer science classes as a computer

science teacher. She also undertook ad hoc substitutes, organized extra-curricular activities and supported other teachers in the use of multimedia and information technology. All teaching activities at this school were carried out by her using computer stations in the computer lab. In addition to conducting classes herself, she also supervised the lessons conducted by other teachers using the equipment of this lab. The experience gained both at the high school in question and during her earlier work enabled her to analyze and evaluate the factors shaping the student work environment in the computer lab of the selected high school.

The research in identifying the developmental and educational needs and psycho-physical abilities of the students was carried out in the school year 2021/22 on a selected sample of sixth class students for which the percentage of SEN students was at least 15%. The author ensured that the sample included not only representatives with a certificates of special education needs issued due to a disability or those at risk of social maladjustment. The full spectrum of special education needs taking place in this lab was achieved by including the following young people in the study: persons with vision impairment, hard-of-hearing students, students with mobility disability, particularly gifted students, students having learning difficulties and adaptation difficulties related to the change of educational environment, including previous education abroad, for example in Ukraine. The selected high school is not attended by individuals with developmental disorders in the form of deafness and blindness, and, therefore, the requirements taking into account these special educational needs will be omitted in the research conducted. However, it should be clearly emphasized that the list of young people's individual educational and developmental needs presented above is not closed. This is because in accordance with the Regulation of the Minister of National Education (Journal of Laws 2020, item 1280), psychological and pedagogical assistance should be provided depending on the recognized needs of adolescents, and the changing socio-economic conditions may indicate the emergence of even other types of needs than those already listed (Rafał-Łuniewska, 2021c). In view of the above, adolescents who were in the process of an ongoing diagnosis of their situation or an ongoing diagnosis of potential, difficulties and interests were also surveyed (Knopik, 2018). In addition, students whose parents/legal guardians did not agree to provide their child with psychological and pedagogical assistance at school were examined. It should be mentioned that the forms of such assistance are, among others, didactic and compensatory classes, counseling and consultations, but also classes developing students' special talents (Jas and Jarosińska, 2015; Leśniewska et al., 2015).

The site of the observations and practical activities carried out was the computer lab of the selected public high school supervised by the Silesian Education Authority in Katowice. The lab is located in the basement of the building, right next to the school's technical rooms and the gym. It has a considerable floor space and a high ceiling. On one of its walls, which forms the south-eastern part of the building's façade, hinged basement windows have been installed and secured with a grate. Their lower edge is more than 2 meters from the ground. The windows face directly onto the pavement of a busy street and provide constant light to the

interior. As the sunlight penetrating through them heats the room intensively, horizontal blinds were installed on the windows. Unfortunately, these windows are not used to ventilate the lab due to the road noise coming from the outside.

The lab is equipped with computer workstations, each of which is a separate student workspace (Figure1). Each station has a desktop computer with a monitor, keyboard and mouse. The workstations are connected with Internet access network and equipped with teaching software enabling the implementation of the core curriculum. All workstations have been interconnected to form one large office area. This was achieved by arranging paired desks facing each other. When the students enter the classroom, they are seated along the two longer edges of the table. The free walking space runs along the walls. There is no furniture or fitted wall shelves behind the students' backs to obstruct access to the individual workstations. Structured cabling, including the power supply, is concealed under the top of the desks. A computer station dedicated to the teacher was placed at one end of the long table, right at the exit. It is connected to a multimedia projector, which provides an additional aid for presenting issues and teaching. A whiteboard was hung on the wall behind the teacher's back. A projector screen was placed on the opposite wall of the room. It is made of frosted glass; at the same time it is a partition wall in the server room. It houses, among others, sound equipment and a central unit for sharing data resources. Two types of fluorescent lamp lighting fixtures were used in the room: ceiling and wall-mounted ones. Both have moderate directionality and limited luminance. The wall-mounted ones were installed in the area opposite the windows and above the whiteboard. The lab does not have directional lighting aimed directly at the working surface of the desks.

In summary, the designed space of the school's computer lab allows each student to work independently at a separate workstation. It is also possible to maintain eye contact between peers, which encourages direct communication and, therefore, the exchange of information and the sharing of knowledge or ideas with others. The positioning of the individual computer workstations and the location of the furniture in the room make it possible to confirm that the free walking space in the room is ensured, as well as the free access to each of the workstations and the shared associated rooms is possible. It can also be concluded that the installation of structured cabling together with the power supply system of the computer room ensure the safe use of the connected equipment, and that the desks and chairs furnishing the lab are adapted to the anthropometric conditions of students and their needs resulting from disabilities (Journal of Laws of 1997 no. 129, item 844: § 24, Journal of Laws 2021, item 2088).

However, an element that needs improvement is the way in which the teacher communicates with the students, which includes both the presentation of issues using the projector and the teacher's supervision of the students' achievements.

It should be noted that the image projected on the projector screen is unreadable. This is due to the fact that the screen was created with decorative glass with a milky surface. It does not allow full color contrast and the images projected on it are blurred. The use of a glass

partition wall as a screen is an aesthetically pleasing solution, but not entirely practical. In addition, the positioning of the workstations means that the image is partially obscured for a large group of people. The projection area is obstructed both by monitors of other workstations and peers sitting closer to the screen. This is because the screening takes place from a side i.e. to the left or right of the workstation occupied by the student. The most limited visibility of the projector screen is for students sitting right next to the teacher's workstation, for whom it is at the other end of the room. Students occupying these workstations may also find it difficult to see the detail in the graphics displayed and to read the text in smaller font on the slides presented by the teacher. Particularly troublesome, however, is the concurrent student-teacher work carried out using the software functionality discussed during class. More often than not, it involves familiarizing the students with a particular way of doing things and with the appearance of the system windows. It forces the student to simultaneously undertake an activity connected with watching the shared screen and an independent activity within the application, being about repeating the tasks after the teacher. The current arrangement of the lab space is not conducive to this form of work. It restricts the student's ability to keep up with how difficult tasks are being solved and to constantly compare his or her progress with the teacher's operations being demonstrated. Although the demonstration is accompanied by an oral message in the form of the teacher's explanations, the lack of coupling of the verbal message with the graphic one slows down students' learning process. In addition, this situation lowers the level of focus of young people, often demotivates them and increases the variability of skills by excluding less skilled or more withdrawn learners from active participation. However, as there is a lot of free space in the classroom and the workstations are equipped with swivel chairs, when new content is presented, students can move freely while watching a film or animation, finding a space with a better view of the projector screen. Unfortunately, the lack of computer workstations located close to the teacher and with a good view of the projection screen area indicates that it is necessary to implement changes to the multi-format multimedia projection in this room. This is because maintaining eye contact with the teacher and free access to the graphical form of the content presented is particularly important for young people with special educational needs.

The second area for improvement is the way in which the teacher supervises the learning progress of their students. In order to increase the effectiveness of teaching, it is crucial that the teacher repeatedly verifies the correct understanding of the instructions given and tasks performed by the student. The arrangement of the classroom space allows the teacher to simultaneously supervise the behavior of all class participants, however, the view of the screens of individual workstations is significantly impeded. The monitors face the side walls and the image displayed on them is not visible from the teacher's workstation. Direct supervision of the student's work in terms of interaction with the application is, therefore, only possible when the teacher moves around the room. The significant size of the group limits the teacher's ability to react quickly and support several people at once without delay. The problem is often

compounded by the attitude of the young people, who do not always report to the teacher the need for support, but also do not have the opportunity to present their solutions to the other class participant (including the teacher) using the view of their screen. Thus, the provision of feedback concerning the learning process is hindered. In view of the above, it is assumed that the presented observations should be reflected in equipping the classroom with additional teaching aids to support the implementation of group activities.

What is more, the lighting requirements of the computer lab do not correspond to the needs of young people and the educational objectives of the learning process. The lighting level deviates from the requirements of the Polish standard PN-EN 12464-1:2022-01, according to which the intensity of lighting in a room intended for classes using computers should be at the level of at least 300 lux. The office area and the whiteboard are insufficiently illuminated. There is also a lack of additional directional lighting, which is dedicated to students with special educational needs. Therefore, it is necessary to ensure optimal technical conditions, including: lighting conditions, and to eliminate distractors, i.e. unwanted stimuli that distract teenagers.

3 Significance of the problem

According to the general education core curriculum (Journal of Laws 2018, item 467), teachers shall take measures aimed at individualized support for the development of each student, according to his or her needs and capabilities. In view of the above, teachers are faced with the task of both identifying the barriers present in the organization of the learning process and proposing solutions that take into account the adaptation of school conditions and educational requirements to the individual pace of development of each student's knowledge and skills. In an attempt to identify educational difficulties among students of the selected high school, the author of the study used a classification taking into account the type of dysfunction of a given student. This is because an assumption was made that effective equalization of educational opportunities and prevention of secondary disorders in the emotional-motivational sphere of students is possible by targeting activities whose method of adjustment takes into account a specific group of symptoms describing educational difficulties. By identifying the barriers resulting from the implementation of classes in the school's computer lab, the educational needs were differentiated for the following groups of students:

- students with vision impairment,
- hard-of-hearing students,
- students with mobility disability,
- particularly gifted students,

- students having learning difficulties,
- and students having adaptation difficulties related to the change of educational environment.

The different needs of students with vision impairment are due to the depth of their visual impairment, which is described, among others, by the visual acuity after vision enhancement procedure and the limitation of the visual field. A teacher working with a student with vision impairment has to take into account the student's irritability and their increased fatigue, which results from increased concentration on written text. It may require extending the working time and dividing the task into smaller parts of material. Students with visual impairment are also often characterized by reduced mobility and activity, which results from impaired orientation and spatial imagination. This translates into difficulties in performing everyday activities, but it also affects visual memory, which is manifested by impaired perception of details in diagrams, graphs or mathematical formulas. In some cases, continued learning at home may be required, enabling the barrier in using digital devices or using the functionality of computer software to be removed. Equally important is the mental preparation of the student environment to accept, welcome and provide support for a student with visual difficulties.

The implementation of the core curriculum in computer science by hard-of-hearing students is inextricably linked to the formation and improvement of linguistic competence and the functioning of communicative behavior. A hard-of-hearing adolescent may experience difficulties related to verbal interaction and emotional control, which translates into their social functioning. He or she also has difficulties in grasping abstract concepts, sequencing events and synthesizing facts. Hard-of-hearing students relatively often have difficulties in understanding temporal-spatial sequencing and cause-and-effect inference. In the context of computer science, these difficulties translate into problems in applying elements of algorithmization and are noticeable when solving tasks in the area of programming. These students also show a greater tendency to rearrange numbers and signs in algebraic operations.

Mobility disabilities are a manifestation of various medical conditions or random events, in which the type and severity of the damage determines the individual’s independence (MEN, 2010). In most cases, young people who are affected by a mobility disability are characterized by one of the following conditions:

- contractures and ossifications,
- atrophy or paresis of limbs,
- and childhood aphasia with epileptic symptoms, commonly known as epilepsy.

Contractures and ossifications limit the performance of some motor tasks, while muscular atrophy can cause severe fatigue due to poor muscle tone and forced body positions at the computer workstation of the school lab. A person with a paresis often has impaired or nonexistent sensation in the paralyzed part of the body, so movements within the affected scope should not be required. In addition, students with mobility disabilities often have impaired spatial orientation and motor memory limitations.

Young people who are exceptionally gifted and talented in the field of IT are characterized by above-average developmental potential defined by perceptual sensitivity, but also by a high degree of creativity-related ability. Students' abilities vary, they stem from both predispositions and interests. It should be remembered, however, that work with a gifted student should not be limited to stimulating cognitive development, but should also include the emotional and social scope. A gifted student is eager to improvise, experiment and test unconventional solutions, but should be supported by the teacher in building social bonds, undertaking cooperation and developing the ability to organize their own work independently.

The group of students with learning difficulties includes those for whom it is a consequence of educational and environmental neglect, as well as those for whom it is the effect of disorders and diseases of the nervous system or other co-occurring dysfunctions. Common causes of learning disabilities include poor attention span, psychomotor hyperactivity or inactivity, fatigue, problematic behavior, communication problems resulting in inadequately low self-esteem, and also the impact of medication on mood or behavior. What is more, educational achievement may be limited by environmental and cultural conditions of development, which concern emigrants (Rafał-Łuniewska, 2022), young people from poor, pathological or educationally inefficient families. The symptoms of learning disabilities manifest themselves in isolated or combined forms. The most common learning disabilities are difficulties in mastering reading and writing correctly, referred to as developmental dyslexia (dyslexia, dysgraphia, dysorthography) and disorders of mathematical skills (dyscalculia) (Rafał-Łuniewska, 2021a). At the third stage of education, they have a significant impact on the student's mastery of algorithmization and the creation of implementations in the chosen programming language. The consequence of learning difficulties may be secondary disorders of the emotional-motivational sphere. These may take the form of neurotic reactions, with the adolescent reacting with excessive anxiety to stressful situations, nervous tics or stammering, and loss of appetite or, conversely, excessive overeating. Fearing rejection, ridicule or criticism, teenagers may become shyer and more withdrawn. They are often unable to show empathy (Jankowska, 2020), as they prefer to reject others rather than be rejected themselves. Another symptom of secondary disorders is hyperactivity and increased motor activity, which is characterized by violent reactions that are disproportionate to the situation. It is accompanied by irritability, impatience, impulsiveness and problems with concentration. It is also often manifested by anger, aggression (Węgrzynowska, 2021) and unrestrained anger (Zawisza-Mlost, 2021). The challenging behavior of adolescents at school is most often aimed at drowning out anxiety and temporarily improving the mood of an adolescent who is going through or has had a rough experience (Kluczyńska, Zabłocka-Żytka, 2020).

4. Proposals for a solution

As the primary goal of adaptation is to make the educational opportunities of adolescents equal and to prevent secondary disorders of the emotional-motivational sphere of students, it is proposed that the modification of the educational process taking place in the computer lab of the selected school will include a change in the organization of the process by dedicating permanent workstations to selected students and improving the conditions of teaching by retrofitting the lab with new teaching aids. These will be used:

- in the interior design of the computer room,
- to equip the lab with dedicated software,
- and to adapt selected workstations to the different learning needs of young people.

The most important improvement measure is a modification in the area of large scale projection. It is proposed to change the surface of the current projection screen, to install two additional screens and projectors and to upgrade the lighting in the lab. To this end, the following is planned:

- affixing protective self-adhesive film in mat white to the entire surface of the current projection screen,
- execution of the cabling installation and ceiling mounting of the second and third projector,
- installation of additional projection screens on the wall opposite to the windows, with the left and right edges 2 meters away from the corner of the room and the bottom edge 1.5 meter away from the floor,
- connection of a 2 HDMI switch splitter devices, which will enable the simultaneous connection of additional projection screens to the teacher's workstation,
- replacement of the fluorescent lamps in the ceiling lighting fixtures with sources giving a light intensity of at least 300 lux in the room and 500 lux at the students' workplaces (desks). In addition, lighting with a CRI higher than 80, a UGR lower than 19 and a neutral light color of between 3,400 and 5,300 K (PN-EN 12464-1:2022-01) is recommended,
- replacement of lighting fixtures above the whiteboard with a model having an adjustable light beam angle and ensuring uniformity of illumination over the entire surface of the board (PN-EN 12464-1:2022-01).

The light intensity has a major impact on the performance of students' tasks. It is particularly important when an adolescent's ability to see is poorer than normal, during extended activity times, when contrast is low or when increased accuracy is required. The Color Rendering Index (CRI) determines the color perception of illuminated objects. Its value is expressed on a scale from 0 for monochrome light to 100 for white light. The lower the CRI value, the more distorted and unnatural the colors are and the more strongly they affect working

comfort, eye condition and well-being of the student. The UGR value indicated above allows to avoid discomfort caused by uncontrolled excessive brightness in the field of vision and ensures uniformity of illumination of adjacent areas. The perceived color of a light source, on the other hand, is defined by its color temperature and is expressed in Kelvin (K). It indicates the sensation that is associated with the atmosphere of a room.

Following on from the argument presented earlier, it is also necessary to change the way in which the teacher supervises the learning progress made by students. Repeated verification the correctness of the understanding of the instructions given by the teacher and the tasks performed by the adolescents requires changes in the interior design of the computer lab and equipping it with additional teaching resources. In this area it is proposed to:

- install software on all the computer stations of the lab, which will make it possible to share the view of the screen to present solutions to other class participants,
- provide training for teachers who teach in the lab on how to enable students to share their screen and how to view multiple students' screens simultaneously from the teacher's station,
- decorate the surface of the side walls of the room with a mirror mosaic or pieces of mirrors several centimeters wide, made along the workstations at a height of 1.1m from the floor, which will cause the image from the students' monitors to be reflected and thus be visible from the place occupied by the teacher.

According to the core curriculum of general education for the third stage of education (Journal of Laws 2018, item 467), the school should create conditions for students to acquire the knowledge and skills needed, among others, to use new technologies critically and creatively and to actively use e-services. The regulation indicates that this is a necessary condition in preventing the risk of social exclusion, in bridging the generation barrier and in improving teacher-student communication. In view of the above, it is an extremely important task for the school to individualize teaching measures and dedicate them to students with special educational needs (Journal of Laws 2019, item 373, as amended). It is proposed to apply the following adaptation measures, which will constitute a form of assistance for the student of the school under examination:

- designating permanent workstations for young people with special educational needs (Figure 1) and retrofitting them with additional software dedicated to their needs,
- supplementing the equipment of several computer workstations with an additional source of directional lighting with the possibility of adjusting the light intensity and setting the directionality of the source,
- installing additional software dedicated to particularly gifted students at selected work-stations (Figure 1).

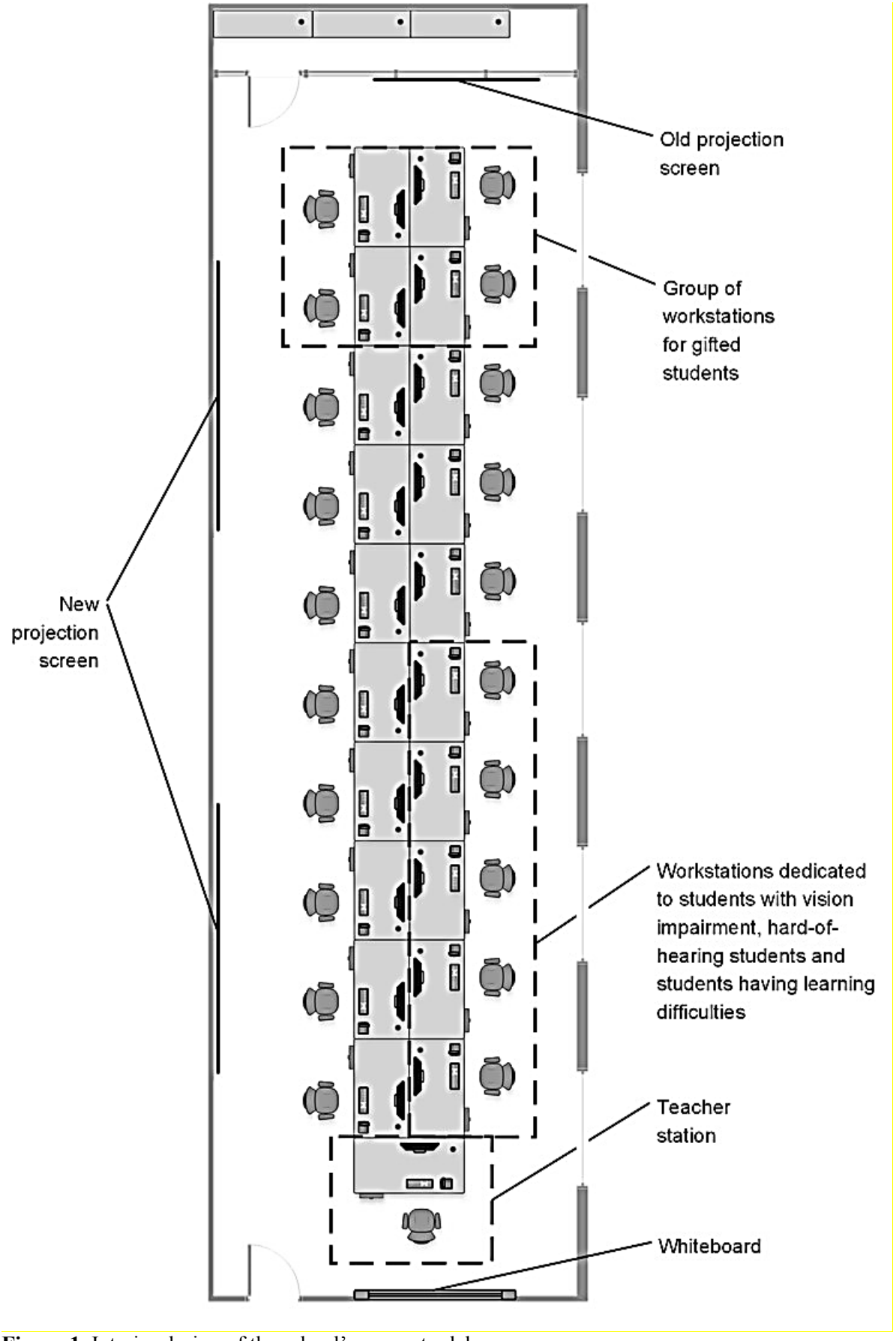

Figure 1. Interior design of the school's computer lab.

Source: own work.

The proposal to differentiate the equipment of the individual workstations stems from the diagnosis made of the school students participating in the described research. The workstations should particularly support the student in solving problems using logical thinking, using computer applications and basic digital devices, and teach him or her to independently find and process information obtained from various sources (Journal of Laws 2018, item 467). When selecting additional software for a student with learning difficulties, the teacher should take into account the activities that are undertaken by the teenager in their everyday life and make sure that they are reflected in the tasks assigned. On the other hand, in the case of a gifted student, it is advisable that the thematic scope of the IT training relates to the specific skills of that student and the tasks assigned represent the duties that the student will perform in their future career. The ways of adapting the working environment to the learner's varied psycho-physical needs are described in more detail below. The classification of special educational needs (Zaremba, 2014) was used for this purpose. Work with students with vision impairment, hard-of-hearing students, students with mobility disability, particularly gifted students, students having learning difficulties is described separately.

4.1. Students with vision impairment

In the computer lab, students with vision impairments should be seated closer to the projection screen and the teacher’s desk. It is important for them to have an uninterrupted view of the whole area of the projected image and to be able to report directly to the teacher their difficulties in adjusting the screen settings of their computer workstation to their abilities. Adapting the workspace of a student with vision impairment also includes equipping the workstation with additional lighting with adjustable light intensity and source directionality settings, also dedicated to students with photophobia. Do not forget about the possibility to darken the whole room using window blinds to reduce the sunlight on the monitors.

The performance of a task by a student with vision impairment may require an increased time limit necessary to locate the information presented on the screen in a large format as it demands scrolling of a longer text, as well as the concentration and cognitive effort of the student. Therefore, it is advisable to refrain from giving them complex tasks, from using multiple-choice tests when checking the student's knowledge and from using concepts in teaching materials that include the visual experience of perceiving the environment. In addition, the teacher’s instructions given to a student with vision impairment should not take the form of gestures or facial expressions when they are not accompanied by a verbal message at the same time, having in mind the proper reception of the message by the person concerned.

What is more, it is necessary to adapt the graphic elements of the presentation to the visual perception of the student. When it comes to requirements concerning material for students with vision impairment, they include the size and typeface of the font (non-serif), as well as the color contrast with the background, margins and spacing between characters and paragraphs.

4.2. Hard-of-hearing students

Among the people included in the observation were hard-of-hearing students who need direct contact with the speaker for visual support and auditory stimulation. Their understanding of what is being said requires that auditory perception be supplemented with content in graphic form or the presentation of practical proceedings. Considering the participation of hearing-impaired young people in the classroom, attention should be paid to the location of their workstations in the school's computer lab. The teacher should ensure that students with hearing or phonological impairments occupy computer workstations located close to each other and with a good view of the projection screen, allowing them to maintain eye contact with their interlocutors and to have free access to the content being presented.

In overcoming difficulties related to the understanding of temporal-spatial sequences and cause-effect reasoning, the teacher should be guided by the principle of using oral statements. It should be remembered that the third stage of education is a time inextricably linked to the improvement of linguistic and communicative competences. This means raising the requirements and expectations set by the school environment, also for hard-of-hearing students, in terms of using terminology and concepts from different areas of computer science, related sciences and applications when formulating statements and justifying opinions expressed. Hearing-impaired and hard-of-hearing students will require teacher support and guidance in acquiring the skills of ordering, valuing and arguing, as well as maintaining a clear layout, logical coherence and appropriate vocabulary of statements (Czechowska, Majkowska, 2020). In addition, articulation disorders will require the teacher to create an atmosphere of acceptance and understanding that fosters communicative relationships with hearing peers, and to extend the time limit for oral expression.

4.3. Students with mobility disability

In the context of computer science classes, where operation of the hardware and software of the school's computer workstation is required, the manual dexterity of the upper limbs is of primary importance. Depending on the degree of the impairment of movement coordination or due to a complete lack of ability to move the hands, limb movement can be assisted or replaced by using other parts of the body. It is the school's responsibility to adapt the working conditions to the student. Computer workstations can be equipped with additional devices to support cursor manipulation and to replace keyboard when typing. Alternative devices are used to this end, for example, in the form of specialized joysticks, larger controllers or software for transcription, i.e. speech-to-text converter or voice control. In addition, touchscreens, movable arm- and footrests or footstools can also be used as accessories to equip the workstation. When organizing the workspace, it is worth paying attention to securing the cabling of the computer hardware, which can restrict the space of people moving around with crutches or using a wheelchair, and the stable fixing of equipment elements by means of non-slip pads. It should not be

forgotten that mobility disabilities also require general adaptation of the school building to accommodate young people's mobility needs, as well as to meet their physiological needs. For students in wheelchairs, the teacher should designate computer workstations located right next to the main path of the lab, providing an unobstructed passage to his or her work area and ones that have unobstructed working space around the seat and peripherals. The teacher should also take care to ensure that the student adopts a correct sitting position during activities and that the wheelchair user's feet are supported on the footrest.

Another disorder of motor function is epileptic seizures, which are a symptom of brain damage. These can take the form of convulsions or silent seizures, which resemble unconsciousness with a clenched jaw. The teacher, in consultation with the parents, should exclude from the teaching process stimuli that trigger seizures. He or she should also eliminate the danger of hitting the head by properly organizing the space surrounding the student. The time of computer classes for people with epilepsy should be shortened. The accumulation of lessons in blocks is not advisable and individualization is needed in this respect.

4.4. Particularly gifted students

Gifted students are characterized by efficient information processing oriented cognitively. However, they require special attention on the part of teachers because of the long-term effort they put into independent work, which allows them to master selected topics. This is because they achieve outstanding results through perseverance in acquiring knowledge, responsibility for self-development and motivation. Gifted students require special care and assistance in solving tasks they cannot solve themselves. The teacher's role then boils down to pointing out an unfamiliar batch of material that the student should familiarize with or to supporting their engagement in conversations with other adolescents, thus increasing the group's involvement in a joint effort to improve skills (Woroniecka-Borowska, 2019).

When teaching gifted adolescents, giving ready-made solutions should be avoided; the teacher should take care of the creativity and independence of their work (Fazlagić, 2022; Janczak, Grześlak, 2020). The teacher should ensure an appropriate selection of tasks. He or she can make them available to students through a learning platform, which is not only a repository of teaching materials, but also a place for storing student work results from workshop activities, conducting tests and collecting feedback from students. It is advisable that it takes the form of the educational cloud, thanks to which teachers and students have remote access to materials regardless of where they access them from (Czechowska, Majkowska, 2020; Knopik, 2022).

Therefore, work with a gifted student should not be limited to stimulating cognitive development, but should also include the emotional and social scope. Through the selection of the scope and form of work, students should have the opportunity to improvise, experiment and test unconventional solutions, but also to build bonds, undertake cooperation and shape the ability to organize their own work independently. Hence it is important that computer

workstations, occupied by particularly gifted young people, are equipped with software that supports the development of their skills. This may include topics such as algorithmization, programming, database handling, digital image processing and the use of multimedia techniques, broadly understood hardware and network architecture or computer security. The most valuable ability in the field of computer science is a predisposition towards algorithmization and programming.

It should be borne in mind that the constant development of information technology means that teachers of computer science shall continue to educate themselves and improve their skills in order to support and assess students' abilities in a balanced way and to support the development of the most talented ones. This is because in addition to discovering students' unique talents, they shall create the conditions for their further development in their chosen field, which is determined by their competences (Szczepkowska, 2019a; Wójtowicz, 2021).

4.5. Students with learning difficulties

Planning individualized support measures requires identifying the areas of functioning in which each student experiences difficulties. Early identification and prompt support for an adolescent is extremely important in terms of the student's understanding of the content communicated to him or her, but also in terms of his or her construction of statements and argumentation of his or her own opinions. In all cases, it is necessary to get to know the student. Planning systematic and individualized support for the student and monitoring the results achieved by him or her, and – if necessary – modifying the methods and forms of his or her education, requires not only cooperation with parents, but also, just as often, an individual pedagogical and psychological diagnosis (Krakowiak, 2017).

In computer science lessons, teachers can support young people by using didactic means that enable multisensory cognition, differentiating written and oral instructions, using formative assessment and consolidating the material by carrying out tasks in the form of projects or teamwork. It is important to strive for harmony in the emotional and social development of young people, whose low self-esteem is eliminated by encouraging initiative and creative activities related to the student's area of interest.

Dyslexia deserves special attention in the context of computer science classes, as difficulties in reading often translate into problems with understanding the content of tasks. Supporting the student in this area will require the teacher to reinforce the message by supplementing or repeating the information in a different way, for example, by way of graphical depiction of the command or by way of verbal explanation. Another developmental disorder that is relevant to the assessment of student achievement is dyscalculia. This is because the tendency to rearrange the order of digits in numbers gives incorrect results from calculations (Rafał-Łuniewska, 2021a). In the case of computer science, the teacher should change the form of testing the student's knowledge by focusing his or her attention on following the reasoning behind the solution. Furthermore, students with learning disabilities may experience difficulties with

cause-effect inference, translating into problems with the application of algorithmic elements. The teacher should then support the adolescent in acquiring ordering and valuing skills through the use of formative assessment (Pintal, 2022).

Tasks given to students with learning difficulties should represent practical applications of the subject matter being discussed, which students encounter in everyday life (Fazlagić, 2022). Instructions should be given in short sentences that accurately capture the essence of the problem. When providing instructions in written form, the teacher should ensure that the text and graphic elements are prepared in accordance with the WCAG (Web Content Accessibility Guidelines) standards. In addition, he or she can extend the time limit to complete the tasks.

The educational environment is of great importance for the functioning of young people at school. The teacher should make use of the potential of the family, especially with regard to the independence and responsibility of the student, because together they can create the right educational atmosphere for dealing with learning and behavioral difficulties. Parents are a valuable source of information about the student (Mucha, 2018; Szczepkowska, 2019b). They can provide the teacher with information on their preferences and dislikes.

Summary

Work with modern technologies allows to conduct classes in varied ways, especially when it comes to the choice of tools, methods and intensity of work. This is because equipment can act as a bridge between the adolescent's world and the surrounding environment. However, each of the above-mentioned needs requires different adaptation measures. The lack of differentiation that equalizes students' educational opportunities may hinder a teenager's functioning in a group, lower his or her self-esteem and reduce his or her motivation to continue working (Dobrowolska, 2018). During adolescence it is of paramount importance to achieve social recognition among peers (Wachowiak & Rudnik, 2020) and to gain prospects for future professional work.

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THE VALUE OF DYNAMIC CAPABILITIES FOR CIRCULAR-ORIENTED INNOVATION AT THE ORGANIZATIONAL LEVEL

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Purpose: The concept of Circular-Oriented Innovation represents a new, valuable, and growing stream of research embedded in management literature. The conceptualization of such innovations indicates that they are involved in the systemic creation and implementation of environmental changes in all dimensions of companies' activities (process, product, organization, business model). Since the effective implementation of sustainable practices requires the development of resources, skills, and competencies/capabilities, especially dynamic capabilities, the paper aims to identify the dynamic determinants of Circular-Oriented Innovation at the organizational level.
Design/methodology/approach: The paper is theoretical and cognitive and is based on an in-depth literature review. The developed conceptual model considers the direct and indirect relationships linking a company's propensity and ability to act for Circular-Oriented Innovation with three types of dynamic capabilities (i.e., relation, absorption, and digitalization capabilities), the organizational processes underlying their building, and elements of the organizational context (leadership, organizational structure, and culture, as well as a long-term strategic vision for the company's development).
Findings: The paper adds to the existing literature and contributes to understanding Circular-Oriented Innovation from the dynamic capability perspective. In addition, they indicate the need for further scientific research that can use the proposed conceptual framework to formulate research proposals and then develop (in the future) testable research hypotheses necessary for empirical verification of this conceptual model.
Originality/value: The critical scientific contribution of the paper is the development of a research framework that goes well beyond existing studies on Circular-Oriented Innovation and Circular Business Model Innovation. The proposed extension of the model's theoretical structure to include propensity (representing behavioral and structural aspects) and ability (i.e., practices, routines, and actions) indicates that a paradigm shift in how companies do business requires developing both propensity and ability to act for Circular-Oriented Innovation, through shaping the structural and organizational context, on the one hand, and simultaneous building of dynamic capabilities, on the other.

Keywords: Circular-Oriented Innovation, propensity-ability perspective, dynamic capabilities, theoretical framework.

Category of the paper: Research paper.

1. Introduction

The concept of Circular Economy (CE) represents a strategic shift in the economic paradigm (Prieto-Sandoval et al., 2019; Bocken et al., 2019; Vence, Pereira, 2019) and marks the replacement of the traditional linear model based on 'take-make-use-dispose' with a 'make-remake-use-return' logic (Parida et al., 2019 after Sandberg). The heart of the Circular Economy is the creation of feedback cycles: resource-product-resource, according to the classic 3R (reduce, recycle, reuse) principle (Liu, 2012; Sehnem et al., 2022). Closing the material flow loop is possible by undertaking activities such as sharing, remanufacturing, and restoration, as well as the combination of processes for maintenance and cascading, reparation and upgrading, product, component, and material reuse, renovation, remanufacturing and refurbishment throughout the product value chain, and recycling (Kirchherr et al., 2017; de Jesus et al., 2021; Kanda et al., 2021; Fernandez de Arroyabe et al., 2021). CE refers to realizing sustainable development's economic and environmental goals (Pieroni et al., 2019). It incorporates the assumptions underlying such concepts as Boulding's (1966) The Economics of the Coming Spaceship Earth, Ayres and Kneese's (1969) Industrial Ecology, Stahel's (1997) Performance Economy, Biomimicry by Lovins et al. (1999), McDonough and Braungart's (2002) Cradle to Cradle Concept, Regenerative Design and The Blue Economy Theory, among others.

The increasing number of publications on the Circular Economy appearing in recent years (Pieroni et al., 2019; Bocken et al., 2019; Brown et al., 2019; Geissdoerfer et al., 2020; Reim et al., 2021; Johnson, 2022; Sandberg, 2023) indicates the growing practical and academic importance of this concept. Initiatives promoting CE are increasingly being introduced not only in European Union countries but also by the governments of China, Japan, the United Kingdom, and Australia (Kanda et al., 2021; Fernandez de Arroyabe et al., 2021). Academic research, in turn, provides many valuable insights into implementing sustainable practices both at the macro and mesoeconomic level, based on the concept of industrial symbiosis and at the company level (Prieto-Sandoval et al., 2019; Franklin-Johnson et al., 2016).

Despite such an extensive body of literature on the Circular Economy, many important research questions still need to be answered. In particular, they concern the determinants of circular activities at the organizational level. Following this research perspective, many authors emphasize the critical role of innovation and argue that it is ecological innovation that is essential for companies to pursue sustainable practices (de Jesus and Mendonça, 2018; de Jesus et al., 2021; Sehnem et al., 2022). However, incorporating the goals and principles of CE into organizational practice requires a systemic approach to a company's eco-innovation activities, which eludes the classical conceptualization of eco-innovation. Therefore, a new and valuable is the analysis of Circular Business Models (CBM), and in particular, the so-called Circular Business Model Innovation (CBMI) or otherwise Circular-Oriented Innovation (COI). The term

COI comes down to undertaking 'coordinated activities that integrate CE goals, principles, and recovery strategies into technical and market-based innovations' (Brown et al., 2019, p. 3) and includes strategies for designing circular products, introducing sustainable business models, and configuring existing value networks (Blomsma et al., 2019; Brown et al., 2019; Johnson, 2022).

Since Circular-Oriented Innovation is concerned with the systemic creation and implementation of eco-innovation in all dimensions of companies' activities (process, product, organization, business model) (Brown et al., 2019; Brown et al., 2021), it is, therefore, essential to understanding which specific capabilities are necessary for COI at the organizational level. The paper makes two critical methodological choices to answer the above research question. First, it is assumed that the concept of Circular-Oriented Innovation can be considered in terms of both the propensity and the ability to act (built on such propensity) for companies to pursue sustainable practices, which not only goes well beyond the existing CBMI studies but, importantly, makes it possible to analyze COI concerning companies' actual circular business abilities. Secondly, the logic of the economic paradigm shift indicates that not only the 'static' resources and skills that a company possesses, according to the Resource-Based View of the Firm (RBV), but also – or primarily – the 'dynamically' conceptualized capabilities that condition the undertaking of practical circular activities should be examined. Following the relevance of this research question, as highlighted in the literature (Prieto-Sandoval et al., 2019; Fernandez de Arroyabe et al., 2021; Stucki et al., 2023), the main objective of this paper is to identify the dynamic determinants of Circular-Oriented Innovation at the organizational level.

To fulfill the research objective, the paper:

- explains the Circular-Oriented Innovation, a concept that represents a new research area that draws from Sustainability-Oriented Innovation (SOI) literature and includes the progress of research on CE at the organization level (Brown et al., 2019);
- makes a decomposition of the COI concept into a company's propensity and ability to implement sustainable organizational practices based on Innovation Theory;
- assumes – following the Resource-Based View of the Firm, Dynamic Capabilities Theory, Organizational Learning Theory, and Open Innovation Theory as theoretical frameworks – that Circular-Oriented Innovation requires companies to develop dynamic capabilities, i.e., relation, absorption, and digitalization capabilities. This assumption is in line with Eisenhardt and Martin (2000), who characterize dynamic capabilities as concrete and identifiable strategic and organizational processes, and with Teece (2007), who emphasizes that these capabilities not only determine companies' adaptation to a dynamically changing market environment but also enable them to shape it by conducting innovation activities;

- shows – through the developed theoretical framework – that a paradigm shift in how companies conduct business following the 3Rs requires developing both the propensity and the ability to act for Circular-Oriented Innovation, through the shaping of the structural and organizational context, on the one hand, and the simultaneous building of dynamic capabilities, on the other.

2. Theoretical Background

2.1. From eco-innovation to circular-oriented innovation

The debate in the literature on implementing sustainable practices at the organizational level was initially focused on eco-innovation. For example, eco-innovation has been recognized as an essential source of strategic change for companies (Klewitz, Hansen, 2014) and a critical factor in improving their economic and environmental performance (Zhang, Walton, 2017; Cai, Li, 2018). Such an assumption is consistent with the realization of a 'win-win' scenario, taking into account both types of benefits and indicating that they arise from the characteristic positive knowledge spillover effects generated by these innovations and the accompanying internalization of adverse environmental impact (Kesidou, Demirel, 2012; Díaz-García et al., 2015). The concept of eco-innovations was developed in the mid-1990s, and one of their first definitions was formulated by Fussler and James (1996), indicating that they are new products, processes, or services that offer value to both the company and consumers while significantly reducing harmful environmental impacts.

Awareness of the momentous importance of eco-innovation has fostered an intensification of academic research. The growing number of studies on the subject has resulted in the emergence of related terms in the literature, i.e., green innovation (Chen et al., 2012; Huang, Li, 2017), environmental innovation (Kammerer, 2009) or sustainable innovation (de Medeiros et al., 2014), whose understanding, however, has not deviated (for the most part) from the logic of eco-innovation. Regardless of the terminological differences, researchers (de Jesus, Mendonça, 2018; de Jesus et al., 2021) agree that eco-innovation is a necessary tool for implementing sustainable practices at the organizational level.

However, introducing even the most radical eco-innovation only sometimes means fully integrating CE goals and principles into the company's long-term development strategy. Indeed, the circular orientation of a company depends more on its ability to create and implement eco-innovation than on separate changes. This is in line with Pieroni et al. (2019) and Sehnem et al. (2022), who point out that the implementation of sustainable practices by companies requires organizational innovation as much as technological or product innovation. In other words, only the art of systemic generation and implementation of eco-innovation enables

companies to change the paradigm of doing business following the 3Rs. Looking for ways to put this assumption into practice, researchers (de Jesus et al., 2021; Bocken et al., 2016) indicate the importance of designing Circular Business Models, which 'have become an essential means of making the circular economy conducive to application in organizations' (Sehnem et al., 2022, p. 4).

The conceptualization of a business model stems from the 'traditional' logic of how a company generates value and means – in simple terms – the organizational and financial architecture for creating, delivering, and capturing value, leading to competitive advantage and, ultimately, profit (Kanda et al., 2021). However, for a company's business model to represent a paradigm shift in doing business according to the 3Rs, it must be circular. The essence of the Circular Business Model is to use the company's abilities to create value not only economically but also socially and environmentally (Pichlak, Szromek, 2022) through eco-design, use of renewable energy sources, minimization of waste, and reuse of goods and extensive use of recycling processes (Linder, Williander, 2017). This is consistent with the notion that a key role of CBM is 'to incorporate the circular economy principles into a design or redesign of business activities and partnerships and to create a cost and revenue structure that is compatible both with sustainability and with profitability' (Zucchella, Previtali, 2019, p. 275).

The concept of Circular Business Models assumes that companies can reduce their negative impact on the environment using an alternative proposition for creating, delivering, and capturing value (Reim et al., 2021). Incorporating the circularity imperative into a business model is a strategic choice. It can follow one of the following modes: downstream circular (changing value capture and delivery through new revenue streams and customer interface), upstream circular (changing value creation systems, such as reverse logistics), and full circular (combining upstream and downstream principles) (Urbinati et al., 2017; Pieroni et al., 2019).

The literature emphasizes that a paradigm shift in doing business at the organizational level, leading to the final closure of material flow loops, requires adapting, redesigning, or transforming existing business models (Johnson, 2022) so that they are based on 'using as little resources for as long as possible, while extracting as much value as possible in the process' (Geissdoerfer et al., 2020, p. 2). In other words, one can conclude that for companies to pursue long-term growth strategies in line with the CE logic, they should implement the Circular Business Model Innovation.

While Business Model Innovation involves changes in business models (Johnson, 2022), the aim of CBMI is to increase the efficiency of resource and material use (and ultimately close the loop of their flows) by changing perceptions of value (Geissdoerfer et al., 2020; Bocken et al., 2016). Moreover, taking such coordinated action requires the creation and implementation of process, product, and organizational eco-innovations, as well as the design of sustainable business models (Brown et al., 2019; 2021), i.e., making changes in practically every layer of a company's operation. Relating Circular-Oriented Innovation to the determinants of systemic eco-innovation activities involves decomposing the COI concept.

Such a methodological procedure leading to the separation of a company's propensity and ability to act for COI is a starting point for their further analysis from the dynamic research lenses.

A company's propensity and ability to undertake innovative activities are immanently related concepts. This is consistent with recent work by, for example, Daronco et al. (2022), who emphasize that propensity is an intangible reflection of ability. 'If organizations don't display a propensity for innovation (...), innovation cannot and will not occur' (Dobni, 2006, p. 331). The notion of a company's ability to innovate is the substance of Innovation Theory. Researchers argue that innovation ability can be considered concerning both technical and non-technological innovations (Ngo, O'Cass, 2009), has a multidimensional character (Hogan et al., 2011), and contributes significantly to the achievement of specific organizational outcomes (Calantone et al., 2002; Dangelico et al., 2017). In turn, 'the propensity to innovate is more closely linked to an organization's DNA and relates to the degree to which the firm will achieve a state of innovativeness' (Daronco et al., 2022, p. 5).

Drawing from Innovation Theory, a company's propensity to pursue sustainable practices is derived from interrelated organizational characteristics and attributes (Daronco et al., 2022), including leadership, organizational structure, and culture, as well as a long-term strategic vision for the company's development. On the other hand, a company's propensity for COI refers to taking practical action through coordination and integration, as well as the transformation and recombination of its resources, skills, and competencies to meet the challenges of adopting the CE paradigm at the organizational level (Johnson, 2022).

When analyzing the propensity for COI, the involvement of the CEO comes to the fore. Vaccaro et al. (2012) argue that the leaders' role is crucial in creating an intra-organizational context conducive to experimentation and introducing flexible organizational systems and structures. In addition, leaders can stimulate the propensity to pursue sustainable practices by formulating a long-term vision for the company's strategic development, developing an effective incentive system, and building an eco-innovative organizational culture. Defined by leaders and communicated to employees, a clear and integrated shared 'green' vision sets the strategic goals and aspirations of the CEO regarding the company's future development (Jansen et al., 2008). Moreover, it becomes part of the organizational identity and determines the scope and expected results of the eco-innovation activities undertaken by the company (Chen et al., 2014). Finally, the critical role of leaders' attitudes, skills, attributes, values, and behaviors also manifests itself by reducing the complexity and uncertainty associated with the implementation of closed-loop strategies, building a climate of tolerance for failure and risk, i.e., creating a 'green' organizational culture (Prieto-Sandoval et al., 2019; Vence, Pereira, 2019).

Unlike propensity, a company's ability to pursue sustainable practices (built on such propensity) requires taking practical actions and is therefore determined by the development of specific resources, skills, and competencies/abilities, especially dynamic capabilities, which addresses the next section of the paper.

2.2. The origin of dynamic capabilities

The examination of resources, skills, and competencies/capabilities that facilitate the development and implementation of Circular-Oriented Innovation was initiated by Barney's (1991) work on the Resource-Based View of the Firm. This concept captures the firm as a set of diverse resources that distinguish it from its competitors. According to the logic of RBV, a company's resources can be tangible (infrastructure) or intangible ('know-how') (Prieto-Sandoval et al., 2019; Chaudhuri et al., 2022), and to be a natural source of competitive advantage, they should be valuable, rare, imperfectly imitable and non-substitutable (VRIN Framework), as well as durable and not easily traded.

An extension of the RBV is the Competence-Based Theory of the Firm, according to which gaining and maintaining competitive advantage is determined not only by the company's resources but also (or primarily) by the competencies it develops. Competencies, particularly core competencies, have strategic value, implying the need to update them constantly (Prieto-Sandoval et al., 2019). Some researchers use the terms competencies and capabilities interchangeably, defining them as bundles of skills necessary to organize resources (Doran and Ryan, 2016), the ability to achieve things by using and coordinating a set of tangible and intangible resources (Dangelico et al., 2013), capabilities that result from repeatedly performing activities in an organization (del Río et al., 2016) or the ability to deploy resources through the use of organizational processes (Albino et al., 2012). These processes are company-specific and can be developed (over time) by combining different resources and capabilities (Amit, Schoemaker, 1993).

According to the impact of capabilities on the development of the company, one can make a distinction between dynamic and operational (ordinary, substantive) capabilities (Teece et al., 2016; Helfat, Peteraf, 2003), captured as the abilities to solve emerging problems (Zahra et al., 2006) through the ongoing use of existing resources, processes and systems.

The most commonly cited definition of dynamic capabilities in the literature is that by Teece et al. (1997), according to which they represent the abilities to build, integrate, and reconfigure internal and external skills, resources, and functional competencies held within an organization to meet the demands of a rapidly changing market environment. Teece (2007, p. 1319) further emphasizes that 'dynamic capabilities enable business enterprises to create, deploy, and protect the intangible assets that support superior long-run business performance', meaning that these capabilities not only enable a company to adapt to a dynamically changing market environment but also to shape it, by carrying out effective innovation activities.

Following the logic proposed by Teece et al. (1997), Helfat and Peteraf (2003) emphasize that dynamic capabilities change the company's resource base and must be embedded in it and repeatable. Eisenhardt and Martin (2000) capture dynamic capabilities in terms of processes (as concrete and identifiable strategic and organizational processes), while Zollo and Winter (2002) define them in the context of organizational routines, referring directly to the evolutionary perspective on change described by Nelson and Winter (1982). Finally, other conceptualizations of dynamic capabilities characterize them much more broadly as the orientation (Wang, Ahmed, 2007) or potential (Barreto, 2010) of an organization, i.e., an aggregate multidimensional construct consisting of various interrelated components (capabilities).

Despite the different conceptualizations of dynamic capabilities, most researchers agree on two fundamental issues related to the nature of these capabilities. The first is the priority role of organizational learning processes in building and developing dynamic capabilities (Teece et al., 1997; Zollo, Winter, 2002; Teece, 2007). Organizational learning manifested both in the form of individual employee skills and in the form of organizational knowledge (embedded in activity patterns, routines, or the logic of actions taken in the company), can prevent the occurrence of so-called 'strategic blindspots' (Teece et al., 1997), and thus enable the company to overcome barriers to innovative activity by strengthening existing and building new organizational capabilities (Johnson, 2022). The second point emphasized in the literature is the assumption that dynamic capabilities are difficult to imitate and, as in the resource concept, are heterogeneous since they are usually built by companies rather than bought on the market (Makadok, 2001; Teece et al., 1997). The need to develop such capabilities requires two subsequent organizational processes: the coordination/integration of the company's existing resources (resulting in a new resource base) and the reconfiguration of resources (their transformation and recombination) (Teece et al., 1997). Expanding on the above concept, Teece (2007) argues that, along with the organizational learning processes, coordination and reconfiguration represent the potential for resource orchestration and are essential for building dynamic capabilities.

The literature also emphasizes that all the organizational processes identified above are essential for Circular-Oriented Innovation. Organizational learning processes facilitate not only the transformation of existing but also the design of new business models for extending product life cycles and implementing recycling strategies to close material flow loops (Bocken et al., 2019) while creating and delivering as much value as possible (Geissdoerfer et al., 2020). Moreover, considering these processes from a knowledge-based perspective links them directly to Organizational Ambidexterity. According to a pioneering publication by March (1991), the essence of knowledge exploration is the development of fundamentally new competencies, for example, through radical innovations and new business models, while the nature of knowledge exploitation remains the improvement of competencies held within companies, leading to the incremental changes. In contrast, concerning coordination/integration and

resource reconfiguration procedures, both Huang and Li (2017) and Salim et al. (2019) argue that they are catalysts for different types of eco-innovation in companies. In addition, Sandberg (2023) points out that resource orchestration processes, not only intra- but also inter-organizational, enhance the creation of sustainable value. This is particularly relevant in the context of Circular-Oriented Innovation, as it allows the broad analysis to include the collaborative relationships undertaken to implement sustainable practices within companies.

3. Dynamic capabilities for Circular-Oriented Innovation – A Conceptual Framework

The literature review indicates that implementing Circular-Oriented Innovation requires the development of specific firms' capabilities to respond to the dynamically changing environment in which they operate (Prieto-Sandoval et al., 2019; Fernandez de Arroyabe et al., 2021; Stucki et al., 2023). The present study assumes that among such capabilities can be distinguished relation, absorption, and digitalization capabilities, as illustrated in Figure 1. Moreover, the developed conceptual framework points out the proposed decomposition of the COI concept, which seems more representative because it indicates that: (1) not all companies have the same circular business abilities; (2) having a mere propensity, or intention, for companies to pursue sustainable practices is not enough for COI; and finally (3) building dynamic capabilities is immanently embedded in the structural and organizational context, and thus requires developing the propensity to incorporate CE goals and principles into organizational practice.

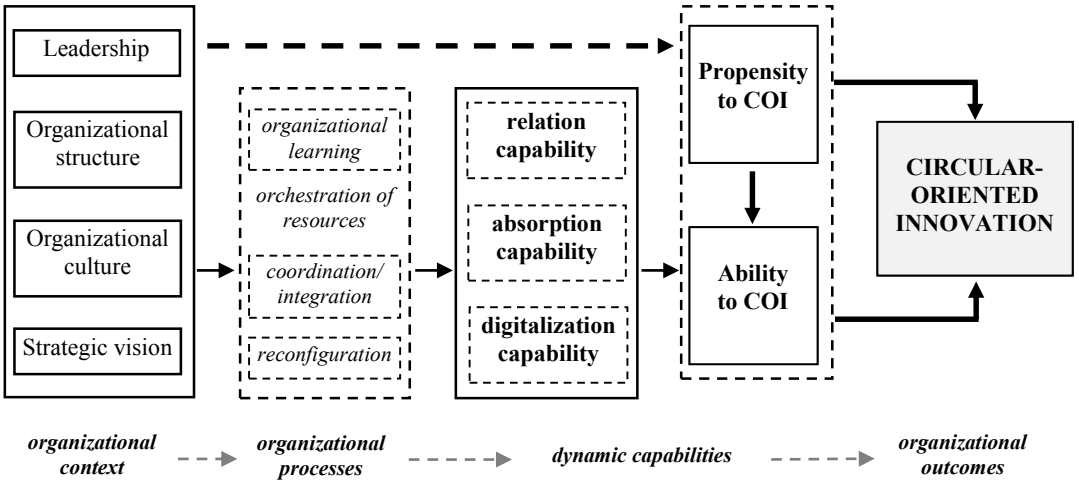

Figure 1. Theoretical framework.

Critical to Circular-Oriented Innovation is relation capability, which leads to achieving 'synergy with relevant stakeholders in the production chain in which the circular economy is being executed' (Sehnem et al., 2022, p. 9). Collaboration contributes to knowledge and

information sharing, conflict management, promoting trust and generating value in companies, leading to improved organizational performance (Czakon, 2009). Researchers (Brown et al., 2021; Sandberg, 2023) emphasize that collaboration is a significant factor in a company's success when shifting from linear to circular practices. When analyzing the impact of relation capability on Circular-Oriented Innovation, some (Johnson, 2022) refer to the Open Innovation paradigm. This concept emphasizes a company's broad interaction with customers, suppliers, research institutions, business partners, and competitors. Open Innovation was first described by Chesbrough (2003), who relates this concept to the intentional (purposeful) inflow and outflow of knowledge, i.e., to all types of innovative activity that extend beyond organizational boundaries. Eisenreich et al. (2021) introduce the concept of Open Circular Innovation and identify the benefits that can be gained by companies seeking to implement circular initiatives (by accessing the knowledge and expertise of various stakeholders and getting their acceptance for the subsequent launch of eco-innovations).

Another capability necessary for Circular-Oriented Innovation is absorption capability, i.e., the ability of a company 'to recognize the value of new, external information, assimilate it, and apply it to commercial ends' (Cohen, Levinthal 1990, p. 128). As Wang and Ahmed (2007) point out, absorption capability is inherently dynamic. Zahra and George (2002) argue that it determines the creation and use of knowledge necessary for building organizational capacity. It also provides competitive flexibility for companies operating in dynamically changing markets. If identifying and assimilating new and valuable knowledge is the basis for conducting effective innovation activities, it is also crucial for Circular-Oriented Innovation (cf. Stucki et al., 2023). Moreover, as Sehnem et al. (2022) convincingly argue, the absorption capability stimulates the innovation-supported economy transformation into a new and eco-efficient circular-oriented system.

Circular-Oriented Innovation, moreover, requires new disruptive technological solutions immanent to Industry 4.0 (i.e., Big Data, 5G, IoT, 3DP, Blockchain, et al.). Suchek et al. (2021) point out that using 3D technologies improves the efficiency of the recycling processes. Advanced digital technologies are essential for driving change throughout the value creation chain (Stucki et al., 2023), and their use can close material flow loops through increased resource efficiency (Antikainen et al., 2018). Adopting a digital orientation catalyzes companies to acquire new skills, competencies, and technical knowledge (Chaudhuri et al., 2022), and enables sustainable environmental and socioeconomic benefits (Bag et al., 2020). Hence, referring to Reim et al. (2021, p. 2754), the last of the capabilities needed to COI at the organizational level is digitalization capability, which 'defines how companies utilize data and analytics to develop increased product lifecycle knowledge'.

The conceptual view of Circular-Oriented Innovation proposed in this paper indicates that a company's ability to pursue sustainable practices requires building and developing dynamic capabilities, including relation, absorption, and digitalization. However, these capabilities must be considered in collaboration. Establishing inter-organizational relationships results in access

to external knowledge, but with absorption capability, a company can assimilate and utilize it effectively. Similarly, the application of new technologies that support the undertaking of circular initiatives requires the recognition of the potential for their value and, therefore, developing absorption capability. In turn, absorption capability – embedded in organizational learning processes – is primarily determined by building intra-organizational relationships and is thus linked to so-called 'internal' relation capability. In summary, the incorporation of CE goals and principles into organizational practice - as a central reference point for the company's long-term strategic development vision, embedded in the organizational culture and structure, and clearly defined and communicated by CEO – indicates the potential for companies to gain actual environmental, social and economic benefits, and as a result, achieve and maintain a sustainable and 'renewable' competitive advantage (Geissdoerfer et al., 2020).

4. Conclusion

The need, emphasized by many researchers, to integrate CE goals and principles into organizational practice is influencing the growing importance of the Circular-Oriented Innovation concept. It justifies undertaking research in this new research area. Such innovations – through the conceptualization and adoption of new business models (Geissdoerfer et al., 2020), as well as the adaptation, redesign, or transformation of existing ones (Johnson, 2022) – lead to increased efficiency of resources and the closing of material flow loops, thanks to a change in the approach to the entire process of generating economic value in companies (Pieroni et al., 2019). However, the systemic creation and implementation of eco-innovation in all dimensions of companies' activities (Brown et al., 2019; 2021) can be risky, especially when CEOs lack experience working with the new circular business model (Johnson, 2022). Therefore, Circular-Oriented Innovation requires developing specific resources, skills, and competencies/abilities, including dynamic capabilities.

The paper's main objective was to identify the dynamic determinants of Circular-Oriented Innovation at the organizational level. Based on the literature review conducted, relation, absorption, and digitalization capabilities are crucial for COI. In the face of increasing environmental pressures and the legitimacy of companies' implementation of sustainable practices, inter-organizational collaboration is becoming increasingly important. Bocken et al. (2014, p. 43) note that 'value is no longer created by firms acting autonomously, but by firms acting together with parties external to the firm through informal arrangements or formal alliances'. Similarly, a systemic change in the logic of how modern companies do business requires an open mindset (Eisenreich et al., 2021; Chaudhuri et al., 2022), not only concerning the assimilation of new organizational knowledge (absorption capability) but also the need for new and advanced digital solutions (digitalization capability) to support the adoption of the CE paradigm.

To conclude, the paper is theoretical and cognitive. Its main scientific contribution is developing a research framework beyond existing studies on Circular-Oriented Innovation and Circular Business Model Innovation. Since the context of dynamic capabilities for Circular-Oriented Innovation has yet to mature sufficiently, the formulation of research proposals, which provide a rationale for developing testable research hypotheses in the future, was deliberately abandoned. Instead, the proposed conceptual separation of the behavioral and structural nature of the propensity for COI from the practices, routines, and activities that make up the ability to innovate highlights an important practical implication, pointing to the fundamental role of the organizational context in building a company's propensity to incorporate CE goals and principles into organizational practice.

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CLIMATE PROTECTION AND SUSTAINABLE DEVELOPMENT AS AN INVESTMENT FOR THE FUTURE FROM INDIVIDUAL INVESTORS' PERSPECTIVE

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Purpose: This article is aimed at analyzing the importance of investments relating to environmental protection and sustainable development promotion considering the individual investors' perspective.
Design/methodology/approach: This article attempts at answering the question of which investments should be considered "green", what their importance is and what the benefits of investing in environmental protection and sustainable development are, and also what activities can be initiated by individual investors to support eco-friendly and pro-community investments. The following research methods were used: reference work review, secondary source analysis (data concerning the following indexes: iShares Dow Jones Global Sustainability, iShares STOXX Europe 600 Oil & Gas and iShares STOXX Europe 600) and deductive reasoning.
Findings: Achievement of EU objectives relating to reaching climate neutrality by 2050 is connected with the need to mobilize capital which will be targeted at investments relating to climate protection and sustainable development. At the same time, green investments bring about specific benefits for the issuers and investors. To support eco-friendly and pro-community activities, individual investors may initiate specific activities concerning financial and in-kind investments.
Social implications: This article presents forms of supporting green investments by individual investors and households. Increased social awareness results in a question of how to invest one's funds to ensure it is in harmony with eco-friendly, pro-community, and ethical attitudes and values.
Originality/value: The article offers cognitive value as it contributes to the body of knowledge regarding the relevance of green investments in addressing climate change.

Keywords: green investments, environmental protection, sustainable development.

Category of the paper: conceptual paper.

1. Introduction

Environmental protection and sustainable development are one of the most important challenges of today's reality. More and more frequent and extreme flooding, increased numbers of hurricanes and prolonged droughts, as well as rising sea levels pose threats of a global environmental disaster. Higher temperature values result in the disappearance of numerous animal and plant species. In particular, a worrying phenomenon is the extinction of pollinating insects. This threatens plant reproduction, seamless animal food chain and food security of humans. According to the Global Assessment Report by IPBES, unless people stop climate changes soon, the Earth will face an environmental disaster (IPBES, 2019).

Stopping dramatic climate changes and their effects have become a priority. The Paris Agreement, or the United Nations Framework Convention on Climate Change, executed in 2016, for its major objective selected reduction of the global temperature rise by the end of this century below two degrees Celsius when compared to the level before the industrial era and effort to keep temperature rise below 1.5 degrees (https://unfccc.int/sites/default/files/english_paris_agreement.pdf). In order to comply with the 1.5 standard, it is necessary to achieve a net zero level of greenhouse gas emissions by 2050 at the latest. In September 2019, the European Union and many UN member states obliged to undertake relevant activities.

Climate neutrality means achievement of balance between emission of greenhouse gases and their absorption, e.g. by planting forests to bind CO2. A prerequisite is structural transformations, including gradual departure from burning coal, crude oil, and natural gas. This objective, however, may be achieved solely when required eco-friendly investments are made. Worldwide, around EUR 82,500 billion has already been invested in environmentally friendly and climate protection-related investments (Barabanov, Basnet, Walker, Yuan, Wendt, 2021).

The problem presented is important from a theoretical and practical point of view. Its importance has led to the development of new publications on the green economy by various international organizations, national governments, think groups, experts and NGOs. These studies mainly focus on a macroeconomic perspective. However, they do not often address the issue of green investment from the point of view of the benefits and risks of individual economic agents, especially investors. In connection with this article, it was undertaken to answer the question: what investments should be considered as so-called green investments, what is the importance and what are the benefits associated with investments in environmental protection and sustainable development, what actions can be taken by individual investors to promote pro-environmental and pro-social investments

The purpose of this article was to analyze the importance of investments related to environmental protection and the promotion of sustainable development, taking into account the perspective of individual investors. The following research methods were used: literature

review, desk research (data on the iShares Dow Jones Global Sustainability, iShares STOXX Europe 600 Oil & Gas and iShares STOXX Europe 600 indices) and deductive reasoning.

2. Literature review

The literature on the subject does not explicitly define green investments. They are referred to as investments in climate protection and sustainable development, and are also called green investments or green investments. The distinguishing feature of the investments in question in relation to conventional ones is that they supplement classic financial criteria (such as amount, time, risk, rate of return), with categories of ecological, social and ethical evaluation.

Inderst, Kaminker and Stewart, conducted an analysis on the definition of green investments based on various criteria, such as asset positions, investment size. Given the lack of consensus on the use and definition of the term "green," they concluded that an open and dynamic approach to definitions and standards should be used (Inderst, Kaminker, Stewart, 2012).

Green investments are also approached as green investments, referring to social investments made to improve the environment (individual environmental donations, socially responsible businesses, etc.). Green investments, or socially responsible investments, are in line with the concept of ecological civilization. Other authors define green investments as those investments that aim to reduce greenhouse gases and air pollutants, without significantly reducing the production and consumption of non-energy products (Utz, 2015). Green investments can also be considered in a broad sense. They are treated as environmental, social, and governance investing, responsible investments, and socially responsible investments (Escrig-Olmedo, Rivera-Lirio, Munoz-Torres, 2017).

Green investments are primarily aimed at influencing environmental improvements. They also affect the activities of those making the investments, namely companies and investors (Yen , 2018).

When analyzing the results of studies on the changes that are associated with pro-environmental investments in companies, I most often refer to the results of operations. Thus, the analysis of data obtained from 16,119 companies, indicated the occurrence of a positive relationship between corporate social responsibility (CSR) and the financial performance of companies (Mikolajek-Gocejna, 2016) emissions can in an effective way manage financial performance (Ganda, Milondzo, 2018). Based on a study by Ghosh, Sarmah, Kanauzia, it was found that investments in green technologies can lead to a reduction in the total cost of the supply chain, as well as carbon emissions (Ghosh, Sarmah, Kanauzia, 2020). On the other hand, according to Atif, Alam, Hossain, the implementation of sustainable investments by companies lowers energy consumption and reduces carbon emissions,

and positively affects financial performance by increasing operational efficiency and taking advantage of new opportunities (Atif, Alam, Hossain, 2019).

The implementation of green investments also influences household behavior. Promoting sustainability and taking environmentally friendly measures are causing changes in consumer decisions, as more and more people are choosing green products over traditional ones (Xing, Xia, Guo, 2019).

In conclusion, the implementation of green investments has certain consequences in the activities of businesses and consumers. According to what we have been able to analyze, there is a lack of studies analyzing the benefits for investors associated with investments in green ventures. The literature also lacks indications for households recommending behaviors that support green investments. In addition, the implications for businesses focus mainly on the impact of sustainability investments on business performance, without a more in-depth analysis of the drivers of improved business performance.

3. Research methodology

The purpose of this article is to analyze the importance of investments related to environmental protection and the promotion of sustainable development, taking into account the perspective of individual investors.

In connection with this article, it was undertaken to answer the question: what investments should be considered as so-called green investments, what is the importance and what are the benefits associated with investments in environmental protection and sustainable development, what actions can be taken by individual investors to promote environmental and pro-social investments?

The following research methods were used: literature review, desk research (data on the iShares Dow Jones Global Sustainability, iShares STOXX Europe 600 Oil & Gas and iShares STOXX Europe 600 indices) and deductive reasoning.

In recent years, a number of new instruments have developed that are defined as pro-environmental investments. Due to the lack of a clear definition of green invetments, investors face difficulties in identifying instruments related to environmental protection and sustainability. The European Union has reached a common agreement and in 2020 supported regulations defining sustainable activities, however, they are mainly useful for entities applying for funds for green investments. On the other hand, they are not necessarily clear for those wishing to invest in green projects. The criteria that are most often used to classify instruments as pro-environmental are presented below, also in a later article.

The first criterion used when selecting investment criteria is the ESG marking. This acronym signifies factors used to create ratings and non-financial assessment of an organization. They have three components: E for Environment, S for Social responsibility and G for Governance. The ESG criteria are used to identify the company, states or projects ensuring favorable environmental and social benefits (e.g. "best in class"). Relating to investment in entities' securities, this criterion enables to identify the entities whose strategies and ongoing decisions consider environmental, social, and governance aspects. Their level may shape the ability to finance new investments from funds provided by investors for whom the sustainable development policy is important. However, any activities non-compliant with the ESG idea, including workplace discrimination, emission of environmentally harmful gases or funding political campaigns may compromise the company reputation in the stakeholders' eyes. In this way, environmental marking ensures certain confidence relating to the wallet and funded projects.

The second type of eco-friendly investment identifiers includes the so-called exclusion criteria. They are identifiable determinants used to eliminate selected sectors, companies or states from the so-called green investment directions. Exclusion criteria may refer to the environment, i.e. comprise factors detrimental for climate (e.g. coal mining), to the social aspects, i.e. violating human rights, child labor, or may be connected with unacceptable ethical and political measures, e.g. weapon supply agreements. In certain areas, the minimum acceptance level for adverse factors may be adopted.

Another criterion is the assessment of entities' measures towards climate improvement. This assessment is connected with analyzing information relating to the hazard caused by them to the natural environment published by business entities. To present the information, the entities must keep relevant records and ensure data reporting concerning the factors exerting adverse impact on the climate. Such book-keeping may comprise information on emissions of carbon dioxide or other greenhouse gases and water consumption. To collect data concerning companies' impact on the environment, non-profit organizations are created, e.g. Carbon Disclosure Project (CDP). This organization collects, in the investors' name, data and information on CO2 emission, climate risk as well as the companies' reduction goals and strategies using standardized questionnaires.

The criterion applied to assess instruments as eco-friendly investments is the organization's participation in creating sustainable development indexes and instruments using sustainable indexes in their formula. During the last twenty years, products with sustainable development indexes appeared on close to all most important stock exchanges. They include e.g. MSCI ESG Index, MSCI Global Environmental Index, MSCI Global Alternative Energy Index, MSC Global Energy Efficiency Index, MSC Global Green Building Index, MSC Pollution Prevention Index, and MSCI Global Sustainable Water Index. Similar offerings can be found in S&P indexes, i.e. S&P Eco Global Index and S&P ESG Index. In STOXX, this is STOXX® Global ESG Leaders Index. The Warsaw Stock Exchange has WIG ESG index. It was created based

on the wallet value of companies considered socially responsible, i.e. the ones complying with the socially responsible business rules, including but not limited to relating to the environmental, social, economic, and governance aspects. Including shares in ESG indexes gives the issuers the ability to obtain significant funds for green transformation. This requires reporting ESG financial data (i.e. environment, society and governance). Individual investments or project funding should be described in detail, and relevant reports should be published.

As stems from the presented analysis, green investment identification is problematic due to the absence of legislative solutions. However, the most important aspect of investing in sustainable products is that they direct funds towards sustainable development.

4. Results

Investment in and issuance of instruments connected with the environmental protection and sustainable development may have versatile favorable effects (Chen, Chen, Zheng, Li, 2023). Generally speaking, they may be analyzed from the perspective of issuers and of investors.

The benefit for the sustainable instrument issuers is primarily obtaining funds for eco-friendly investments (Nawrocki, Szwajca, 2021). Transformation in the so-called "green" direction requires long-term investments which will bring return a long time later (Martinez-Oviedo, Medda, 2019). Hence the problem of obtaining funds. However, the issuance of green bonds or other securities enables to obtain funds for those activities.

The positive outcome is also the results of eco-friendly and/or pro-community projects. Following a green transformation, a company should experience measurable benefits, including lower costs, improved risk management and relations with the local community, employees, suppliers, and banks funding it. (Siedschlag, Yan, 2021), This means that the company's developmental foundations and perspectives are better in the longer term which should translate into financial results and support the appraisal.

Analyzing the benefits of issuing instruments which are considered green investment, this project contributes to the company reputation. Investors perceive such business entities as eco-friendly and pro-community institutions. They are a more and more important investment direction. The studies by Ernst&Young reveal that one fourth of people born in 1981-1996 perceive sustainable investing as the most important factor when selecting investment products nowadays (https://www.ey.com/en_gl/sustainability-financial-services).

From the investors' perspective, investments in projects and business models connected with the climate protection and sustainable development are more and more perceived as an opportunity to earn ensuring compliance with ethical rules and standards at the same time

(Martin, Moser, 2016). It is disputable, however, if investment in financial instruments which are climate- and society-friendly entails lower effectiveness (rate of return).

According to the studies by the Federal Office for the Environment (FOEN) among 2000 respondents, investment in environmentally friendly financial instruments did not bring any inferior profits. On the contrary, at least one half of respondents declared that they were higher (CSSP& Southpole, 2016). Other analyses indicate that the profitability of sustainable funds is comparable to the profitability of traditional investments in shares though the former entail lower risk. The analyses by Morgan Stanley (Stanley, 2019) among entities trading in securities indicated that the profits from the so-called green investments do not differ significantly from the traditional ones but they are exposed to fewer fluctuations than the instruments valued based on the prices of crude oil or other fossil fuels.

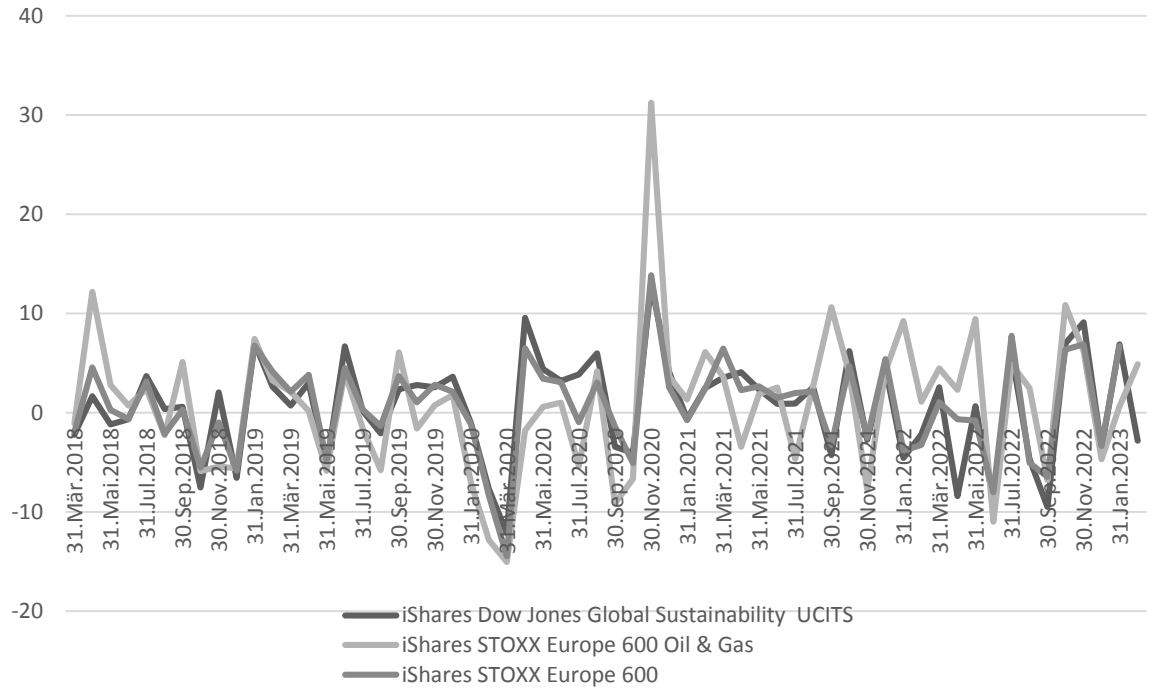

Figure 1. The monthly rates of return for iShares Dow Jones Global Sustainability UCITS ETF, iShares STOXX Europe 600 Oil & Gas UCITS ETF (DE) and iShares STOXX Europe 600 ETF (for the period from 31/03/2018 to 31/01/2023).

Source: own compilation based on data https://www.ishares.com/de//produkte/ [obtained on 05/03/2023].

Similar conclusions can be drawn analyzing monthly rates of returns for three instrument types. Figure 1 depicts monthly rates of returns for the following funds: sustainable development iShares Dow Jones Global Sustainability), in crude oil sector shares (iShares STOXX Europe 600 Oil&Gas) and the gas sector shares, and in the shares of 600 largest European companies (iShares STOXX Europe 600). That is data from the last five years, i.e. from March 2018 to January 2023.

According to the diagram, the rates of return for individual instruments displayed a similar trend. The largest fluctuations were observed for the rates of return for the funds of the crude-oil sector company shares. The lowest fluctuation could be seen for the rates of return for sustainable funds. Moreover, the rates of return for iShares Dow Jones Global Sustainability and iShares STOXX Europe 600 are highly convergent (the correlation coefficient is 0.93). This means that investments in sustainable funds are not only characterized by profitability comparable to standard instruments, but also entail lower risk.

To sum up, investments in environmental protection and sustainable development are beneficial both for the issuers and for the investors. From the macroeconomic perspective, the funds obtained from the capital providers are used to finance projects and activities aimed at improving the environment and impact the community.

5. Discussion

Money transformed within a financial system is a lever of environmental protection measures. Performance of eco-friendly measures, including e.g. transformation of power engineering and transport to achieve climate neutrality, is based on access to funds (Rydzewska, 2022, p. 251). Green investments are a source of capital when funding environmental protection and sustainable development projects, and also bring specific benefits for issuers and investors.

Business entities issuing instruments constituting green investments get the opportunity to obtain funds for eco-friendly and pro-community goals. In the longer term, the green transformation offers measurable benefits, including lower costs, improved risk management and relations with the local community, employees, suppliers and banks funding it. Investors investing in green investments may get rates of return comparable to the traditional instruments, with a lower risk and in harmony with their eco-friendly, pro-community and ethical values.

The processes supporting eco-friendly investments should involve not only institutional but also individual investors. For such a phenomenon to occur, households may take different measures. Figure 2 shows measures to be taken to that aim. They may refer to the banking system, to investments in securities indirectly and directly, to indirect financial investments and to direct in-kind investments.

The first area supporting eco-friendly investments is the banking sector. In this respect, households should analyze the banking offer and if the products included in it are connected with sustainable development. The offer should refer not only to securities advisory, but primarily to banking instruments, including special eco-friendly saving offers (bank deposits, passbooks) as well as credits and loans for eco-friendly purposes. Thanks to such savings, the investors may allocate their funds according to the ethical attitudes and values

related to the environmental protection. The loans and credits will allow funding private projects related to the environment improvement (e.g. green energy sources).

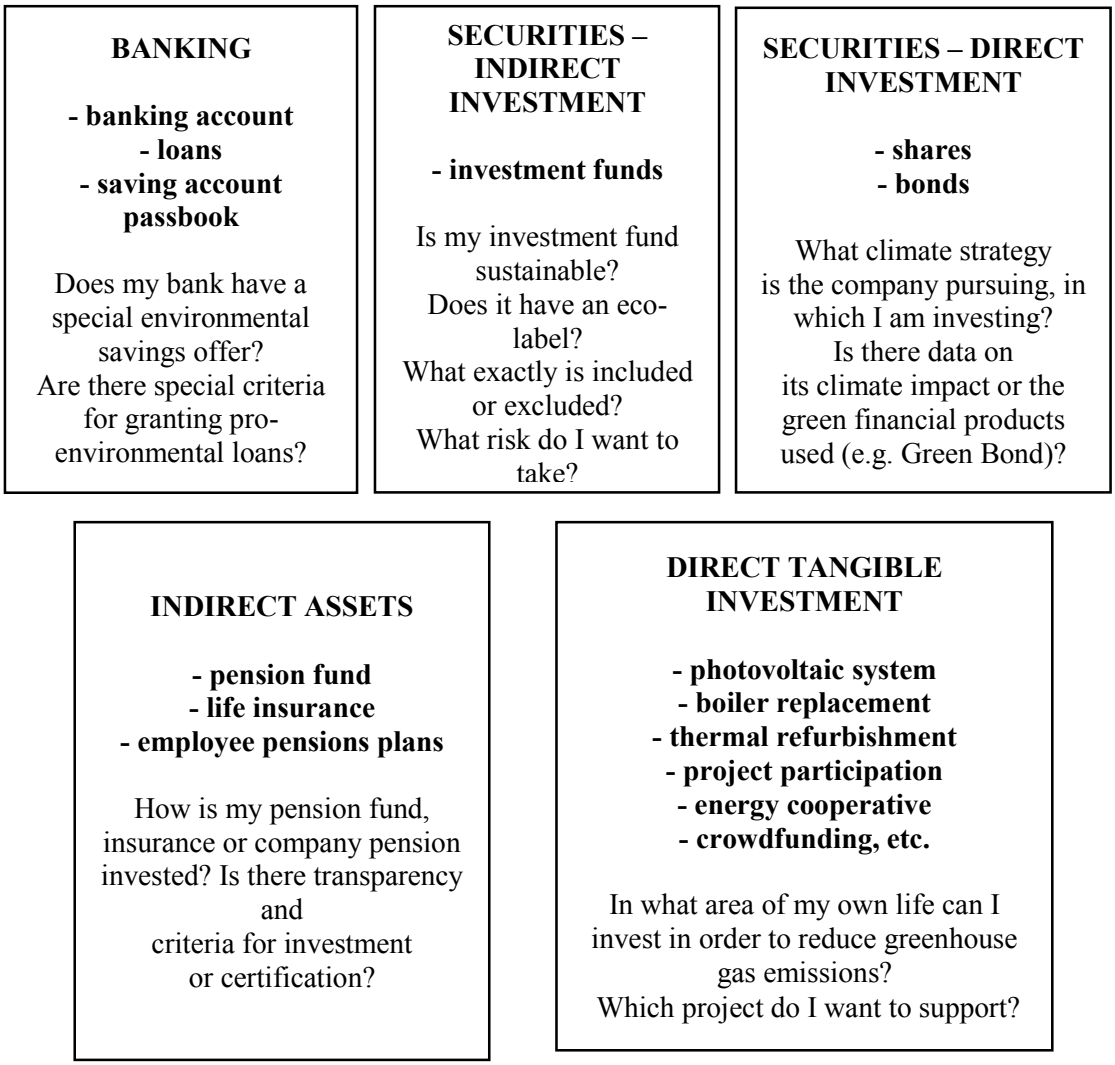

Figure 2. Forms of supporting investments in environment protection and sustainable development by individual investors.

Source: own work.

The second area is investments in securities indirectly, e.g. by means of sustainable development investment funds. By issuing participation units, those funds obtain finance from capital providers and invest them in shares, venture capital projects, private equity ones, etc. However, the investments must conform to the principles of sustainable development and ESG standards comprising aspects relating to the environmental protection (Environmental), social responsibility (Social) and management, corporate governance and counteracting corruption (Governance). To recognize such funds, investors may use digital platforms presenting their offer (e.g. Cleanvest platform).

The third area is direct investments in securities, usually shares or debt securities of specific business entities. However, for those investments to be related to sustainable development, they must refer to companies carrying eco-friendly activities and/or reducing any operations

detrimental for the climate in their corporate strategy. The problem is the identification of such business entities. They are selected, as it was already mentioned, based on the criteria of identifying activities conforming to ESG, criteria of entities' exclusion (e.g. in connection with the environment degradation, support for war activities), publication of reports and information on sustainable development and participation in creating sustainable development stock exchange indexes. Thanks to that, individual investors may look for new investment opportunities compliant with their values and financial expectations.

The fourth area refers to indirect financial investments. This means that when selecting retirement funds, insurance companies or company pension schemes, investors should find out what projects their funds are allocated to and if they are environmentally friendly. Moreover, it is important to learn the criteria of instrument selection for the investment and if they are certified. When selecting retirement and investment funds, exclusion criteria are also important, meaning elimination of directions detrimental from the sustainable development perspective.

The last area are the direct in-kind investments. Those activities are connected with individual decisions concerning everyday life, including purchase and/or installation of eco-friendly solutions, e.g. solar panels, biomass heating system, e-car or electric bike. They may also refer to common social projects, including energy cooperatives (participative solar power plants) where the residents fund or co-fund eco-friendly projects. This area comprises also common crowdfunding initiatives. This instrument involves collecting funds from a great number of small investors (mainly Internet users) and using them to finance projects. With respect to green investments, this includes numerous projects related to climate protection and pro-community initiatives.

6. Conclusions

Based on the analysis carried out in this study, it can be concluded that green investments are associated with certain benefits. For companies, they mean funds to finance environmental protection measures. They also improve business performance through cost savings and better risk management. They improve a company's reputation by improving relations with the local community, employees and contractors. For investors, on the other hand, green investments are a form of financial instruments that allow them to obtain rates of return comparable to traditional instruments, with lower risk. In addition, they are a direction of capital allocation that is consistent with pro-environmental, pro-social and ethical values. A survey conducted by Ernst&Young shows that about a quarter, so-called millennials, see sustainable investing as the most important factor in choosing investment products.

In conclusion, the problem of green investment is becoming increasingly urgent and important. In order to achieve the EU's environmental goals of achieving climate neutrality by 2050, it is urgent to mobilize more and, above all, private capital that will be channeled into investments related to climate protection and sustainable development. This also applies to individual investors, who can support pro-environmental and pro-social activities through their allocation choices in financial and physical investments. Households as individual investors have a number of options in this regard. These include decisions to choose pro-environmental banking instruments; to invest directly in securities (stocks, bonds) of companies operating in accordance with sustainability and ESG standards; to invest indirectly in sustainability investment funds or pension funds. The last option is in-kind investments related to daily operations, such as the purchase and installation of green solutions, such as photovoltaic panels, a biomass heating system, an e-car or an electric bicycle.

The considerations conducted in the paper and the conclusions formulated:

- contribute to the development of theory on instruments supporting climate protection actions, including but not limited to financial instruments included in the so-called green investments,
- in the management aspect, they indicate the need to improve the processes related to the development of legal frameworks, technological and expert support, education and development of financial instruments for activities related to sustainable development,
- from the social point of view, they indicate the need for further support for activities, including those of a financial nature, in the field of pro-ecological activity, due to their social importance.

A limitation in this article is the absence of data on the developmental trends of green investments and the directions of using funds for investments relating to the environmental protection and sustainable development. It should be emphasized, however, that the green finance notion is a relatively new one, developing both in the theoretical and in the practical aspect. The paper may therefore serve as a basis for further analysis relating to the development of instruments used to finance pro-ecological and pro-community investments.

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EVALUATION OF ENVIRONMENTAL PERFORMANCE IN COKE PRODUCTION – TOWARDS EMISSION REDUCTION AND INPUT RATIONALIZATION

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Purpose: Coke production is hindered by a number of serious environmental nuisances. It is also a capital- and cost-intensive production. Despite these complex production conditions, coke is regarded as a critical raw material due to its key importance in steel production worldwide and there are few circumstances nowadays that indicate a possibility of rapid change of the existing state of affairs. For these reasons, it is becoming extremely important in coke production to look for investment solutions that will enable the reduction of environmental hazards while at the same time rationalizing the economic outlays incurred in their implementation. Thus, the goal of this article is to present a methodology for evaluating the environmental effectiveness of investments in coking plants, making it possible to balance environmental and economic benefits.
Design/methodology/approach: The research made use of an analysis of environmental hazards in process terms, an index for evaluating environmental effectiveness and rules for assessing compliance with the Best Available Techniques (BAT) conclusions. In order to verify the proposed methodology, a multi-variant analysis was used relating to selected pro-environmental investment projects.
Findings: Against the background of previous analyses in this area, the considerations and research carried out are distinguished by the inclusion of a process approach to sources of emissions in coke production, rather than a point approach, and simultaneous consideration of environmental and economic criteria.
Practical implications: The presented methodology can also be applied to coking plants without major difficulties and additional costs, which is an additional, application value added of the article.

Keywords: environmental efficiency in coke production; reduction of pollutants in coke production.

Category of the paper: Research paper.

1. Introduction

Coke production is a technology for the high-temperature airless degassing of hard coal at a final temperature above 1,000°C, which takes place in a coking plant. In the commonly used so-called classic coking technology, from 1 Mg of dry coal an average of 750 kg of coke, 350 m^3 of gas, 35 kg of tar, 10 kg of benzol, 2.5 kg of ammonia and 50 kg of water containing many coal decomposition products, mainly phenolic compounds and ammonia, is obtained (Szlęk et al., 2009).

The basic production tasks of a coking plant boil down to the preparation of a coal mixture and the production of:

- Coke.
- Purified coke oven gas.
- Chemical coking products.

The main production branches of a coking plant include:

a) The coal plant.
b) The furnace plant.
c) Coal washing plant.
d) Sorting plant.

The process of proper coke production (Dudek-Dyduch, Dyduch, 2005) consists of the following basic technological operations:

- Filling the coking chambers with the coal mixture.
- Firing the coke oven battery.
- Coking of the coal mixture.
- Pushing out the coke.
- Cooling of the coke.
- Extracting gas from coking chambers.

The activity of coking plants can be classified as one of the most environmentally burdensome (Kwiecińska et al., 2017; Yang et al., 2018, 2019). The process of coke production is accompanied by the release of numerous air pollutants into the air, including very harmful ones, namely, carcinogenic (Mu et al., 2017; Dehghani et al., 2020; Lovreglio et al., 2018). This release takes the form of channeled and fugitive emissions of gaseous and particulate pollutants (Kozielska, Konieczyński, 2015). Channeled emission occurs when substances are introduced into the air in an organized manner through an emitter (stack) and it is measurable with standard measurement methods. Despite these complex production conditions, coke is treated as a critical raw material due to its key importance in steel production worldwide and currently there are few circumstances indicating that the status quo is likely to change quickly (Ozga-Blaschke, 2016; Blaschke, Ozga-Blaschke, 2015; Warzecha, Jarno, 2014).

Given the circumstances presented above, coke production plants are classified as those likely to cause significant environmental pollution, which clearly imposes on the plant operator the obligation to obtain a so-called integrated permit for the activities conducted.

Integrated permits are an instrument introduced by European Community Council Directive 96/61/EC on integrated pollution prevention and control. In the following years, as part of law enforcement, on November 24, 2010, the European Parliament and the Council adopted Directive 2010/75/EU, i.e., *The Industrial Emissions Directive* (IED). On January 6, 2011, the provisions of this directive became binding on all Member States (*Guidance on Assessment under the EU Air Quality Directives*).

The IED unifies the principles for establishing the conditions for the operation of industrial plants of relevance to environmental quality. In accordance with para. 12 of the Directive, the permit should include all measures necessary to achieve a high level of protection of the environment as a whole and to ensure that the plant complies with the general principles governing the basic obligations of the operator. The permit should include emission limit values for polluting substances or equivalent parameters or technical measures, appropriate requirements to protect the soil and groundwater and monitoring requirements. The permit conditions should be based on the best available techniques (BAT).

In light of the above, the environmental expectations on industrial plants are constantly increasing, therefore it is becoming increasingly important to manage coke production in the idea of sustainable development (Li et al., 2020; Makgato et al., 2019; Li, Cheng, 2020). It concerns the development conditioned by the ecological space, and through the assumed synergy of economic, environmental and social aspects, one which is safe and beneficial for people, the environment and the economy. The basic way of influencing and stimulating the operators of industrial plants in the field of environmental protection are environmental management instruments which can be divided into direct (legal-administrative) and indirect (economic-market) ones.

From the point of view of a coke plant operator, the most important direct instruments include: emission standards, air quality standards and technological requirements (Osmólski, Morel, 2013). Emission standards are strictly defined for individual emission sources and pollutants often in dedicated, activity-specific legal regulations. In order to check if the standard is met, emission measurements are performed (Wang et al., 2012; Yuan et al., 2017; Rychlewska et al., 2021). Emission measurements are commonly performed and technically unproblematic, but they do not give a complete picture of the impact of plants on air quality (Martins, Fonseca, 2018; Iraldo et al., 2009). They mostly concern single facilities in the production chain and a single emitter. Meanwhile, as already mentioned, in environmentally burdensome industries, which also include coking, emissions have many sources and concern many pollutants simultaneously. Under these circumstances, the need arises to improve the methods of assessing the environmental impact of industrial plants in the direction of taking into account the entire production process and many different criteria.

Another instrument is air quality standards, the values of which are defined on the basis of medical and biological diagnosis of the elements of the environment to the dose of a given pollutant, which allows to formulate acceptable levels of air pollution, which should not be exceeded (Amodio et al., 2013; Pilarczyk et al., 2013). The assessment of the impact of a plant on air quality is obtained by performing pollutant dispersion modeling, which is performed when applying for an integrated permit or its update (Żeliński et al., 2018). Deterministic models are mainly used in this assessment, which requires data on the unambiguous environmental effects of the projects introduced. These models are cheap and time efficient and at the same time work well in practice as forecasting models. Their basic task is to determine concentrations of pollutants in the air by solving equations describing physical and chemical phenomena occurring in the atmosphere, using independent variables describing conditions, types and amounts of emissions (dimensions of the emitter, temperature and velocity of gases at its outlet, emissions of particular pollutants), meteorological parameters, topographical and other parameters (Ma et al., 2019; Bailey et al., 2018; Van Donkelaar et al., 2016). Currently, these methods are being refined to assess the spread of pollutants in transboundary areas due to uneven implementation of environmental targets by countries (Mostafanezhad, 2021; Chen, Taylor, 2018). It is worth mentioning at this point that most existing models are mathematically complex, require a lot of data and time to calculate. For these reasons, they are best suited for regional, national and international analyses, and less often find direct practical application.

Technological requirements (Babich, 2021) include, among others, legal requirements such as BAT conclusions and their list of best available techniques to be implemented by a specific type of production activity (Sobolewski et al., 2006; Dellise et al., 2020; Evrard et al., 2016; Evrard et al., 2018; Huybrechts et al., 2018). The implementation of BAT in the process of implementation of environmental governance in the energy law of the European Union is currently postulated, which would definitely increase the rank and impact of these regulations (Giljam, 2018). Compliance of industrial plants with the requirements of the above-mentioned direct instruments provides a guarantee of safe, innovative use of the environment (Kuznetsov et al., 2019; Generalova et al., 2019; Zabelina, Sergienko, 2021), but also creates a risk for production activities that the required solutions will be too costly and therefore not always implementable. In this way, there is very often a clear separation between legal standards and industrial considerations.

Indirect instruments of an economic-market nature are instruments that stimulate rather than prescribe (Wasiuta, 2015; Chornomaz et al., 2017). These instruments are most often in the form of fees per unit of pollution introduced into the environment and are the main financial tool for influencing production facilities. Environmental charges were introduced mainly to encourage production plants to use natural resources rationally and economically and to finance environmental protection projects. The results of various environmental studies indicate that the use of fees and taxes is effective in reducing emissions (Brizga et al., 2021; Hu et al., 2019; Niu et al., 2016).

Direct and indirect instruments are an important element in the management of a coking company and can be selection criteria when investment decisions have to be made. These instruments are also guidelines for the development of environmental management strategies and multi-annual investment plans. Nevertheless, as already mentioned and as highlighted in the literature (Deng et al., 2017; Zhang, Wu, 2020) environmental management standards are not able to regulate all aspects related to industrial emissions. So, their application requires coke producers to take a responsible approach to environmental investments and decision makers to continuously improve existing standards.

In connection with the presented legal and environmental conditions, all coking plants operating in the European Union have been obliged to comply with the aforementioned regulations and existing environmental protection standards. Due to the cost-intensive nature of coking production, adapting production to the environmental requirements set out in EU legislation is a difficult challenge. The more so as additional legal restrictions are expected in the future for companies operating in sectors with exceptional environmental nuisance. Therefore, the goal of this article is to present a methodology for evaluating the environmental effectiveness of investments in coking plants, which enables the balancing of environmental and economic benefits and provides decision-making support for coke producers in the investment decision-making process. In the context of the thus formulated objective of consideration and research, the main research problem is as follows: *How to holistically assess a technological investment in the coking industry, taking into account environmental requirements and the investor's capital capabilities, bearing in mind the entire production process and its accompanying emissions?*

The viewpoint presented in this article is therefore not the more common regional or economic one. Nor does it refer exclusively to environmental or technological aspects. The authors of the study attempt to assess pro-environmental solutions for coking plants from a sustainable perspective, taking into account both current legal and environmental conditions, as well as capital constraints determining the final decisions of coke producers. It is worth noting that all environmental standards and norms must ultimately be translated into practical measures implemented in the industry. Otherwise, no environmental management instruments will be effective.

The research included: (1) Environmental hazard analysis from a process perspective; (2) Environmental performance evaluation index; and (3) The degree of compliance with *Best Available Techniques* (BAT) conclusions (Giljam, 2018; Mavrotas et al., 2009). In order to verify the proposed methodology, a variant analysis was used relating to selected pro-environmental investment projects. The considerations and research carried out - against the background of previous analyses in the area in question - stand out above all:

- Inclusion of a process-based (Li et al., 2020) and not a point approach (concerning 1 emitter) to emission sources in coke production.
- Considering several pollutants simultaneously.

- Analyzing environmental, technological and economic criteria in parallel.
- Taking into account the investor (decision-making) point of view.

The presented methodology may also be applied in coking plants without major difficulties and additional costs, which is an additional, practical value of the article.

2. Data and Methods

2.1. Environmental and investment assumptions

According to the literature, the results of the quantitative analysis indicate an apparent dominance of the share of emissions of CO_2 (99,2%) over the sum of other substances (CO, NO_x/NO_2, SO_x/SO_2, HCN, NH_3, CH_4, benzene, NMVOC, dust) (Zhong et al., 2013; Hu et al., 2014; Telenga-Kopyczyńska et al., 2010). Outside of CO_2, emissions of SO_x/SO_2, NO_x/NO_2, CO and dust present the highest share of emissions in a coke plant. The results of the qualitative analysis indicate PM10 and BaP as environmental nuisance substances (Hys et al., 2018). The main source of particulate emissions including BaP is fugitive emissions from the filling, coking and pushing out processes. In contrast, channeled emissions are mainly from the battery firing process with NO_X/NO_2 and SO_X/SO_2 emissions. Taking into account the recurrence, quantity and environmental nuisance of pollutants under current legal conditions, 4 pollutants were selected for environmental performance analysis: BaP, PM10, NO_2, SO_2, as substances both characteristic for coke production and having quantitative and qualitative impact on the state of air cleanliness. The further analysis did not include total dust due to the lack of a permissible level for this pollutant in the air and research results showing that the PM10 fraction accounts for almost all the total dust.

The pollutants selected as a result of the analysis were assigned to each of the technological processes mentioned in the introduction, according to their emission characteristics, which is presented in Table 1.

Table 1.
Selected pollutants from specific technological processes

Process	Pollution
Preparation of the coal mixture	PM10
Filling of coke oven batteries	SO_2, PM10, BaP
Coking of the coal mixture	NO_2, SO_2, PM10, BaP
Firing of coke oven batteries	NO_2, SO_2, PM10, BaP
Pushing out the coke	NO_2, SO_2, PM10, BaP
Wet cooling of the coke	SO_2, PM10, BaP
Coke sorting	PM10
Burning coke gas	NO_2, SO_2, PM10

Source: Own elaboration based on Przewodnik metodyczny (2010): Uwalnianie i transfer zanieczyszczeń do środowiska będących efektem eksploatacji instalacji koksowniczych w Polsce. Zabrze, Zabrze, Published by the Institute for Chemical Processing of Coal.

For further analysis it was assumed that the coking plant under study is characterized by the technological output parameters listed in Table 2. Within the analyzed coking plant there are 5 coke oven batteries without dedusting and desulphurization plants, which reflects the maximum environmental harmfulness of coke production.

Table 2.
Baseline techniques in the coke oven output plant

Process	Baseline techniques
Carbon plant, batch preparation	No dedusting plant
Filling	Hydroinjection
Coking	Exhausted coke oven batteries, large leaks
Firing	Discharged coke oven batteries, no flue gas recirculation, no desulphurization plant
Pushing	No dedusting plant
Wet cooling	Extinguishing towers with depleted filling
Sorting and transportation of coke	No dedusting plant
Burning coke gas	No coke gas desulphurization plant, poor condition of burners

Source: own work.

Next, 6 investment projects were proposed which would enable the modernization of the adopted coking plant in order to reduce its environmental nuisance, taking into account the characterized technological processes. These variants constitute a compilation of possible technical and investment measures including (a detailed description of individual investment projects is presented in the study results section):

- Construction of new coke oven batteries.
- Construction of a desulphurization plant.
- Construction of a dedusting plant.
- Installation of an inertial dust collector.
- Partial overhaul of coke oven batteries.
- Partial overhaul of the heads.
- Replacement of doors.
- New filling trucks.
- New quenching towers.
- Sealing of charging and technological openings.

Compilation of the above-mentioned activities within the framework of the assessed variants was aimed at presenting a catalog of solutions possible to be applied in the whole coke production process, oriented at simultaneous reduction of channeled and fugitive emission for all pollutants listed in Table 1. The developed variants are therefore process-oriented and take into account the multi-emission nature of coke production (Kulczycka, Smol, 2015). This approach is not used either theoretically or in practice due to the fact that the applicable standards and regulations refer to channeled emissions, single emitters and unit emission sources. Nevertheless, from the point of view of the need to protect the environment, tightening

standards and principles of sustainable development, it should be considered advisable from a theoretical and practical point of view.

Environmental inconvenience of the baseline variant and proposed investment variants was characterized by:

- Total emissions of a given pollutant [Mg/year].
- Number of points with exceedances of acceptable standards for a given pollutant using indicators presented in Table 3.

Table 3.
Ratios adopted in the analysis of environmental nuisance for individual pollutants in process terms

Process	Ratio for individual pollutants [g/Mg coke].			
	BaP	SOx	NOx	PM10
Firing	0.003	990	900	80
Pushing	0.018	45	15	30
cooling	0.003	20	-	20
Sorting plant	-	-	-	5
Coal plant	-	19	15	20
Filling	0.006	7	-	5
Coking	0.270	19	15	5

Source: own work.

2.2. Research phases and principles for assessing environmental performance

Having made the aforementioned environmental and investment assumptions, an assessment of environmental performance was undertaken. As part of its calculation, the following variables were used:

1. Investment outlays [in PLN] **(I)** for the implementation of individual projects, which were determined on the basis of current prices of necessary assets and labor on the basis of a market survey.
2. Value of avoided emission [in Mg/year] **(Em)** calculated as the difference of the emission in the baseline scenario and the emission obtained after the implementation of the technological changes planned in the given scenario.
3. Cost of avoided emission **(C_{Em})** (external cost of pollution) [in PLN/Mg] is an estimated value which includes, among others, costs of hospitalization, sick leaves, rehabilitation and lost years of life connected with the emission of a given pollutant - its amount was given in the report of the European Environment Agency - (*EEA Technical report, Costs of air pollution from European Industrial facilities 2008-2012 - an updated assessment,* p. 26).
4. Environmental benefit **(B_{env})** [PLN/year] which is the product of the avoided emission **(Em)** and the cost of avoided emission **(C_{Em})**.

The adoption and definition of the above variables made it possible to calculate the so-called environmental effectiveness **(Ef_{env})**, which is the ratio of the environmental benefits obtained to the investment outlays incurred:

$$Ef_{env} = \frac{B_{env}}{I} = \frac{E_m \times C_{Em}}{I} \tag{1}$$

This method was proposed for large combustion plants as a guideline for obtaining a derogation from compliance with BAT (*Podręcznik dotyczący zasad udzielania odstępstw od granicznych wielkości emisyjnych zawartych w Konkluzjach BAT dla dużych źródeł spalania (LCP)*) due to the possibility of the so-called disproportion of costs to environmental benefits. In the article it was used to assess the environmental effectiveness of individual investment variants, as it reflects the proportion between the achieved emission reduction and the expenditures incurred to achieve it. However, the original variant of this method was modified by calculating the following:

- The environmental benefit as the sum associated with the reduction of all described pollutants accompanying the production of coke.
- Investment outlays as a sum related to the implementation of all technological changes proposed in a given variant.

The results obtained after calculating the environmental effectiveness allow to economically and environmentally assess the profitability of the given investment variant. However, they do not provide grounds for assessing the degree to which a given solution fulfills the concessions included in the BAT guidelines. For these reasons, the authors propose a further modification of the calculation and correction of the calculated value of environmental effectiveness by the degree of compliance of a given investment variant with the BAT conclusions (BAT%):

$$Ef'_{env} = \frac{B_{env}}{I} \times BAT_{\%} \tag{2}$$

At the same time, it is postulated that the degree of meeting the BAT conclusions should be calculated as a resultant for all technological processes in coke production due to the circumstances mentioned in the introduction. In practice, this will be done by calculating the arithmetic mean for the fulfillment of BAT conclusions in the processes of firing, planting, coking, pushing, quenching, desulphurization and in the processes carried out in the sorting plant and the coal plant. Such an approach was applied in the following part of this article.

3. Results

As already mentioned, 6 investment projects were proposed as part of the presentation of the methodology for evaluating investment efficiency in the coke production process. The scope

of changes and technical modifications characterizing the adopted investment variants is presented in Table 1.

For all these variants and the baseline variant, a pollutant dispersion analysis was conducted and the number of points where acceptable emission standards were exceeded was determined. This was done taking into account the multi-emission nature of coke production for such emitters as: BaP, SO_2, PM10 and NO_2. The COPDIMO software was used to achieve the goal. The obtained results for each of the variants are included in Table 4.

Additionally, Table 4 presents all the economic parameters necessary for calculating the environmental effectiveness in a single, non-aggregated approach, i.e., the investment outlays determined on the basis of market research and the value and cost of avoided emissions.

Next, Table 5 presents the results of the assessment of compliance with the BAT conclusions by all analyzed variants in process terms - covering 8 key production processes - and in summary terms, calculated as an arithmetic mean of all processes.

The results of the corrected environmental effectiveness (including the above-mentioned degree of compliance with the BAT conclusions) are presented in Table 6. This table also ranks all the analyzed variants according to the following criteria:

1. Partial, used in the calculation of effectiveness, i.e., inputs, environmental benefit, and the degree of meeting the BAT conclusions.
2. Aggregated to environmental effectiveness and adjusted environmental effectiveness.

Table 4.
Evaluation of environmental and economic aspects of the analyzed investment alternatives

Pollution	**BaP**	**SO_2**	**PM10**	**NO_2**
Baseline variant: 5 coke oven batteries used, including accompanying devices, without dedusting and desulphurization plants				
Number of points with exceedances	102	3	0	0
Variant 1: Construction of 5 new coke oven batteries and dedusting plants, new charging cars and new quenching towers, desulphurization plant, dedusting of sorting and coal plants				
outlays [million PLN]	73.6			
Avoided emissions [Mg/year]	1.05	4,498.90	559.79	3,051.21
Costs of avoided emission [PLN/Mg]	5,499,700.00	42,105.60	98,857.00	19,001.70
Environmental benefit [PLN/year]	5,769,185.30	189,428,883.84	55,339,160.03	57,978,177.06
Environmental effectiveness	0.11	2.57	1.05	1.31
Number of points with exceedances	0	0	0	0
Variant 2: 1. Partial overhaul of coke oven batteries 2. Replacement of all doors using the original solution, sealing of charging and technological holes, inertial separator.				
outlays [million PLN]	7.9			
Avoided emissions [Mg/year]	0.52	114.47	192.38	1,033.13
Costs of avoided emission [PLN/Mg]	5,499,700.00	42,105.60	98,857.00	19,001.70
Environmental benefit [PLN/year]	2,846,644.72	4,819,828.03	19,018,109.66	19,631,226.32
Environmental effectiveness	0.36	1.07	2.41	2.49
Number of points with exceedances	60	1	0	0

Cont. table 4.

Variant 3: 1. Construction of 2 new coke oven batteries 2. Partial overhaul of batteries and heads with adjustment 3. Replacement of the door using the original solution of batteries 4. Sealing of charging and technological holes 5 Inertial dedusting plant				
outlays [million PLN]	21.2			
Avoided emissions [Mg/year]	0.71	128.06	250.93	1,831.61
Costs of avoided emission [PLN/Mg]	5,499,700.00	42,105.60	98,857.00	19,001.70
Environmental benefit [PLN/year]	3,891,587.72	5,392,043.14	24,806,187.01	34,803,703.74
Environmental effectiveness	0.18	0.28	1.17	1.64
Number of points with exceedances	36	1	0	0
Variant 4: 1.Construction of 3 new coke oven batteries 2.Partial overhaul of heads 3. New construction doors 4. New charging truck 5. dedusting plant for 3 batteries				
outlays [million PLN]	32.8			
Avoided emissions [Mg/year]	0.94	171.18	299.90	2,241.57
Costs of avoided emission [PLN/Mg]	5,499,700.00	42,105.60	98,857.00	19,001.70
Environmental benefit [PLN/year]	5,175,217.70	7,207,636.61	29,647,214.30	42,593,640.67
Environmental effectiveness	0.16	0.23	0.91	1.38
Number of points with exceedances	8	2	0	0
Variant 5: 1.Partial overhaul of coke oven battery heads 2. New construction doors 3. New charging truck on all batteries 4. Dedusting plant for all batteries 5. Building a desulphurization plant				
outlays [million PLN]	36.4			
Avoided emissions [Mg/year]	0.87	4,422.10	258.04	1,070.91
Costs of avoided emission [PLN/Mg]	5,499,700.00	42,105.60	98,857.00	19,001.70
Environmental benefit [PLN/year]	4,762,740.20	186,195,173.76	25,509,060.28	20,349,110.55
Environmental effectiveness	0.26	5.12	1.41	1.38
Number of points with exceedances	18	0	0	0
Variant 6: 1. Partial overhaul of the heads of all batteries 2. Doors of new construction of all batteries 3. New charging truck on all batteries 4. Dedusting and desulphurization plant on all batteries 5. New quenching towers				
outlays [million PLN]	40.8			
Avoided emissions [Mg/year]	0.88	4,487.80	321.13	1,070.91
Costs of avoided emission [PLN/Mg]	5,499,700.00	42,105.60	98,857.00	19,001.70
Environmental benefit [PLN/year]	4,812,237.50	188,961,511.68	31,745,948.41	20,349,110.55
Environmental effectiveness	0.21	4.63	1.41	1.38
Number of points with exceedances	18	0	0	0

Source: own work.

Table 5.

Assessment of compliance with the environmental criteria laid down in BAT

Processes	**Variants**					
	1	**2**	**3**	**4**	**5**	**6**
Firing	100%	50%	75%	90%	85%	85%
Filling	100%	50%	50%	100%	100%	100%
Coking	100%	50%	75%	90%	85%	85%
Pushing	100%	50%	50%	100%	100%	100%
Quenching	100%	0%	0%	0%	0%	100%
Desulphurization	100%	0%	0%	0%	100%	100%
Sorting plant	100%	0%	0%	0%	0%	0%
Coal plant	100%	0%	0%	0%	0%	0%
Total fulfillment	100%	25%	31.25%	47.50%	58.75%	71.25%

Source: own work.

Table 6.
Summary of environmental and economic assessment results

Variants	Assessment criteria									
	1	2	3	4	5	6	7	8	9	10
	outlays [million PLN]	Ranking acc. to 1	Environmental benefit [PLN/year]	Ranking acc. to 3	Environmental effectiveness	Ranking acc. to 5	Meeting the BAT conclusions [%]	Ranking acc. to 7	Holistic effectiveness assessment	Ranking acc. to 9
1	73.6	1	308,515,406.23	1	4.19	4	100.00	1	4.19	2
2	7.9	6	46,315,808.73	6	5.87	3	25.00	6	1.47	4
3	21.2	5	68,893,521.60	5	3.25	5	31.25	5	1.02	6
4	32.8	4	84,623,709.28	4	2.58	6	47.50	4	1.23	5
5	36.4	3	236,816,084.79	3	6.51	1	58.75	3	3.82	3
6	40.8	2	245,868,808.14	2	6.03	2	71.25	2	4.30	1

Source: own work.

Thus, taking into account the expenditures, the most expensive option is 1, which assumes the most advanced modification of the basic coking installation, including construction of 5 new batteries. The expenses incurred for its implementation are over PLN 73 million. However, its use is connected with elimination of all excess points and the highest value of environmental benefit. This variant is also characterized by 100% compliance with BAT conclusions. Therefore, it can be stated that it is the most beneficial for the natural environment. Nevertheless, from the economic point of view, it will certainly not be chosen by the investor, because in practice it means construction of a new coking plant from scratch, which with the current environmental requirements - relating to individual emission sources and types of pollution - is not legally necessary and will not be economically viable.

The cheapest option is Variant 2, which assumes only a partial overhaul of the battery, replacement of doors and sealing of charging and technological openings and installation of an inertial dust collector. Nevertheless, the implementation of this variant would mean the lowest reduction of exceedance points for BaP, the lowest value of environmental benefits and the lowest degree of meeting the BAT conclusions in terms of process. Therefore, the investment expenditure incurred would bring negligible environmental benefits.

Therefore, in the context of the obtained partial results, it is worth looking at the value of the aggregated assessment of individual variants performed with the use of environmental effectiveness and adjusted environmental effectiveness taking into account, apart from the investment outlays and environmental benefits, also the degree of meeting the BAT conclusions.

Taking into account the original form of economic effectiveness, the most beneficial variants are Variants 5 and 6. The environmental effectiveness for the first of the mentioned options is 6.51, and for the second - 6.03, which means that the value of environmental benefits obtained thanks to these options exceeds the value of investment outlays by more than six times.

Variant 5 - the most beneficial in terms of environmental effectiveness - assumes: partial overhaul of the battery heads, insertion of doors of a new design, installation of a new charging truck and use of the dedusting and desulphurization plant. The expenditures related to this variant amount to over 36.4 million PLN and are over 50% lower than in case of Variant 1, while ensuring a comparable environmental effect. In Variant 5, the number of exceedance points for BaP was significantly reduced (from 102 to 18) and points with exceedances for other emitters were eliminated: SO_2, PM10 and NO_2. This variant is also characterized by a high (third highest, after Variant 1) degree of meeting the BAT conclusions, amounting to 58.75%.

Variant 6 - the second in terms of environmental effectiveness - assumes the renovation of all batteries, installation of the dedusting and desulphurization system, replacement of all doors with new ones and purchase of a new charging truck for all batteries. The expenditures related to this variant amount to over PLN 40.7 million and are over 44% lower than in case of Variant 1, while ensuring a comparable environmental effect. In Variant 6, the number of exceedance points for BaP was significantly reduced (from 102 to 18) and points with exceedances for other emitters were eliminated: SO_2, PM10 and NO_2. This variant is also characterized by a high (second highest, after Variant 1) degree of meeting the BAT conclusions, amounting to 71.25%.

Bearing in mind the identified imperfection of the measurement of environmental effectiveness, the article proposes its correction by the degree of compliance with the BAT conclusions in process terms, which strengthens the importance of environmental criteria in the assessment and selection of the final investment variant. After the application of the indicated adjustment, the best variant turns out to be Variant 6 which gives the best effects in terms of outlays, environmental effectiveness and meeting the BAT conclusions. Additionally, we also avoided indicating Variant 2 as third in the hierarchy of importance, which was the case when measuring environmental effectiveness in the unadjusted option. In this case, Variant 1 - the most expensive and most beneficial from the environmental point of view - takes the second place, followed by Variant 5, which offers environmental benefits very similar to the leader of the ranking at a slightly lower level of meeting the BAT conclusions but lower investment outlays.

4. Conclusions and discussion

The methodology of environmental effectiveness assessment described in the article can be a valuable tool for coking plants, supporting the process of making investment decisions. The considerations presented in the introduction show that these plants - due to significant environmental nuisance (Kwiecińska et al., 2017; Yang et al., 2018, 2019) – must be guided in their choices by both economic and environmental criteria. The proposed method of evaluating investment projects in the coking industry is therefore adapted to current social and legal-

environmental requirements. In addition - due to its more restrictive nature assuming a process approach and the multi-carbon nature of coke production - it is also forward-looking in nature related to tightening environmental requirements and social needs and expectations (Li et al., 2020; Makgato et al., 2019, Li, Cheng, 2020).

The investment options presented and their evaluation also allow us to see the multiplicity of decision options available and quickly assess their environmental and economic impacts. They also create a spectrum of possibilities from among which the decision-maker can choose those that are suited to his financial possibilities, but at the same time give the best possible environmental effect.

The presented methodology and the obtained results can also be used in an accessible and quick way in the context of indirect (economic-market) instruments of environmental management, as the choice of an appropriate investment option allows to optimize the burden of environmental charges for pollutant emissions in production processes (Wasiuta, 2015; Chornomaz et al., 2017). Especially since previous studies expose the effectiveness of financial restrictions in reducing emissions (Brizga et al., 2021; Niu et al., 2016), which increases the likelihood of their increase in subsequent years. Investors in environmentally burdensome industries should therefore take the above circumstances into account in order to take actions which are socially responsible, but also optimal in economic terms.

In a broader context, the considerations presented in this article draw attention to a certain fragmentary character of the assessment of the environmental harmfulness of coking plants and other industrial installations referred to in the legal regulations mentioned in the introduction. They omit the occurrence of sources of fugitive emissions and do not take into account parallel occurrence of many sources of pollution in successive production processes. Therefore, on the basis of the obtained results and observations, direct (administrative and legal) instruments of environmental management may be improved in order to eliminate the shortcomings mentioned above (Wang et al., 2012; Yuan et al., 2017; Rychlewska et al., 2021; Martins, Fonseca, 2018; Iraldo et al., 2009). Environmental assessment should be carried out in a comprehensive manner, taking into account the entire production process. If it concerns only single emitters and production facilities, it has in fact an illusory dimension. Although it meets the existing standards, it does not allow to minimize environmental risks, which gives rise to serious consequences for human health and life (Dehghani et al., 2019; Yang et al., 2019).

Further research in the context of environmental performance of industrial facilities can be pursued as a benchmarking study for other industries. They can also relate to guiding the improvement of direct and indirect environmental management tools. They should also be oriented towards the actual assessment of the harmfulness of industrial processes, carried out not only in the context of current legal-environmental standards, but taking into account their holistic impact on the quality of the environment and human life.

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A DECOMPOSITION STUDY OF THE TIME SERIES OF ELECTRICITY CONSUMPTION FORECASTING ERRORS

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Purpose: This paper attempts to present a method for studying hourly time series of forecasting errors in electricity consumption in the context of daily and weekly seasonality.
Design/methodology/approach: The proposed approach is based on MSTL (Bandara, Hyndman, Bergmeir, 2021) decomposition of hourly forecast error series. The method is presented using the example of household electricity consumption based on data (Makonin, 2019). The time series was divided into a training set and a test set. The forecast was made based on the training set for the test period. Next, the time series of differences between the actual (test set) and forecast values was examined. Calculations were performed in the R environment.
Findings: Decomposition of the forecasting error time series makes it possible to isolate the seasonal (systematic) components of forecasting errors. The values of daily and weekly errors show how forecast values deviate from actual values in a systematic way. These values can be used to adjust forecasts in subsequent periods.
Research limitations/implications: Identification and inclusion of seasonal components in forecasting errors may not improve forecast quality. The assumption made about daily and weekly seasonality of the error may not be met.
Originality/value: This paper presents a decompositional approach to examining the time series of forecasting errors in order to identify deterministic error components for possible adjustment of future forecasts.

Keywords: forecasting error decomposition, error time series, forecasting error analysis, multi-seasonal decomposition.

Category of the paper: Research paper, Conceptual paper.

1. Introduction

Forecasting electricity consumption is of significant economic importance. It is primarily related to electricity demand planning.

Various approaches and models are used to forecast electricity consumption (Islam et al., 2022; Ghalehkhondabi et al., 2017). In addition to classical methods (Hyndman, Athanasopoulos, 2018), artificial intelligence models are also used (Ahn, Kim, 2022).

Electricity consumption series are characterized by seasonality (daily, weekly and yearly) which forecasting models should take into account (Shao et al., 2017).

In business practice, profiles (mainly annual) of electricity consumption are often used (Duarte et al., 2022; Anvari et al., 2022; Bargiel et al., 2019). The main reasons for using consumption profiles are: there are historical data gaps (Kowalska-Styczeń et al., 2022); consumption readings are taken at a different frequency than required.

As a result, forecasts have large errors, which can be subjected to various analyses. In general, averaged forecasting errors are determined, such as Mean Absolute Error, Mean Squared Error. A more detailed study of forecasting errors can involve Fourier analysis (Yang et al., 2022). In such a situation, the time series of forecasting errors can be analyzed like any time series.

In this paper, it is assumed ad hoc that the forecasting error series is characterized by the same seasonality as the electricity consumption series. For the identification of individual components, the considerations presented here refer to a forecasting perspective in which the error time series is sufficiently long.

The main objective of this paper is to present the author's method for investigating forecasting errors in the context of daily and weekly seasonality based on the MSTL decomposition (Bandara et al., 2021), for hourly data. The identification of the daily and weekly components of the error series shows what proportion of the overall error is accounted for by daily and weekly systematic variation. The identification of systematic components can be used to adjust the forecasting model in subsequent forecasting periods.

2. Materials and methods

Secondary data was analyzed (Makonin, 2018). The time series "Residential_1.tab", which shows electricity consumption [kWh] in bungalows (belongs to single-level houses built in the 1940s and 1950s). Hourly data from 2012-06-01 to 2015-05-31 were used for the analysis.

The time series was divided into two subsets (two time windows). Each subset covered one year.

The first subset covered the period from 2012-06-01 to 2013-05-31 and constituted the learning part (training set). Based on this set, a forecast was made for the following year.

The second subset of data covered the period from 2013-06-01 to 2014-05-31 and constituted the test part (test set) for forecasts built on the basis of the first subset. Based on the second subset and the forecasts covering this period, a series of forecasting errors was determined and analyzed.

The data and the division of the data into subsets are shown in Figure 1.

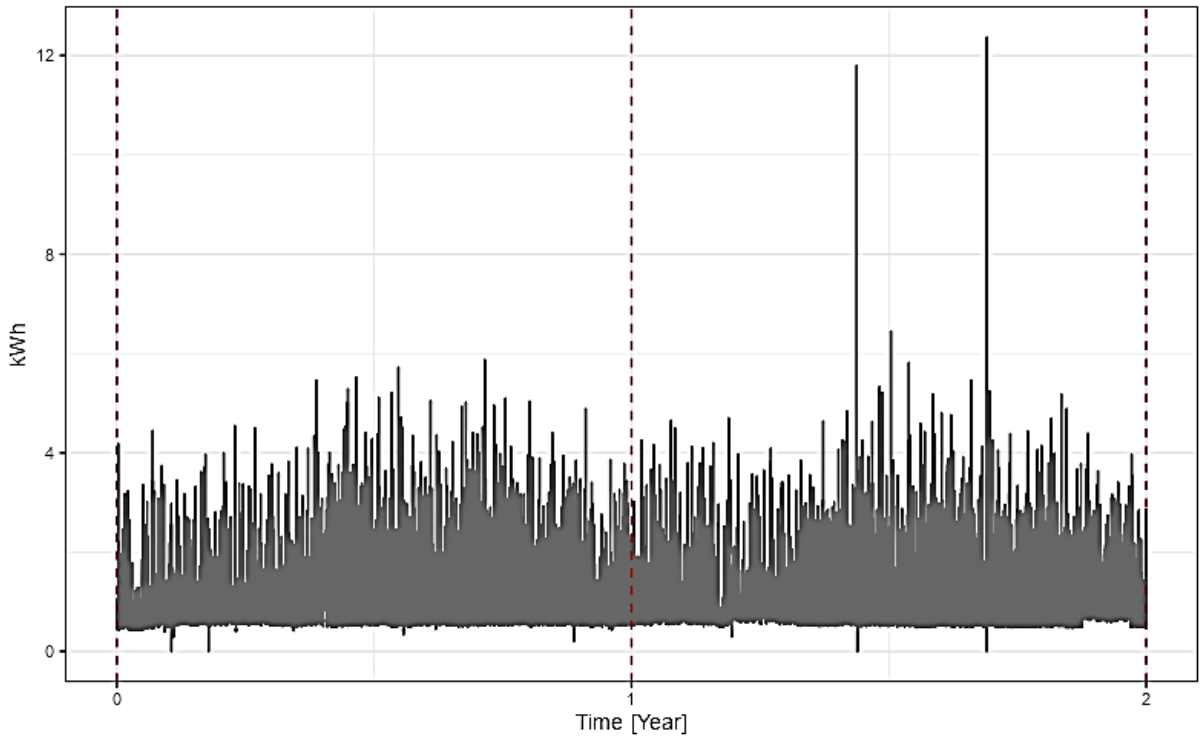

Figure 1. Hourly electricity consumption by training and test sets.

The research was carried out in stages related to the division of data into subsets. In the first stage, a forecast for the following year was built. A seasonal naive model was used, taking into account annual seasonality.

In the second stage, forecasting errors were determined for the test set and an MSTL (Bandara et al., 2021) decomposition of the error series was performed. The average daily and weekly profile of forecasting errors was determined. The strength of seasonality and trend in the errors was examined using measures (Wang et al., 2006):

$$F_T = \max\left(0, 1 - \frac{Var(R_t)}{Var(T_t + R_t)}\right), \tag{1}$$

$$F_S = \max\left(0, 1 - \frac{Var(R_t)}{Var(S_t + R_t)}\right), \tag{2}$$

where:

T_t is the smoothed trend component,

S_t is the seasonal component,

R_t is a remainder component.

Equation (1) determines the strength of the trend component and equation (2) the seasonal component. The MSTL decomposition is additive, so the strength of the seasonal component (2) was counted separately for the analyzed seasonality and together. Measures of component

strength (1) and (2) take values from 0 to 1. The closer the value to 1, the stronger the component.

All calculations were performed in the R environment (R Core Team, 2022), using the "forecast" package (Hyndman et al., 2022).

3. Results

The data subsets studied have a similar distribution of values (Figure 2).

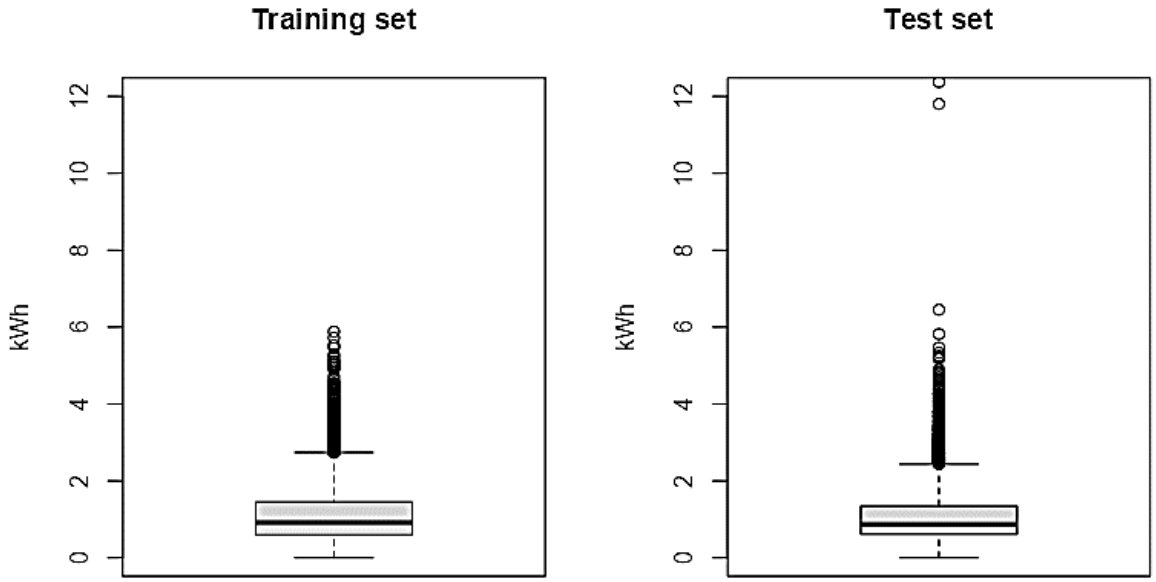

Figure 2. Distribution of values of the considered data sets.

The basic numerical descriptive characteristics are shown in Table 1.

Table 1.
Basic descriptive characteristics of the data sets under consideration

Measure	Training set	Test set
Minimum	0.000	0.000
1st quartile	0.596	0.614
Median	0.918	0.873
Mean	1.141	1.098
3rd quartile	1.454	1.343
Maximum	5.880	12.372
Standard deviation	0.699	0.697

The main difference in the distributions relates to the maximum values. There are two definite outlier observations in the test set. Since the problem relates to electricity consumption for two hours during the year, this has no significant impact. Moreover, there is no indication that the recorded consumption is a consequence of the error. Thus, these observations were left in the set.

Based on the training set, a forecast was made for the following year, that is, for the time period of the test set. The forecasting results are shown in Figure 3.

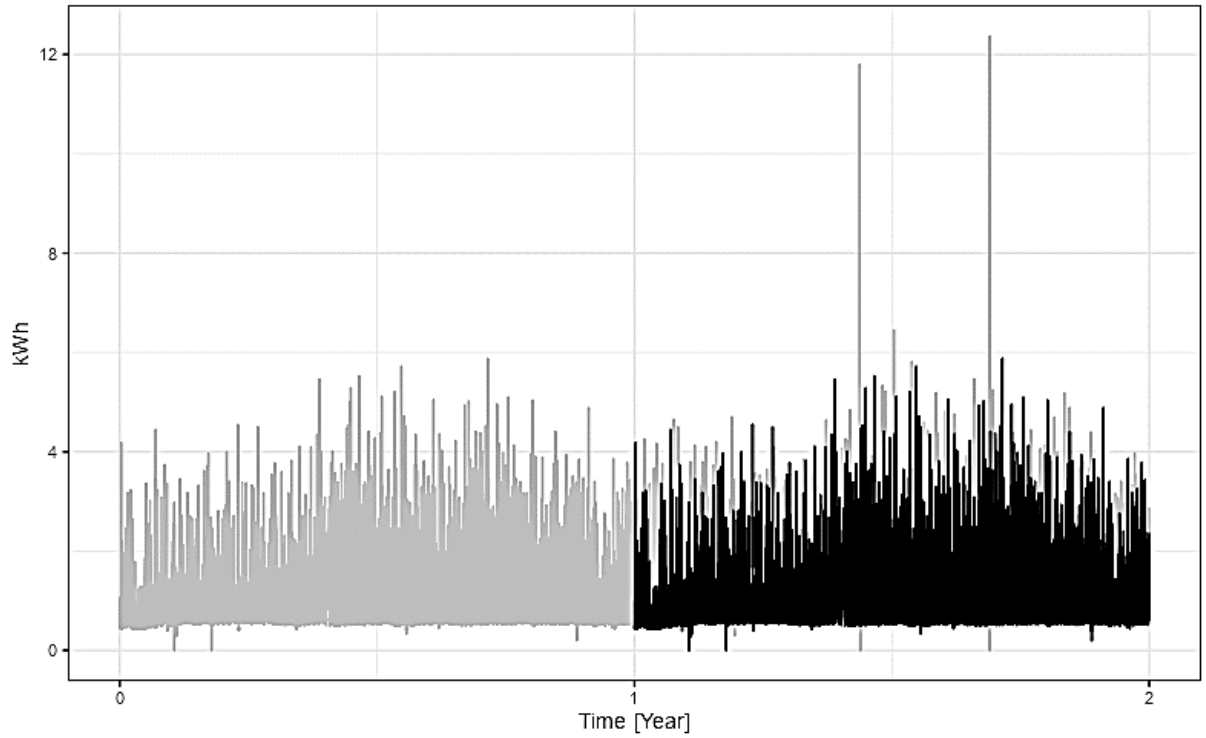

Figure 3. Actual (gray) and forecast (black) values of electricity consumption.

For the test set, forecasting errors were calculated as the difference between actual and forecast values. Figure 4 shows the time plot of forecasting errors, the autocorrelation function (ACF) and the partial autocorrelation function (PACF).

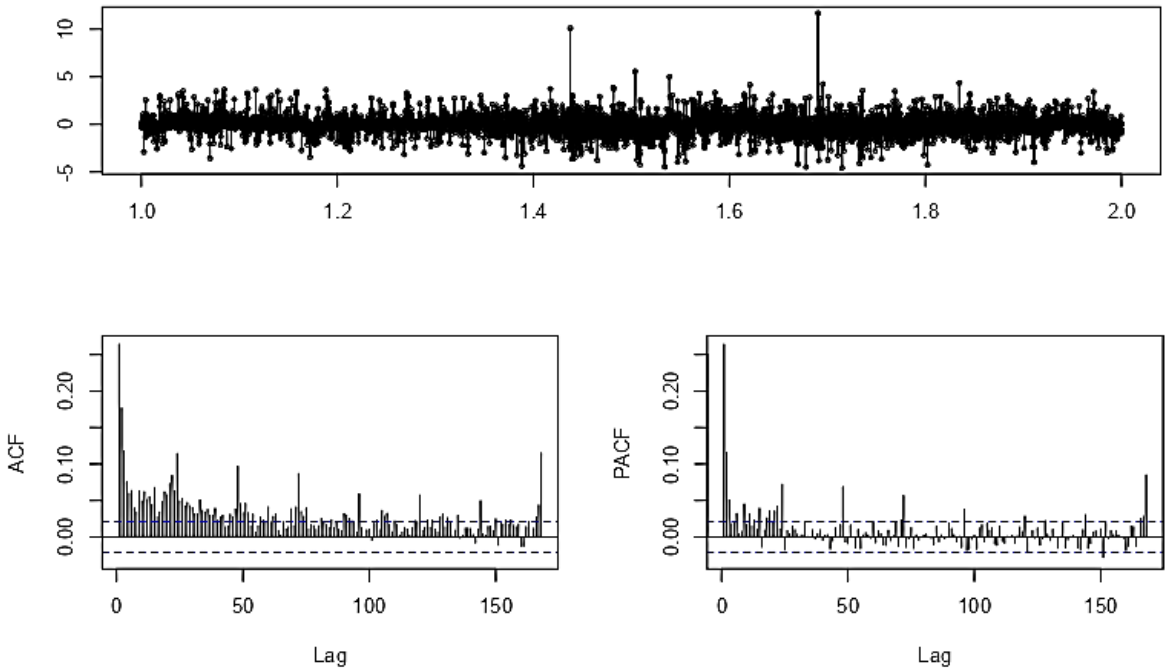

Figure 4. Forecasting error series and ACF and PACF charts.

In the ACF and PACF charts, one can see significant peaks for 24-hour delays (and multiples). One can also see a clearly greater autocorrelation for 168-hour delays. This confirms the presence of daily and weekly seasonality in the series.

Decomposition of the error series was performed using the MSTL method (Bandara et al., 2021). The individual components of the decomposed forecasting error series are shown in Figure 5.

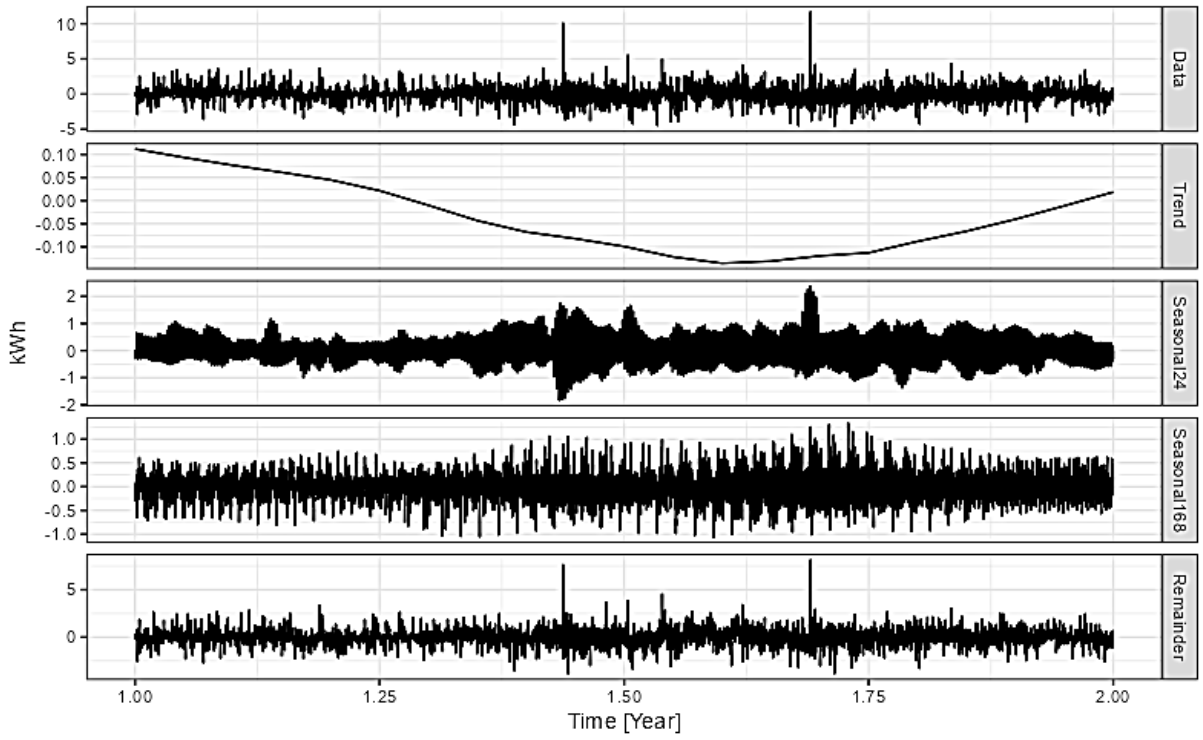

Figure 5. Error time series decomposition.

In Figure 5, the "Data" time series shows the development of forecasting errors. The following time series: "Trend," "Seasonal24" and "Seasonal168" present the deterministic components of the forecasting error series. The "Remainder" component, on the other hand, should present the error series related to randomness, although technically it is the difference between the "Data" error series and its deterministic component.

By comparing the average forecasting errors counted for the "Data" series and those counted for the "Remainder" series, it is possible to assess how the elimination of the deterministic components of forecasting errors affects the quality of the forecast. The following errors were determined for the considered series and are shown in Table 2: Mean Absolute Error (MAE), Mean Squared Error (MSE), Mean Absolute Percentage Error (MAPE), Median Absolute Error (MdAE), Median Squared Error (MdSE), Median Absolute Percented Error (MdAPE).

Table 2.
Total forecasting errors and errors after elimination of deterministic components

Error	Time series	
	"Data"	**"Remainder"**
MAE	0.535	0.427
MSE	0.704	0.414
MAPE	50.4%	41.1%
MdAE	0.310	0.271
MdSE	0.096	0.074
MdAPE	30.4%	28.4%

Given the large size of the analyzed set (8,760 observations), it can be assumed that for all calculated measures, significantly lower values were obtained for the "Remainder" series.

The strength of the trend component determined according to formula (1) is 0.085. This means that the trend component in the forecasting error is very weak. For the seasonality components, considered together, the value of measure (2) is 0.377. For the component of daily seasonality (Seasonal24) is 0.274. While for weekly seasonality (Seasonal168) it is 0.182. This means that the seasonality in the analyzed series is weak. At the same time, daily seasonality is relatively stronger than weekly seasonality.

The components of the series are determined using the STL method (Cleveland et al., 1990). Consequently, the seasonal components are not regular. By averaging (using medians) the daily deviations (Seasonal24) and the weekly deviations (Seasonal168), the daily error profile and the weekly error profile can be obtained, as shown in Figure 6.

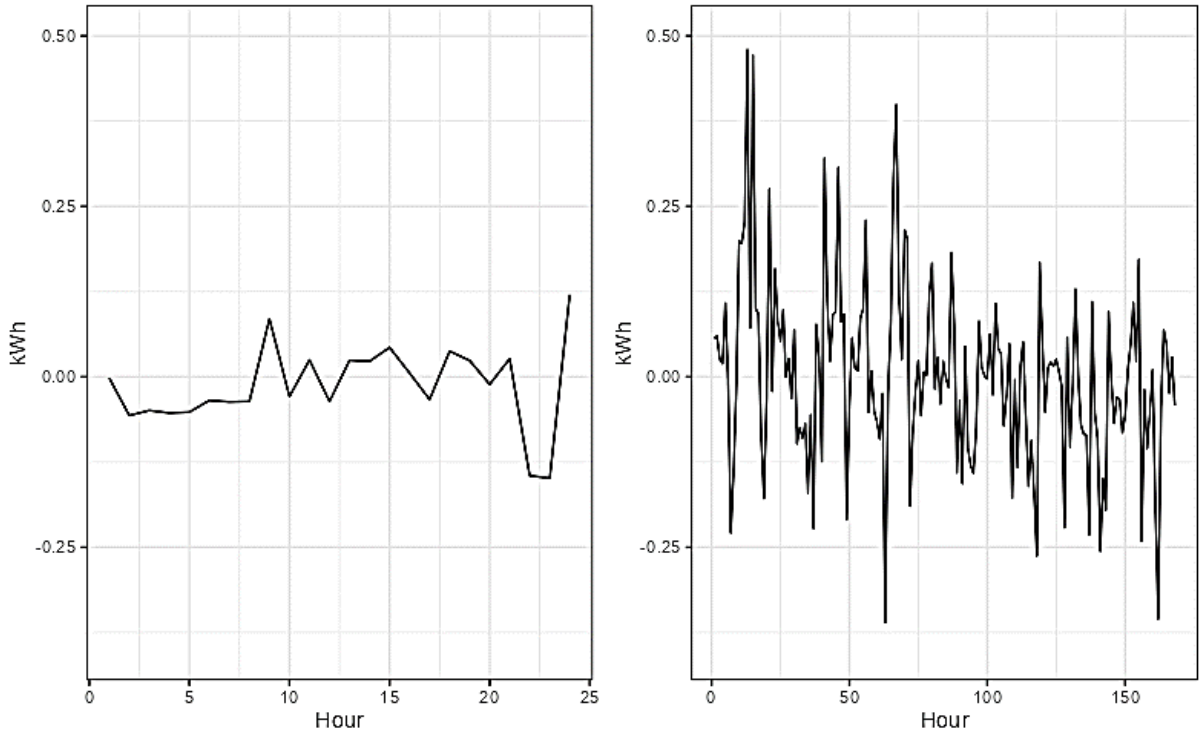

Figure 6. Median-averaged daily and weekly forecasting error profile.

The averaged profiles shown in Figure 6 present the average forecasting error for the corresponding hour during the day (for the daily profile) and during the week (for the weekly profile). Of interest from the analyst's point of view is whether there is regularity in the errors made. Analysis of the graphs and the course of errors over time indicates that there is no obvious regularity. The daily profile's randomness test (Wald, Wolfowitz, 1940) indicates that it can be considered random (statistic = -0.835, runs = 11, n1 = 12, n2 = 12, n = 24, p-value = 0.404). On the other hand, the results of the randomness test for the weekly profile (statistic = -3.250, runs = 64, n1 = 84, n2 = 84, n = 168, p-value = 0.001) indicate a lack of randomness. At the same time, it is difficult to pinpoint a clear reason for the lack of randomness in this series. However, in technical terms, it is a consequence of too many runs.

4. Discussion and conclusions

The paper proposes to study a range of forecasting errors using MSTL decomposition. The decomposition makes it possible to extract the deterministic components of the error, which can be used to correct the forecasting model.

Deterministic components show systematic forecasting error, which, when eliminated, can improve the quality of forecasts. This is shown by the values in Table 2. At the same time, it should be noted that forcing seasonality does not necessarily make it obvious. Thus, it is reasonable to study the strength of the relevant components of the time series in advance (Wang et al., 2006).

Accounting for multi-seasonality in the decomposition of a time series can also be done using harmonic analysis (De Livera et al., 2011). Preliminary consideration of the corresponding harmonics (Fourier analysis) can be an alternative to the proposed approach. Harmonics corresponding to daily and weekly seasonality will be regular. On the one hand, they will not take into account the change in seasonality over time. On the other, the determination of daily and weekly profiles will be relatively simple, unencumbered by variability.

Notably, the analyzed time series of forecasting errors was characterized by relatively weak seasonality. This fact may undermine the assumption of the presence of multi-seasonality in the errors or indicate a good forecasting model. Furthermore, one can consider whether decomposition with a single dominant seasonality could be sufficient. Then, the classical decomposition or STL decomposition could be used.

In summary, the proposed method can be particularly useful when:

- forecasts are subject to large errors,
- the predictive model is based on incomplete or aggregated data.

In general, decomposition study of a range of forecasting errors:

- involves breaking down the total forecast error into seasonal components and determining the contribution of individual systematic factors to the error,
- aims to identify the causes of forecasting errors and enable a better understanding of why the forecast was inaccurate,
- can be used to assess the quality of different forecasting methods and compare their effectiveness.

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PHOTOVOLTAICS - SENTIMENT ANALYSIS OF TWEETS PUBLISHED IN POLISH

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Purpose: Based on sentiment analysis of tweets, determining people's thoughts, feelings and opinions on photovoltaics.
Design/methodology/approach: Tweets posted in Polish that contained among others the word "photovoltaic" were downloaded automatically. The tweets' content has undergone preprocessing. All characters other than letters, URLs, hashtags, emojis, usernames, and phrases used to search for tweets were taken out of their text. The tweets' sentiment value was determined. To display the proportion of favourable, negative, and neutral tweets, visualisations were created. Word clouds were employed to display the tweets' most popular words.
Findings: For tweets related to photovoltaics, proportions of positive, negative and neutral tweets were determined.
Research limitations/implications: Only Polish-language tweets' content was examined. Without author oversight, sentiment analysis was carried out automatically by the "ccl emo" service. Only viewpoints expressed by Twitter users were analysed. It was assumed that if a tweet contains the word photovoltaic, its content is about photovoltaics.
Practical implications: Automatic assessment of people's opinion towards photovoltaics.
Originality/value: Opinions on photovoltaics were collected. Based on the growing number of tweets, it was found that interest in photovoltaics in Poland is steadily growing.

Keywords: sentiment analysis, Twitter, photovoltaics.

Category of the paper: research paper, case study.

1. Introduction

As the effects of global warming become more apparent, there is growing concerned about the harmful effects of the traditional energy sector on the environment. Societies are taking action to reduce greenhouse gas emissions (Peng, Lu, Yang, 2013; Pestana, Rodrigues, Morgado-Dias, 2018; Decuypere et al., 2022). Globally, the use of renewable energy is expanding to help reduce air pollution and carbon emissions (Dincer, Dincer, Ibrahim, 2000; Moriarty, Honnery, 2011). The benefits of green energy are acknowledged by many nations,

which has led to changes in energy acquisition policies (Pellerin-Carlin et al., n.d.; Salim, Rafiq, 2012; Omri, Daly, Nguyen, 2015; Bórawski et al., 2019; Eyl-Mazzega, Mathieu, 2020). An important factor in the transition to a low-carbon energy system is public acceptance and support for renewable energy (Kim et al., 2021). Public sentiment and opinion on renewable energy have been studied in (Noblet et al., 2015; Stokes, Warshaw, 2017; Hamilton, Hartter, Bell, 2019; Qazi et al., 2019; Lee, 2022; Peñaloza et al., 2022).

The global renewable energy sources (RES) market is growing steadily (especially in the solar and wind sectors) and its growth has not even been slowed by the coronavirus pandemic (Bilgili, Ozturk, 2015; Bhuiyan et al., 2021; Eroğlu, 2021; Quitzow et al., 2021). Among renewable energy sources, photovoltaic technology has the greatest potential due to its low cost and simplicity of installation (Mota et al., 2020; Alves dos Santos et al., 2021; C.B. et al., 2021; Castilho et al., 2021). The photovoltaic sector in Poland is currently of a very dispersed nature and is based on micro installations. At the end of 2019, micro-installations accounted for over 70% of the total installed photovoltaic capacity in Poland. Residents were encouraged to invest in photovoltaics through solar support energy programs like the governmental program "My Electricity", and the long-term EU support based on the Regional Operational Programs (Gręboszc-Krawczyk et al., 2021).

In recent times, households, industries and services in Poland have been facing increasingly higher bills for electricity consumption (Chomać-Pierzecka et al., 2022). The increase in electricity prices has led to even greater interest in photovoltaics, but choosing the right solution is not simple. This is influenced in Poland by the following factors, among others:

- the right size of installation (overproduction of electricity does not make economic sense) (Zrównoważonego et al., 2015),
- terms and conditions for accounting for electricity overproduction with distribution system operator (Zator, Lambert-Torres, 2021),
- deciding whether or not to purchase an electricity storage system (Zator, Lambert-Torres, 2021),
- relatively limited knowledge of the technical criteria for selecting the appropriate solution for energy needs; purchase decisions are mainly determined by the price of the installation, the lifetime of photovoltaic panels, the availability of solutions determining the time of investment implementation, and the aesthetics of the panels (Chomać-Pierzecka et al., 2022).

As the digital age progresses people frequently express their ideas and post them on social media. To examine people's thoughts, feelings and judgements, instead of surveys and interviews, a method known as sentiment analysis may be used. Sentiment analysis offers a method for automatically analysing sentiment, emotion, and opinion in written language (Xu, Chang, Jayne, 2022). It involves the process of analyzing, processing, generalizing from, and making sense of emotionally charged subjective texts, such as comments on people, events, things, etc., posted by users online (Deng et al., 2022).

One of the popular and well-known services where people can express themselves is Twitter (Chinnasamy et al., 2022). It is one of the most popular micro-blogging platforms. A user can follow a stream of messages (tweets) posted by another user (Panagiotopoulos, Sams, 2012). Through short messages (known as "tweets") users can instantly communicate their ideas or information on a variety of subjects or interests. (Das, Sun, Dutta, 2015). To support more conversational features, users have established certain conventions. They can republish other people's tweets ("retweeting"), and include the "@" and/or "#" symbols in their tweets (Boyd, Golder, Lotan, 2010; Panagiotopoulos, Sams, 2012). Users can refer to or directly address other users by using the "@" symbol (Akshay, Java, Xiaodan, Song, Tseng, 2007; Honeycutt, Herring, 2009). Using hashtags marked with the "#" symbol, allows users to group posts about a particular subject or event (Small, 2011; Bruns, 2012).

Twitter can be a source of big data. Various tools can be used to analyse downloaded data. Due to a large amount of data, techniques such as text mining, data mining, machine learning, topic modelling, sentiment analysis and similar approaches are used. Exploration of data collected on social media is a new field. It is becoming increasingly popular due to its affordability, accessibility and anonymity (Evans-Cowley, Griffin, 2012; Das, Sun, Dutta, 2015; Das et al., 2019). It is possible to predict how popular or current topics will develop by using sentiment analysis on data from social networks (Ağrali, Aydin, 2021). There are many studies in the literature about sentiment analysis on data extracted from the Internet (Pang, Lee, 2004, 2008; Read, 2005). Sentiment analysis of tweets is a topic covered in many studies (Go, Huang, Bhayani, 2009; Sarlan, Nadam, Basri, 2014; Zavattaro, French, Mohanty, 2015; Çoban, Tümüklü Özyer, 2018; Ayan, Kuyumcu, Ciylan, 2019; Das et al., 2019; Alqaraleh, 2020; Fadel, Cemil, 2020; Garcia, Berton, 2021; Antypas, Preece, Collados, 2022; Sunitha et al., 2022; Gabarron et al., 2022; Nezhad, Deihimi, 2022). The use of sentiment analysis of tweets to find out people's opinions on renewables was presented (Jain, Jain, 2019a, 2019b; Loureiro, Alló, 2020; Kim et al., 2021; Corbett, Savarimuthu, 2022; Ibar-Alonso, Quiroga-García, Arenas-Parra, 2022; Zarrabeitia-Bilbao et al., 2022).

2. Research Methodology

On January 9, 2023, from Twitter 119554 tweets were downloaded. This was accomplished using the Python snscrape library. This library contains several functions to gather tweets, user data, profile data, hashtags, and comments. It makes these elements accessible via a Twitter API-free interface. It offers useful flags that assist in filtering tweets based on criteria like the number of likes, responses, language, tweet ID number, etc. (Blair et al., 2021; Nkonde et al., 2021; Sarkar, Rajadhyaksha, 2021).

There were no retweets in downloaded tweets. Tweets had to include one or more of the following nouns, adjectives or phrases in Polish:

- nouns: “fotowoltaika”, “fotowoltaice”, “fotowoltaiką”, “fotowoltaikę”, “fotowoltaiki”, “fotowoltaiko”, “fotowoltaik”, “fotowoltaikach”, “fotowoltaikami”, “fotowoltaikom”,
- adjectives: “fotowoltaiczna”, “fotowoltaiczną”, “fotowoltaicznego”, “fotowoltaicznej”, “fotowoltaicznemu”, “fotowoltaiczni”, “fotowoltaicznych”, “fotowoltaicznym”, “fotowoltaicznymi”, “fotowoltaiczne”,
- phrases: “instalacja pv”, “instalacjach pv”, “instalacjami pv”, “instalacją pv”, “instalacje pv”, “instalację pv”, “instalacji pv”, “instalacjo pv”, “instalacjom pv”, “pv instalacja”, “pv instalacjach”, “pv instalacjami”, “pv instalacją”, “pv instalacje”, “pv instalację”, “pv instalacji”, “pv instalacjo”, “pv instalacjom”.

These nouns, adjectives and phrases are in all possible grammatical cases for the Polish language and are translations of the terms “photovoltaics”. Phrases are a bigram formed from the word “instalacja” – (eng. installation) and abbreviation of a word “photovoltaics“.

In the next step, the author removed:

- tweets were written in languages other than Polish,
- duplicate tweets (some tweets were retrieved multiple times because they contained more than one word or phrase used during the search, such as "fotowoltaiczna" and "fotowoltaicznej"),
- tweets whose content was the same as the content of other tweets (it was frequently an advertisement for a company's services, products, or jobs); the content was treated as a string of characters and compared using the comparison operator “==”.

Then the tweets' content was pre-processed. All characters other than letters, URLs, hashtags, emojis and user names were removed from the tweets. Additionally, the terms used to search for tweets have been also removed. Next, the number of words in the cleaned content of each tweet was checked. Less than two-word tweets were deleted. After these operations, the number of tweets was 70307.

The ***ccl_emo***[1] service, created by CLARIN-PL[2], was used in the next step. In Polish, this service is also known as “Wydźwięk” and “Sentiment” (in English). It is a service for statistically analysing texts' overtones and emotions (Janz et al., n.d.; Grubljesic, Coelho, Jaklic, 2019). It can be used using Python language[3]. In addition to this service, other CLARIN-PL’s services were used. These were:

- Any2txt - a service that transforms text files (e.g. doc, docx, xlsx) into text.
- Speller2 - a service that verifies the text's spelling. It uses a tool called Autocorrect[4] for this.
- Wcrft2 - is a basic morpho-syntactic tagger for Polish.

[1] https://wiki.clarin-pl.eu/pl/nlpws/services/ccl_emo; https://clarin-pl.eu/index.php/wydzwiek/.
[2] CLARIN-PL is a Polish scientific consortium, part of the European Research Infrastructure CLARIN (Common Language Resources and Technology Infrastructure)(*CLARIN-PL*, n.d.).
[3] This service is also available as a web application at http://ws.clarin-pl.eu/sentyment.shtml.
[4] https://languagetool.org/pl/.

– WSD - a service for word sense disambiguation, which works for Polish texts. As a source of possible senses, it uses plWordNet, which consists of lexical units grouped into synsets which are linked by lexico-semantic relations. A lexical unit represents a lexical meaning and is a triple: lemma, part of speech and sense identifier (Janz et al., n.d.).

For the selected lexical units stored in plWordNet emotive annotation was added. Lexical units were described by (Janz et al., n.d.):

– sentiment polarity – it is expressed on the 5 grade scales: strong & weak vs negative & positive, plus neutral.
– basic emotions - gladness, trust, enjoying something expected, sadness, anger, fear, disgust, surprise with something unpredictable - these emotions are created based on the 8 basic emotions mentioned by Plutchik and his Wheel of Emotions (Plutchik, 1980; Wierzbicka, 1992a, 1992b).
– fundamental human values – utility, good of another man, truth, knowledge, beauty, happiness, uselessness, harm, ignorance, error, ugliness, unhappiness - the fundamental human values indicated by (Puzynina, 1992) were used.

Table 1.
Example of calculating the sentiment of a tweet

Sample tweet	Prawda o fotowoltaice jest ***smutna*** [-1]: za pieniądze podatnika wciskane są ludziom instalacje, które bardziej obciążają różnymi kosztami system ***energetyczny*** [1] niż produkują prąd. Ktoś za te ***straty*** [-1] musi zapłacić - płacą podatnicy. A w nocy i zimą, gdy potrzeba dużo prądu, fw nie działa.
Sentiment calculation	***straty*** [1] = 1 ***smutna*** [-1] + ***straty*** [-1] = -2
	The number of positive words (1) < The number of negative words (2)
	The sentiment of the tweet = negative

Sources: original research.

At this stage, each tweet's cleaned content was saved to a separate text file and sequentially processed by Any2txt, Speller2, Wcrft2, WSD and ccl_emo services. Among others, spelling checks and word sense disambiguation were done. For words, emotive information like polarity (positive, negative, neutral or ambiguous), 8 basic emotions and 12 fundamental human values were retrieved. This information was saved to separate text files (each tweet to one file). Then the sentiment for each tweet was calculated using information from these files. Table 1 shows how the sentiment of a tweet was calculated. In square brackets, there is information about the polarity of the words before them for one of the downloaded tweets. Words with negative polarity have a value of -1, and those with positive polarity have a value of 1. A tweet has a negative sentiment if there are more negative words than positive ones. Positive sentiment is if there are fewer negative words than positive ones. A neutral sentiment if the ratio of positive to negative words is equal.

In the next step, for each tweet, it was counted how many words, with annotated basic emotions and fundamental human values, it contained. From Table 2, it can be read that the example tweet contained 3 words with the emotion “gladness”, 2 words with the emotion “anger”, and 1 word with the emotion “sadness”.

Table 2.
The number of words with annotated basic emotions - sample tweet

TweetId	gladness	enjoying something expected	trust	disgust	fear	anger	surprise with something unpredictable	sadness
1611753205972570113	3	0	0	0	0	2	0	1

Sources: original research.

3. Results

Using a ribbon chart figure 1 shows how many of the analyzed tweets were published in individual years and months. It can be seen from it that only 27 tweets were published in 2010, 42 tweets in 2011 and 15456 tweets in 2021. In 2022 it was 28753 tweets with the most in September and the least in April. Similarly, figure 2 shows how many users published the analyzed tweets in particular years and months. It can be read from it that in 2021, 10681 users published the tweets and the most users published in December.

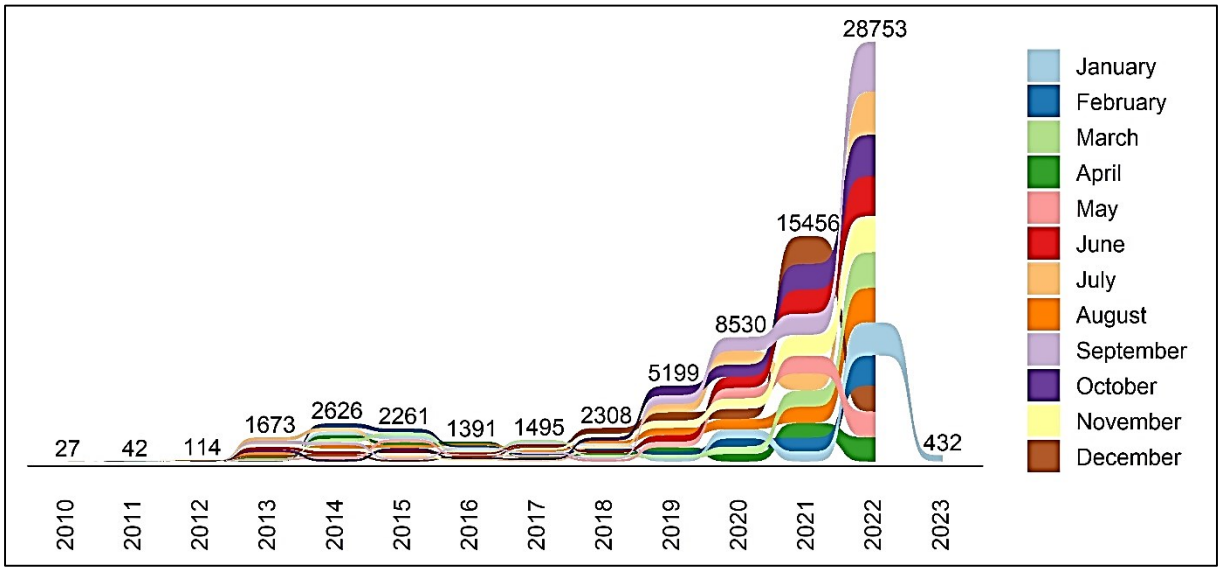

Figure 1. Number of tweets by year.

Sources: original research.

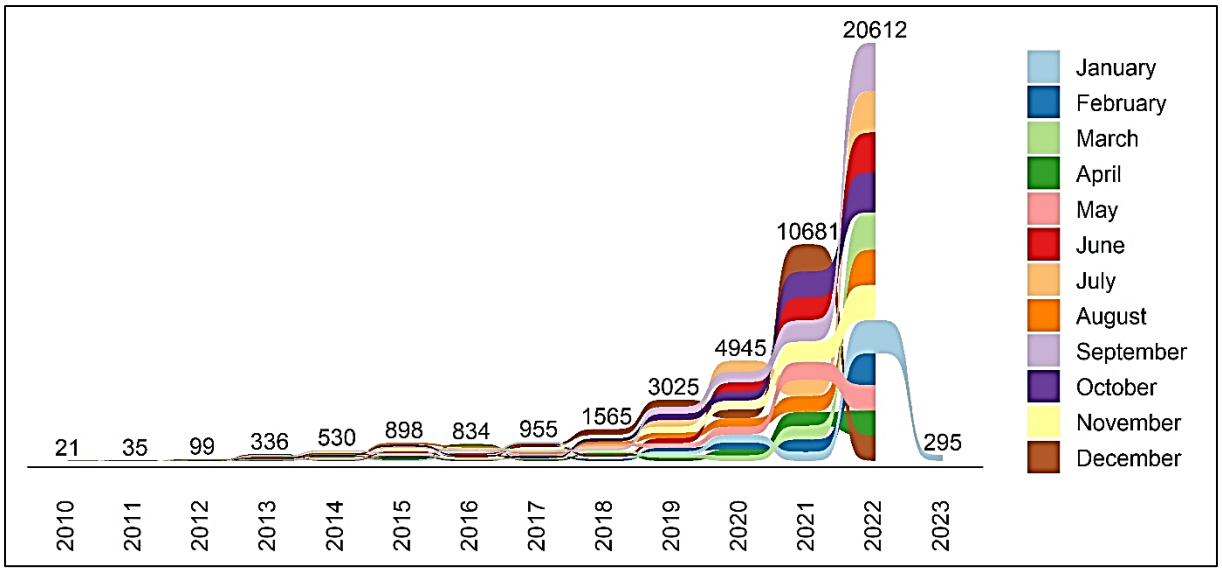

Figure 2. Number of the user by year.

Sources: original research.

Table 3 shows how many tweets were published by users and how many users there were in total. The number of total users during the analysis period was 20433. It can be read from this table that 12278 users published one tweet. 535 users posted 5 tweets each, bringing the total to 2675 tweets. 7 users published between 401 and 3000 tweets each. Together they published 6861 tweets.

Table 4 shows how many hashtags each tweet had. It can be read from it that 59974 tweets, which are 85.3% of the tweets analysed, had no hashtags. 3743 tweets had 1 hashtag each. 88 tweets had 10 hashtags.

Table 3.
The number of tweets published by users

The number of published tweets by the user	The number of users	The total number of published tweets
1	12278 (60,089%)	12278 (17,463%)
2	3332 (16,307%)	6664 (9,478%)
3	1497 (7,326%)	4491 (6,388%)
4	810 (3,964%)	3240 (4,608%)
5	535 (2,618%)	2675 (3,805%)
6	398 (1,948%)	2388 (3,397%)
7	260 (1,272%)	1820 (2,589%)
8	205 (1,003%)	1640 (2,333%)
9	143 (0,7%)	1287 (1,831%)
10	124 (0,607%)	1240 (1,764%)
11-20	505 (2,471%)	7124 (10,133%)
21-50	234 (1,145%)	7122 (10,13%)
51-100	65 (0,318%)	4540 (6,457%)
101-400	40 (0,196%)	6937 (9,867%)
401-3000	7 (0,034%)	6861 (9,759%)
Total	**20433 (100%)**	**70307 (100%)**

Source: original research.

Table 4.
Number of hashtags in tweets

Number of the hashtag in one tweet	Number of tweets
0	59974 (85,303%)
1	3743 (5,324%)
2	2452 (3,488%)
3	1600 (2,276%)
4	943 (1,341%)
5	660 (0,939%)
6	313 (0,445%)
7	198 (0,282%)
8	119 (0,169%)
9	93 (0,132%)
10	88 (0,125%)
from 11 to 20	124 (0,176%)
Total	**70307(100%)**

Source: original research.

Figure 3 shows the percentage of positive, negative and neutral tweets by year. We can see from it that in the year 2022 23.8% of tweets had negative, 46.1% neutral and 30.1% positive sentiment.

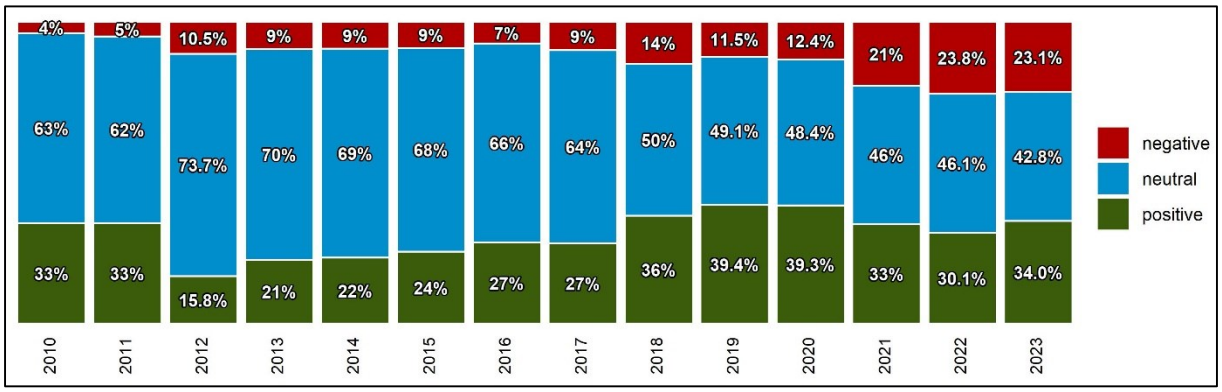

Figure 3. Percentage of positive, negative and neutral tweets.

Sources: original research.

Figure 4 shows the percentage of words with annotated basic emotions by year. Positive emotions are marked in green (gladness, enjoying something expected, trust). Negative emotions are marked in red (disgust, fear, anger, surprise with something unpredictable, sadness). We can see from it, that words with positive emotions had the following percentages in 2022 - gladness 23.9%, enjoying something expected 8.5% and trust 12.4%.

Figure 5 shows the percentage of words with annotated fundamental human values. The positive human values are marked in green (beauty, happiness, good of another man, utility, knowledge). Among the positive human values, not once did the “truth” occur. The negative human values are marked in red (unhappiness, error, harm, ignorance, uselessness, ugliness).

Figure 6 and 7 shows the most frequent words and hashtags in tweets. They are presented in the form of a word cloud. By analysing these words, it is possible to determine what the tweets were about.

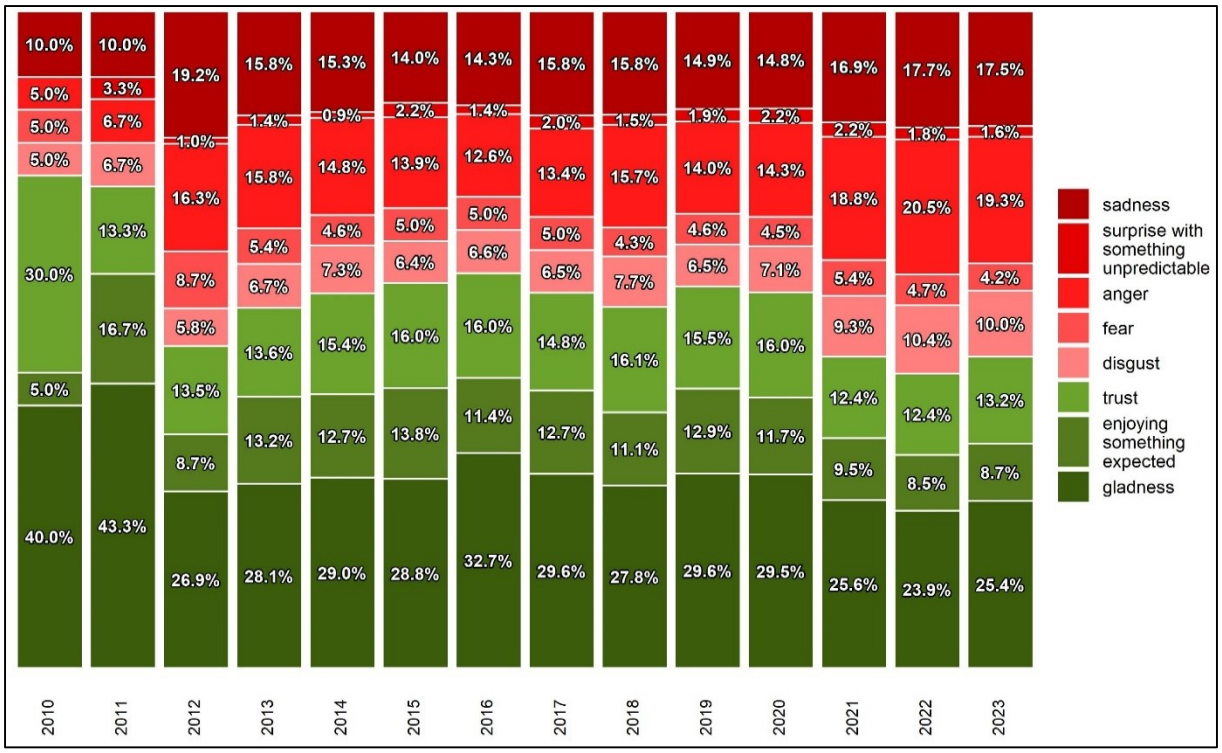

Figure 4. Percentage of words with annotated basic emotions by year.

Sources: original research.

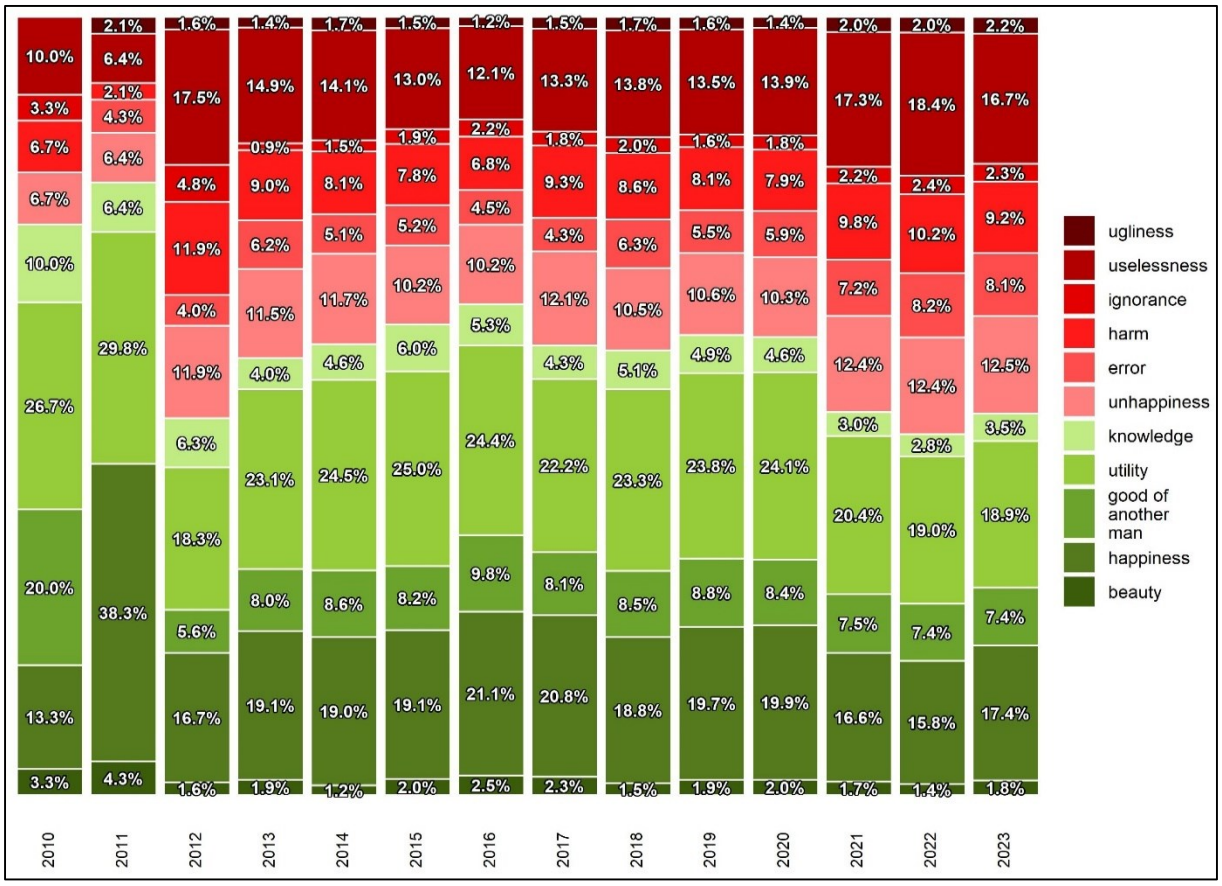

Figure 5. Percentage of words with annotated fundamental human values by year.

Sources: original research.

Figure 6. Most frequently used words.

Sources: original research.

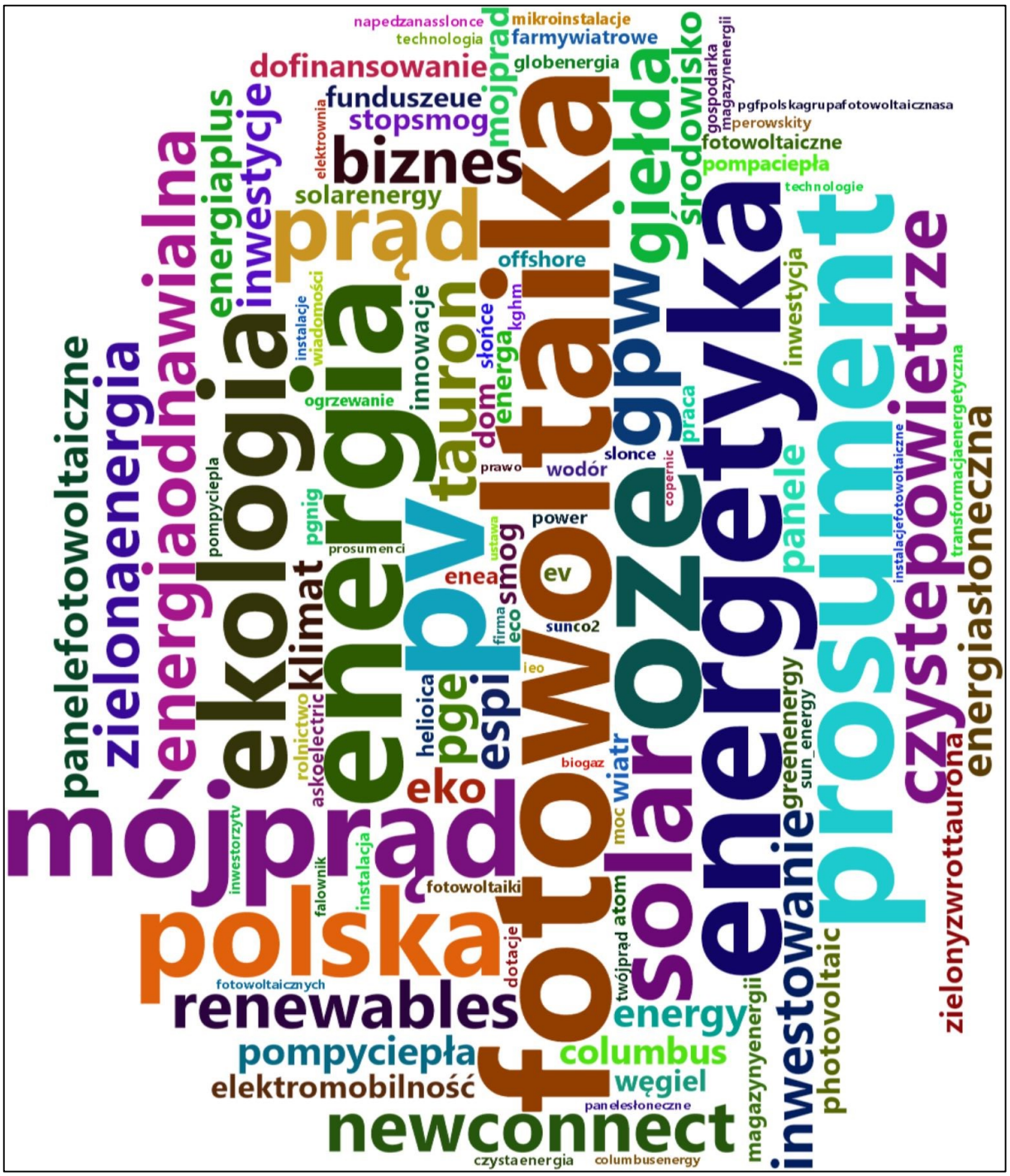

Figure 7. Most frequently used hashtags.

Sources: original research.

4. Conclusion

Analysis of tweets allowed to establish the following conclusions:

- an increasing number of tweets show that interest in photovoltaics is growing all the time, especially after the year 2017,
- there is variation in the number of tweets published by users. Most often, users published only 1 tweet. Such users accounted for 60.089% of all users. The smallest group were users who published between 401 and 3.000 tweets each.
- in recent years, the number of tweets with positive and negative sentiment has been increasing, while the number of tweets with neutral sentiment has been decreasing,
  - the percentage of negative tweets has trended upward since 2010; in 2010 the percentage of negative tweets was 4% and in 2022 it was 23.8 %.
  - from 2012 onwards, the number of tweets with neutral sentiment decreased from 73.7% to 42.8%,
  - tweets with positive sentiment were highest in 2019 and 2020 at 39.4% and 39.3% respectively,
  - the number of tweets with neutral sentiment was the lowest in 2023.
- in 2012, 2021, 2022 and 2023 the percentage of words with annotated negative basic emotions was greater than that with positive ones. They were about 50.96%, 52.59%, 55.18% and 52.58% respectively,
- in 2012, 2021, 2022 and 2023 the percentage of words with annotated negative fundamental human values was greater than with positive ones. They were about 51.58%, 50.8%, 53.61%, and 50.99% respectively,
- analysing the most frequently used words, it can be assumed that tweets addressed the following issues related to photovoltaics:
  - households as the main users of photovoltaics – words: “dom” (eng. house), “domowy” (eng. domestic), “budynek” (eng. building), “gospodarstwo” (eng. household), “mikroinstalacja” (eng. micro installation), “prosument” (eng. prosumer), “własny” (eng. own), “właściciel” (eng. owner),
  - the main components of a photovoltaic installation – words: “słoneczny” (eng. solar), “ogniwo” (eng. cell), “panel”, “falownik” (eng. inverter), “moduł” (eng. module), “akumulator” (eng. battery), “bateria” (eng. battery), “magazyn” (eng. storage),
  - amount of energy produced by the photovoltaic installation over a given period – words and abbreviations like: “mwh” (MWh, eng. megawatt hour), “kilowatogdzina” (eng. kilowatt-hour), “produkować” (eng. to produce), “wytwarzać” (eng. to generate), “produkcja” (eng. production), prąd (eng.

"electricity"), "energia (eng. energy), "elektryczny" (eng. electric), "rocznie" (eng. annually), "roczny" (eng. annual), "miesiąc" (eng. month), "wynik" ("result"),
  - photovoltaic installation capacity and the factors affecting it - words: "moc" (eng. power), "mw" (eng. MW), "kilowatt" (eng. kilowatt), "k" (eng. kilo), "dach" (eng. roof), "kierunek" (eng. direction), "metr" (eng. metre), "powierzchnia" (eng. area), "łączna" (eng. total),
  - considering the purchase of an electric or plug-in hybrid car – words: "auto" (eng. car), "samochód" (eng. car), ładować (eng. to charge),
  - complaints about intensive persuasion to buy photovoltaic – words: "dzwonić" (eng. to call), "oferować" (eng. to offer), "zadzwonić" (eng. to call), "telefon" (eng. phone), "sprzedać" (eng. to sell), "sprzedawca" (eng. salesman), "sprzedaż" (eng. sales), "proponować" (eng. to propose), "promować" (eng. to promot), "bot"[5],
  - financial support for the purchase of photovoltaic – words: „dopłata" (eng. subsidy), "dotacja" (eng. subvention), "dostać" (eng. to get), "wsparcie" (eng. support), "wspierać" (eng. to support), "gmina" (eng. district), "rząd" (eng. government), "przepis" (eng. law), "ustawa" (eng. law),
  - the profitability of investment in photovoltaics – words: "koszt" (eng. cost), "kosztować" (eng. to cost), "opłacalny" (eng. worthwhile), "zwrot" (eng. return on investment), "zwrócić" (eng. return on investment), "kredyt" (eng. credit),
- analysing the most frequently used words can determine that tweets did not only concern photovoltaic but also in general:
  - electricity and heat production from varoius energy sources – "atom", "atomowy" (eng. atomic), "biogazownia" (eng. biogas plant), "elektrownia" (eng. power plant), "eneriga" (eng. energy), "gaz" (eng. gas), "gazowy" (eng. gas), "jądrowy" (eng. nuclear), "odnawialny" (eng. renewable), „prąd" (eng. electricity), "farma" (eng. farm) "turbina" (eng. turbine), "węgiel" (eng. coal), "węglowy" (eng. coal), "wiatrak" (eng. wind turbine), "wiatr" (eng. wind), "wiatrowy" (eng. wind), "woda" (eng. water), "wodór" (eng. hydrogen), "źródło" (eng. source), "grzać" (eng. to heat), "ciepło" (eng. heat), "pompa" (eng. pomp),
  - green power generation and the air quality – "czysta" (eng. clean), "ekologia" (eng. ecology), "ekologiczny" (eng. ecological), "środowisko" (eng. environment), "emisja" (eng. emission), "zielone" (eng. green), "zielony" (eng. green),
- analysing the most frequently used hastags, it can be assumed that tweets addressed the following issues:
  - photovoltaic – words / concatenations of words / abbreviation: "fotowoltaika" (eng. photovoltaics), "pv" (eng. photovoltaics), "instalacjefotowoltaiczne" (eng. photovoltaics systems), "prosument" (eng. prosumer), ,"prosumenci" (eng.

[5] Telephone bot - make sales calls to potential customers.

prosumers), “mójprąd”[6] (eng. my electricity), “panelefotowoltaiczne” (eng. photovoltaics panels), “panele” (eng. panels), “magazynenergii” (eng. energy storage), “magazynyenergii” (eng. energy storages), “twójprąd” (eng. your electricity),

- ecology, clean electricity generation – words / concatenations of words / abbreviation: “oze” (eng. renewables), “czystepowietrze” (eng. clean air), “solar”, “energiasłoneczna” (eng. solar energy), “czystaenergia” (eng. clean energy), “zielonaenergia” (eng. green energy), “renewables”, “energiaodnawialna” (eng. renewables), “środowisko” (eng. environment), “smog”, “stopsmog”, “solarenergy”, “greenenergy”, “eko” (eng. eco), “eco”,
- heating – words / concatenations of words: “pompaciepła” (eng. heat pump), “pompyciepła” (eng. heat pumps), “pompyciepla” (eng. heat pumps), “ogrzewanie” (eng. heat),
- companies related to electricity generation, photovoltaic or/and renewable energy – words: “askoelectric”, “columbus”, “columbusenergy”, “copernic”, “enea”, “energa”, “pgfpolskagrupafotowoltaicznasa”, “zielonyzwrottaurona”, “pge”, “pgnig”,
- energy carriers – words: “wodór” (eng. hydrogen), “węgiel” (eng. coal), “biogas”, “atom”,
- financial support for the purchase of photovoltaic – words: “dotacje” (eng. subventions), “dofinansowanie” (eng. subsidy), “funduszeue” (eng. EU funds).

The conducted research confirms that Twitter can be a source of big data. Twitter data can be used for sentiment analysis to find out people's thoughts, feelings and opinions on “photovoltaics”. Only the opinions of Polish speakers who posted on Twitter were identified in this study.

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PERSONAL DATA SECURITY SYSTEM IN LOCAL SELF-GOVERNMENT UNITS

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Purpose: The article deals with the topic of personal data security systems in various local government units (LGUs) located in Poland. In addition, the personal data security system, information technology and personal data were defined. The aim of the article was to draw attention to the importance of data processed in local government units and to present the results of research in this area.
Design/methodology/approach: The considerations and analysis made it possible to identify the causes of the negative impact on personal data and to present the types of threats that may occur in connection with incorrect processing of personal data.
Findings: The article presents the essence of the information security management system and the most important threats resulting from improper management of personal data. The article defines local government units in the context of knowledge of legal provisions in the field of personal data processing. In addition, the article recommends the use of good practices in the field of proper data protection.
Practical implications: Research proves important issues regarding the quality of personal data processing in local government units.
Originality/value: The information contained in the article deals with the subject of the functioning of local government units, personal data protection and the growing importance of technology used for data processing, supplementing the limited number of publications on the presented topic.

Keywords: personal data security system, security, personal data protection.

Category of the paper: research and review publication.

1. Introduction

The personal data security system is one of the most important elements of the organization's functioning, taking into account the value of the processed personal data. Some kind of organization's assets, such as data processing, determine the success or failure of the organization's functioning. The factors determining the proper management of personal data

are human, technical and technological, organizational factors and those resulting from sudden, unexpected events. Including them in the personal data security system contributes to the sustainability of organizations, which are local government units, and to the reduction or elimination of administrative and financial penalties imposed on units by the supervisory authority, which is the President of the Office for Personal Data Protection.

The introduction and application of regulations related to the proper processing of data determines the correct functioning in the three-tier structure of local government (gmina, poviat, voivodship), and thus determines the correctness of personal data processed in their structures, also with the use of information technology. Creating registers of residents, placing information in the Public Information Bulletin (BIP), using monitoring, or commissioning IT services to other entities requires proper protection of personal data.

Information security is currently one of the most important elements of the data security system in public, private and non-profit organizations. Public security is *a state based on legal norms, in which the conditions for the efficient functioning of a state organization are ensured [...]* (Fehler, 2010).

The functioning of the described organizations is based on the dynamism of world development, which is why it is so important to adapt to the changing environment or create such organizations that will be able to exist in the unpredictable future, where personal data and protection determine the safety of the individuals to whom the data relate. The protection of personal data, constituting the information security system, concerns the new provisions governing data processing, which have gained great importance since 2018. Although data protection is not something new, its value has increased after the introduction of Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of individuals with regard to the processing of personal data and on the free movement of such and the repeal of Directive 95/46/EC (General Data Protection Regulation).

What is worrying, however, is the fact that the provisions on the protection of personal data in local government units are often unknown or known only to a small or moderate extent. Often, only inspectors or administrators of personal data are familiar with the regulations, while other people who process huge amounts of personal data on a daily basis, e.g. in the process of communication, collecting data about employees and residents, or recording the results of training, are not familiar with the regulations.

The main purpose of the article is to identify the risks associated with incompetent data processing or resulting from ignorance of the law, define the concept of information, personal data, personal data security system, present the benefits of proper data processing and present the essence of the functioning of local government units based on huge amounts of processed data. In order to achieve the main goal, the results of research carried out for the purposes of the doctoral dissertation, corresponding to the aspects of the subject matter, were presented, the functioning of local government units in the aspect of information processing and the effectiveness of the data security system were verified.

2. Information security management system as the basis for the functioning of local government units

The system, i.e. *a set of relations between mutually coupled elements* (Sienkiewicz, 1994, p. 159) can function on the basis of the system and information, thus creating an information system defined as a multi-level structure enabling the processing of indicated information. The information system is also one of many elements of the sequence of events that creates the decision chain in the management system. The management system, in turn, is a set of activities, which includes activities that create subsequent parts of the resource management process along with their mutual relationships. In addition, the management system should be supported by the information system, while the technical means constituting the management infrastructure should be identified with the IT system of a given organization, i.e. *the automated data processing system* (Klonowki, 2004).

Information security management and personal data protection are aimed at minimizing the risk of theft, negative use of data or data loss. So what is personal data? According to Art. 4, point 1 of the GDPR: *personal data means information about an identified or identifiable natural person ("data subject"); an identifiable natural person is a person who can be identified, directly or indirectly, in particular on the basis of an identifier such as name and surname, identification number, location data, online identifier or one or more specific physical, physiological, genetic, mental factors, economic, cultural or social identity of a natural person* (GDPR, point 1). Information, on the other hand, is perceived as a specific amount of data, it is the source of the proper functioning of the organization, as well as the opportunity to achieve a competitive advantage. Thus, information is the number of conclusions that can be obtained from a particular message. Very often the word "data" is equated with the word "information", which is why these words are used interchangeably, according to the glossary of synonyms (Ludwiczak et al., 1998). Increasing the security of information and personal data is a series of activities aimed at determining the procedure for securing data and information. For optimal security of the processed data, it is necessary for organizations to comply with all standards regulating the functioning of the organization in this aspect, i.e. standards regulating the functioning of the Information Security Management System (ISMS), procedures, policies, audits, services of the personal data protection officer, social engineering tests and training which additionally complement the knowledge obtained from international standards, relevant laws or the GDPR.

The Information Security Management System - ISMS, operating on the basis of international standardization standards, indicates the model of the continuous improvement cycle (PDCA) in accordance with the concept of W.E. Deming. The process approach in information security management draws users' attention to procedures and rules ensuring the security of IT systems and networks (Wołowski, et al., 2012) (Figure 1 and 2).

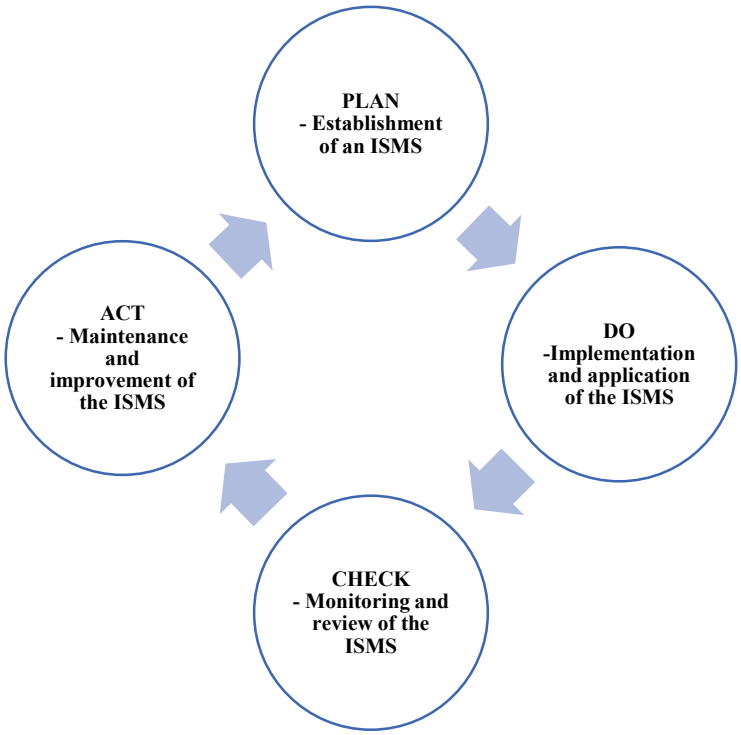

Figure 1. PDCA model used in ISMS processes.

Source: own study based on PN-ISO/IEC 27001:2017-06.

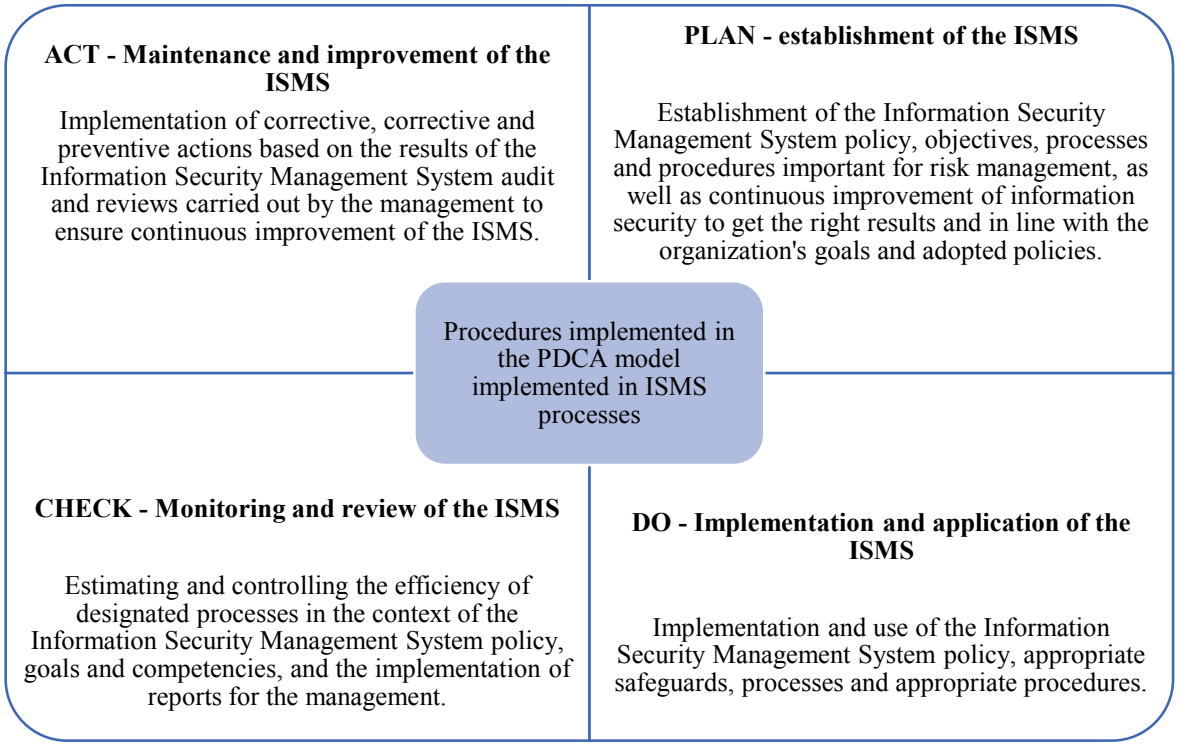

Figure 2. Procedures implemented in the PDCA model implemented in ISMS processes.

Source: own study based on F. Wołowski, J. Zawiła-Niedźwiecki, Bezpieczeństwo systemów informacyjnych edu-Libri, Kraków-Warszawa 2012, s. 17.

When determining the methods of personal data processing, when designing the IT system and during data processing, all organizational and technical measures should be taken to effectively implement the principles of personal data protection, comply with the requirements of the GDPR, and protect the rights of persons whose data is processed (Schwartz, Solve, 2010). This mainly applies to local government units due to the amount of data processed in their structures, also with the use of information technology. The register of residents requires the identification of the local population and the creation of appropriate information clauses, or a register of processing activities also in the aspect of sharing personal data, where very often data processing is automated. Undoubtedly, therefore, the Information Security Management System should be implemented at entities performing public tasks. Because it covers not only the protection of personal data, but also other information that needs protection, including classified information.

3. Data security in local government units

Surveys conducted among local government units were conducted in 2021. The research tool was a questionnaire addressed to 372 local government units representing both commune, poviat and voivodeship governments in all voivodeships. The target population of local government units included 2,807 entities (16 voivodeships - voivodeship offices, 314 poviats - poviat starosty, 2,477 communes - commune office, municipal office/city and commune office, municipal office, city hall) (Samorząd…, 2023).

The results obtained from the conducted survey gave the opportunity to obtain conclusions that allowed the assessment of the current data security in local government units and the recommendation to ensure acceptable protection of personal data.

177 women (47.6% of respondents) and 195 men (52.4% of respondents) participated in the survey. The characteristics of the respondents indicate that a greater number of people dealing with the subject of personal data protection in local government units are men. It is worth noting, however, that this indicator is not significantly higher compared to the number of women. The number of respondents by gender is presented in the Figure 3.

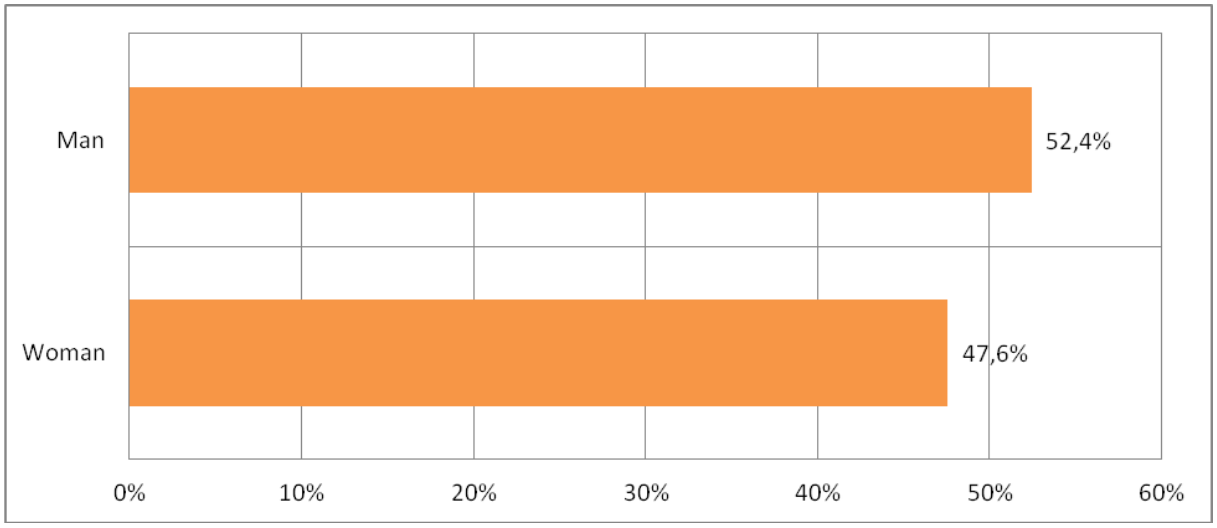

Figure 3. Characteristics of the respondents by gender.

Source: own study based on conducted research.

The type of self-government represented by local government units is presented in figure 4. Most of the respondents were from commune self-governments, which accounted for 236 local government units (63.4%). Poviat self-government 128 local government units (34.4%). The smallest group was constituted by the voivodeship self-government, i.e. 8 LGUs, which accounted for 2.2% (Figure 4).

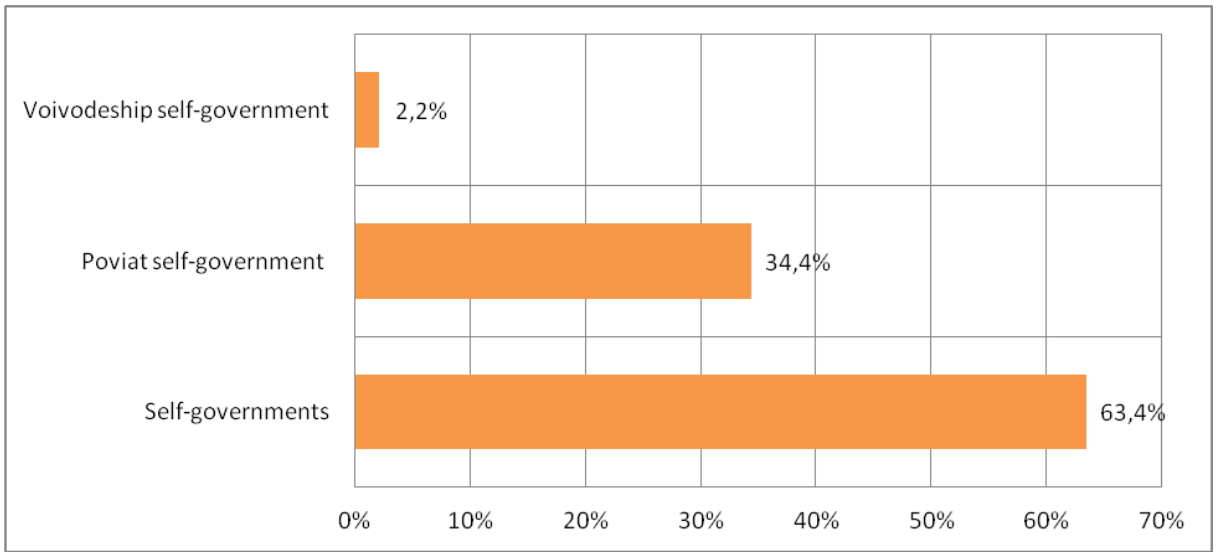

Figure 4. Characteristics of the respondents due to the represented local government.

Source: own study based on conducted research.

In the analysis of the results obtained from the conducted research, it was important to maintain the consistency of the structures with regard to the spatial distribution and type of local government unit, which made it possible to view the representativeness of the research sample and the possibility of generalizing the results obtained in the questionnaire.

Respondents were asked to indicate the answer regarding the presence of documents regarding the protection of personal data in a given LGU. It was recognized that the necessary documents creating security in local government units are: a template for the register of recipients of personal data, a cookie policy, a monitoring policy, an information clause on data processing in e-mail correspondence, a list of personal data files, a template for the incident register, a register of categories of personal data processing, policy clean desk, requirements to ensure confidentiality, integrity and accountability, template of the contract for entrusting the processing of personal data, clause of consent to the processing of ordinary personal data, instruction for managing the IT system, templates of information clauses, register of personal data processing activities, instruction in the event of threats and incidents, register of persons authorized to process personal data, employee statements regarding knowledge of data protection rules, authorization to process personal data. The above-mentioned types of documents were presented to the respondents, then they were asked to mark the answer whether a specific document is included in the LGU (Figure 5).

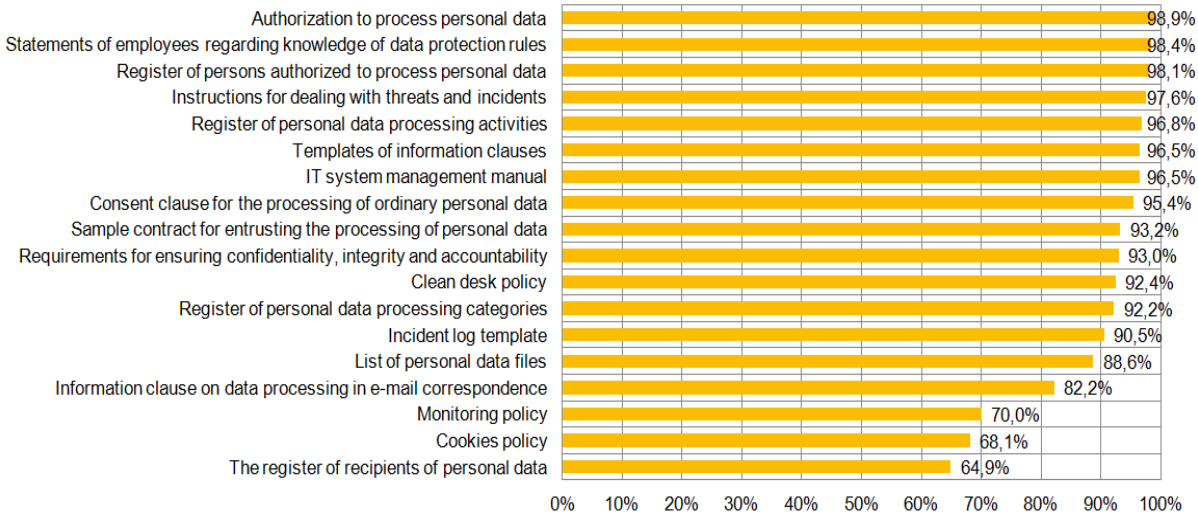

Figure 5. Types of documents used in units.

Source: own study based on conducted research.

Respondents almost unequivocally indicated that the above documents are included in local government units. Authorization to process data is available in local government units. This was the answer of 98.9% of local government representatives. Similarly, employees' statements regarding knowledge of data protection principles (98.4%), or the register of persons authorized to process personal data (98.1%). The fewest representatives of local government units indicated the register of recipients of personal data (64.9%), cookie policy (68.1%) and monitoring policy (70.0%).

The answers given regarding the use or implementation of implementation plans for particular types of monitoring mostly prove the presence of a given technology among LGUs. 64% of representatives of local government units answered that video monitoring is used in their organizations. 54% of respondents also reported the presence of monitoring of IT systems

of the software used, 43% of monitoring of websites, 40% of monitoring of IT systems of e-mail and 23% of the use of monitoring systems for entrances to specific rooms. Noteworthy, however, is the information on the use of various types of monitoring by LGUs, and the lack of a document on the monitoring policy in 30% of local government units (Figure 6).

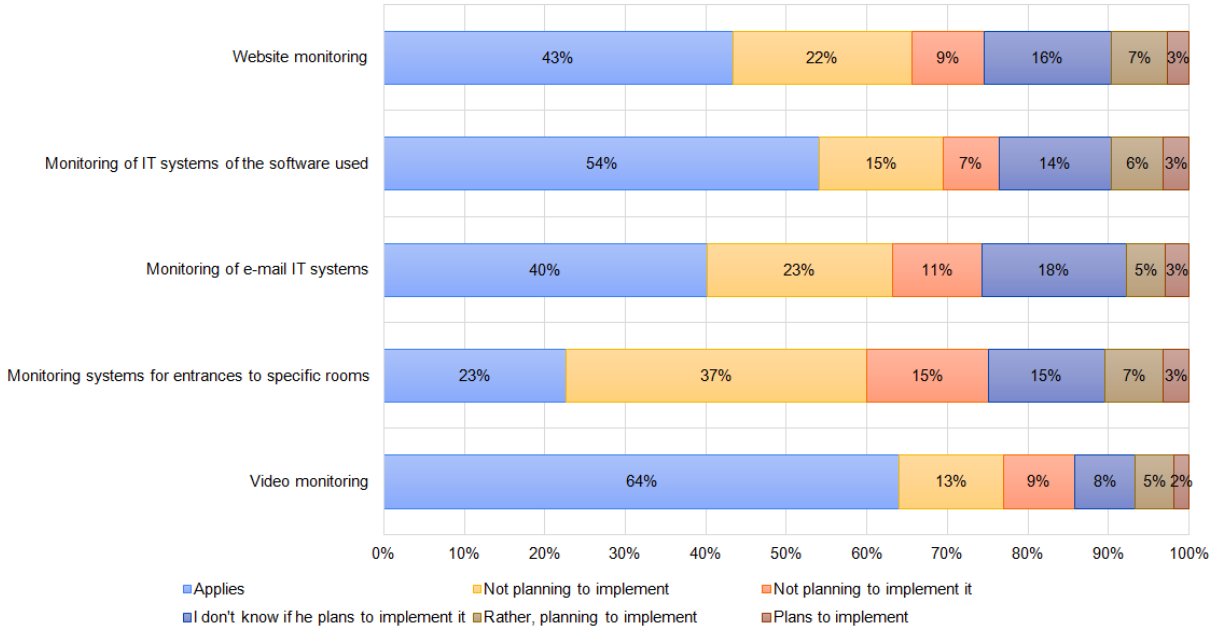

Figure 6. Types of monitoring used in local government units.

Source: own study based on conducted research.

Knowledge of the provisions of the GDPR in terms of individual scopes should not raise doubts that the respondents of individual local government units know the provisions on the protection of personal data to a large extent and to a very large extent. However, unfortunately, also local government units do not comply with the provisions of the GDPR, despite the fact that 46% of local government representatives (the survey was addressed to personal data inspectors, personal data administrators or people dealing with issues related to personal data protection) answered that they know the provisions to a very large extent concerning breaches of personal data protection, and 36% that they know this scope of the provisions of the GDPR to a large extent. 44% of respondents know the provisions on the processing of personal data to a very large extent, and 35% to a large extent. Similarly, in terms of the scope of the provisions on data protection breaches: 41% of respondents indicated that they know these provisions to a very large extent, and 36% to a large extent (Figure 7).

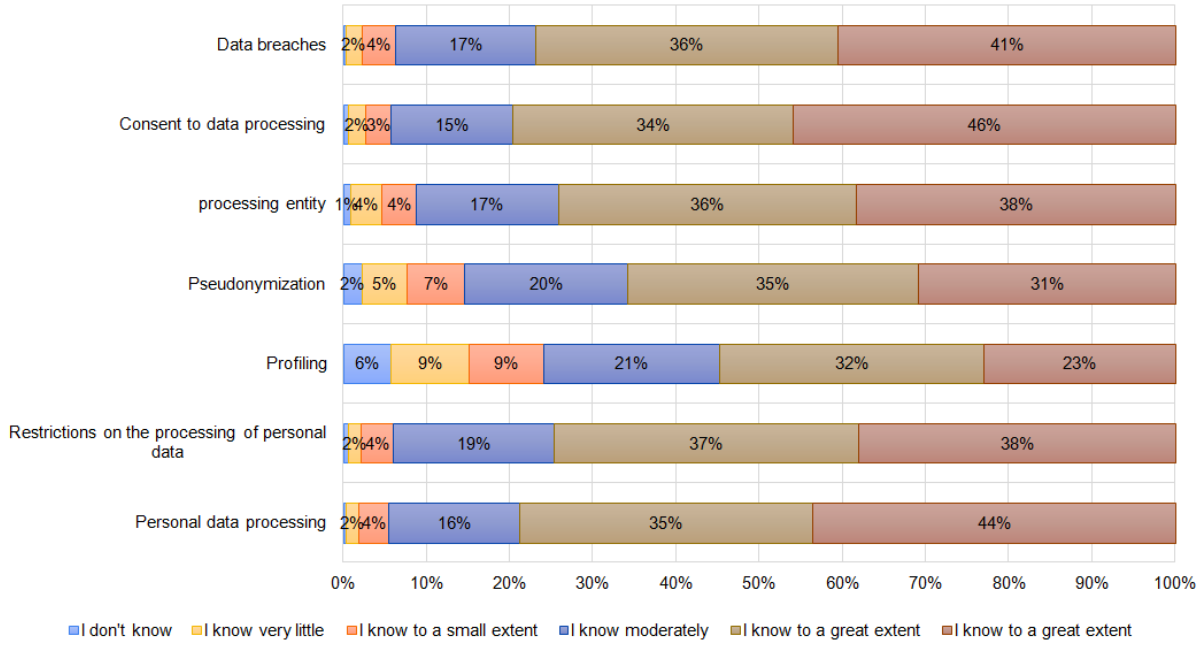

Figure 7. Knowledge of GDPR regulations in local government units.

Source: own study based on conducted research.

Questions regarding administrative and financial penalties issued against the unit show that 94.6% of the units were not subject to administrative and financial penalties, unfortunately, however, a disturbing fact applies to 5.4% of the surveyed local government units that inform about the imposed penalties (Figure 8).

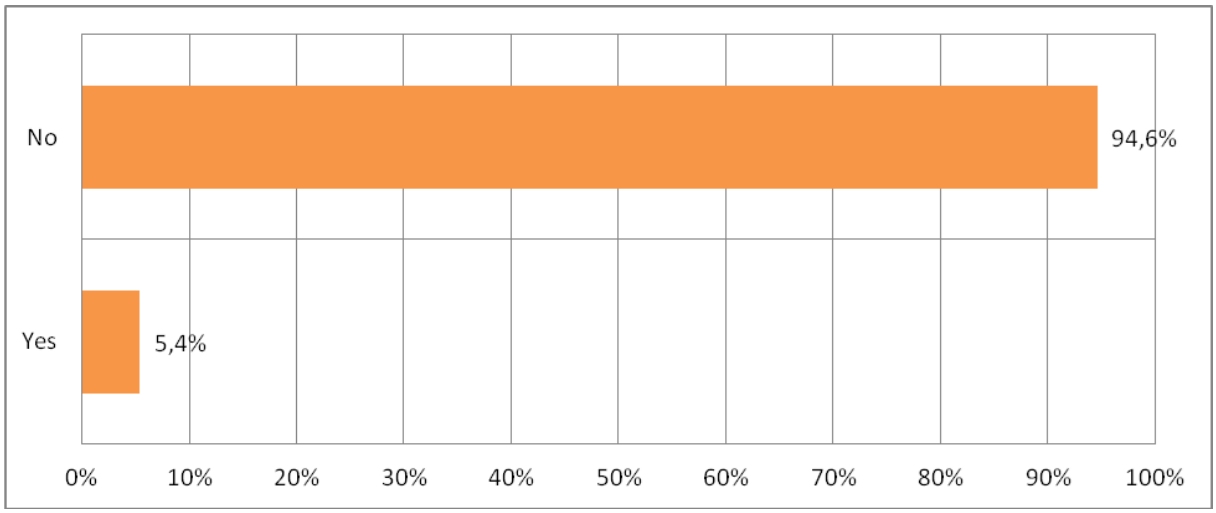

Figure 8. Penalties applied to LGUs by the supervisory authority.

Source: own study based on conducted research.

Administrative money penalties were imposed on 5% of the surveyed LGUs, out of 5.4%, and corrective measures on 95%. Unfortunately, this shows the premises regarding the lack of knowledge of local government employees in the aspect of the GDPR and other provisions governing the data security system (Figure 9).

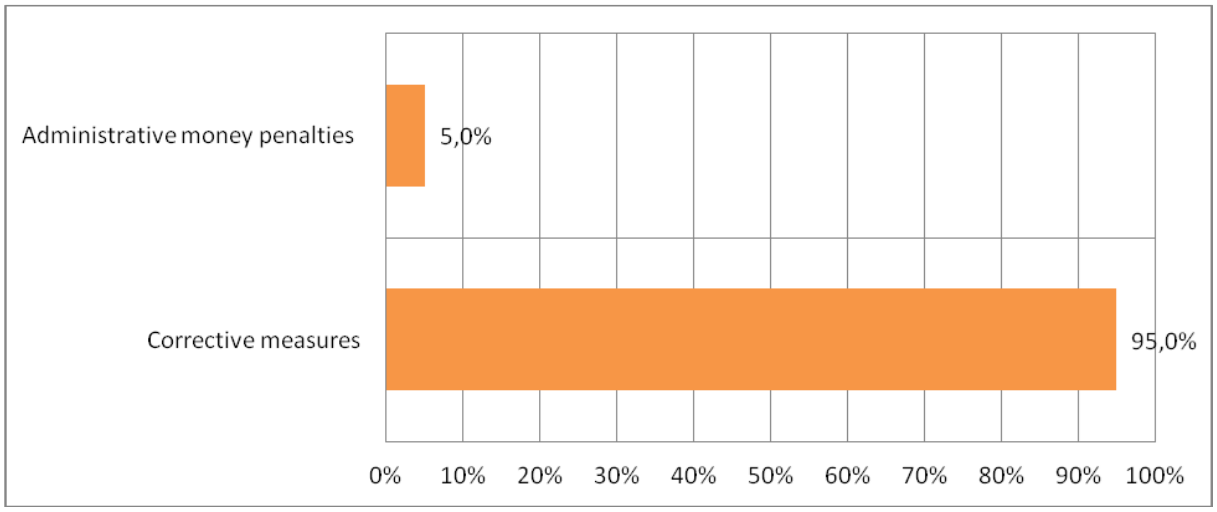

Figure 9. Types of penalties imposed on is by the supervisory authority.

Source: own study based on conducted research.

The highest type of penalty imposed by the President of the Personal Data Protection Office was applied to Mayor Aleksandrów Kujawski (personal data controller). The fine granted is PLN 40,000, and the basic premises for imposing it were:

- lack of a contract for entrusting the processing of personal data with entities to which the data was transferred,
- lack of internal procedures regarding the review of resources available in the Public Information Bulletin in terms of determining the period of their publication.

On the other hand, examples of administrative penalties belonging to the category of corrective measures imposed by the supervisory authority on local government units include:

- conducting additional risk analysis and conducting additional training,
- two-step login to e-mail accounts,
- fulfilling the information obligation towards a natural person,
- recommendations regarding the data set and assigning them to individual employees,
- removal of personal data from the documentation published in the Public Information Bulletin.

It should therefore be noted that the management of organizations in the aspect of security and data protection should display elements of continuous improvement, taking into account the changes taking place in the modern world and the regulations that adapt to the changing environment of the organization's functioning. In addition, organizations must take into account the risks that accompany data processing and the factors that may cause such risks.

4. Types of threats related to the loss of personal data

Each processed personal data may bring many benefits to the organization and to the data subjects, however, in connection with the implementation of the processing process, there may be as many threats. Recital 75 of the GDPR informs about the negative aspects of the processing of personal data that may lead to physical or material or non-material damage, which primarily concerns (GDPR, recital 75):

- identity theft,
- discrimination,
- financial loss,
- identity fraud,
- violation of the confidentiality of personal data protected by professional secrecy,
- infringement of good name,
- significant social damage,
- significant economic damage,
- unauthorized reversal of pseudonymisation,
- deprivation of the ability to exercise control over your personal data,
- deprivation of the possibility of exercising rights or freedoms.

However, it is worth bearing in mind that the risk of violating the rights or freedoms of natural persons always has a different probability of occurrence and a different severity of the threat, therefore, when assessing the possibility of threats, one should always take into account (Izydorczyk, 86a):

- scientific studies with practical applications,
- administrator's own experience,
- experience of other administrators,
- guidelines, codes and/or opinions developed and disseminated by national and international social organizations and protection authorities.

According to T. Izydorczyk, hazard identification is one of the most difficult processes, and the field of organization and management uses the following methods to identify hazards (Izydorczyk, 86b):

- using the experience and methods developed by external experts,
- use of prepared catalogs of threats,
- brainstorming among people involved in hazard identification.

The General Data Protection Regulation does not provide information on how to identify threats, therefore knowledge in this area begins with the application of the provisions of the GDPR. This is due to the legal requirement of risk assessment in connection with violations of the rights or freedoms of natural persons.

In the literature, the most common causes of potential threats are mentioned (Bógdał-Brzezińska, 2012):

- incorrect protection of servers, cryptographic devices and auxiliary devices,
- damage to devices and/or telecommunications line connections,
- inappropriate or insufficient software,
- gaps and errors causing data loss,
- lack of awareness of users in the field of ICT security, validity of processed data, the possibility of personal data protection, expected penalties related to violations, etc.,
- intentional damage to IT systems,
- intentional attacks,
- short technology lifetime,
- deliberate incidents committed by users (management staff, employees), e.g. connecting devices to an unsecured network or connecting external devices containing malware,
- unauthorized actions by administrators and/or users.

Appropriate data protection is the supervision of information security, i.e. the system by means of which the functioning of the organization (its activities) in the field of information security is controlled and managed (Figure 10).

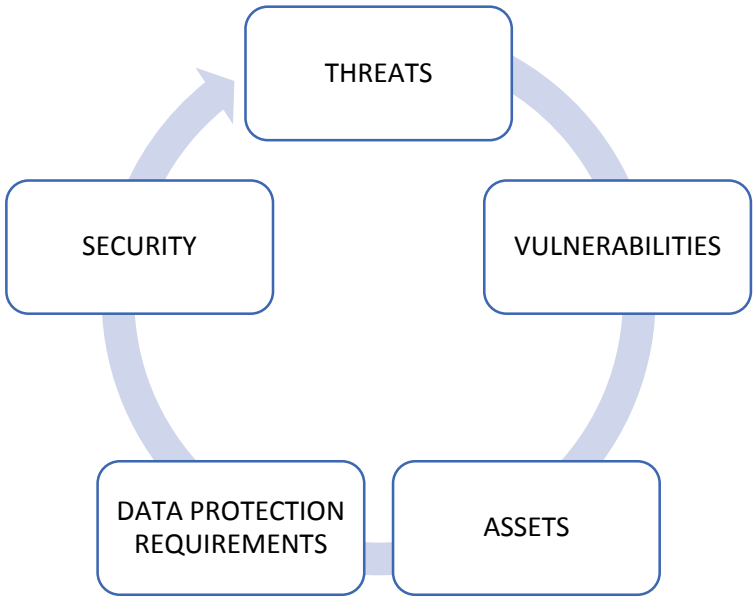

Figure 10. Elements of the information system in JST.

Source: own study based on Zieliński, www.uodo.gov.pl, 8.02.2023.

In accordance with the security requirements contained in art. 39 of the Act on the protection of personal data processed in connection with prevention and combating crime, the personal data controller is obliged to apply the following measures (Dz.U. 2018, point 39):

- technical means,
- organizational measures,

which will ensure proper protection of the processed personal data. Measures must be appropriate to both the type of threat and the category of data protected and appropriate to ensure a level of security that corresponds to the specific threat.

The proper functioning of local government units with regard to the protection of personal data, i.e. the functioning of an appropriate data protection system, is a requirement of the currently applicable provisions of law and a necessity to ensure adequate protection of processed data, which today are invaluable for humans.

The undertakings undertaken by local government units in connection with the processing of personal data should be included in the risk-based approach, include an assessment of the impact on the protection of personal data, check the level of ICT security and verify the facts in connection with the correctness of processing. Activities related to the dissemination of the code of good practice will allow for the improvement of the personal data processing process while ensuring compliance with the provisions of law on the protection of personal data and increasing the sense of responsibility among employees of local government units in this regard.

5. Summary

A proper data protection system allows for effective management of local government units and for precise determination of the possibility of risk to personal data. Local government units processing numerous personal data, both of employees and citizens, have created sufficient reasons to focus on their functioning and to verify them in terms of the protection of the processed data. Compliance with the provisions on the protection of personal data and the implementation of good practices in the field of correctness of data processing should be participatory in order to involve all employees in the protection of personal data and taking into account all factors affecting the protection of such data.

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TECHNOLOGIES INTENSIFYING MODERN ECONOMY IN THE PRIVACY ASPECT

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Purpose: The article deals with the development of information technology in terms of the competition of modern enterprises. The article defines dedicated servers, cloud computing, artificial intelligence and the Internet of Things as technologies affecting privacy. The aim of the article was to draw attention to the possibilities of building a competitive advantage by organizations using technology and to the threats to privacy in relation to these technologies.
Design/methodology/approach: The analysis of the subject matter made it possible to verify the capabilities of enterprises in relation to technology and to identify technologies that intensify the modern economy in terms of privacy. In addition, the article presents the results of the conducted research on activities carried out using technology.
Findings: The article presents the technologies necessary for the implementation of the most important activities in organizations. The article defines dedicated servers, hosting, VPS servers and cloud computing and recommends solutions for the possibility of storing data outside the organization.
Originality/value: The information contained in the article deals with the subject of technologies affecting both the functioning of the organization and privacy. In addition, the article discusses the organization's own servers and hosting packages.

Keywords: dedicated servers, cloud computing, artificial intelligence, privacy.

Category of the paper: research and review publication.

1. Introduction

The changes taking place in the modern world and the development of technology allow for the implementation of new, innovative services, which is conducive to improving the conditions for the functioning of the organization and increases the possibility of achieving the company's goals. In addition, technologies make organizations meet customer expectations, are able to acquire new recipients of their products or services, overcome existing difficulties and achieve the position of a leader in a given industry. However, it is very important to use technology correctly both in terms of privacy protection and the proper intensity of its development.

2. Dedicated servers and VPS servers

The Along with the huge increase in the development of information technology in conjunction with electronic communication, the area of competition of modern enterprises has changed. The source of competitive advantage is undoubtedly technology and access to the Internet (Talar et al., 2014). Implementation of basic services via the Internet is a great facilitation for the functioning of a person and an organization in general, and in the era of unexpected crises, the only possibility of communication and obtaining resources.

In many enterprises, huge profits are generated by e-commerce sales, i.e. Internet sales. It is not profitable to build or rent physical sales places and additionally pay sellers. Much better to get storage space and carry out Internet shipments, employing only the necessary employees. E-services can also be an additional source of income for these hybrid enterprises.

However, in order to fully develop e-services, enterprises are exposed to many barriers that completely prevent them from entering the on-line market or to some extent block access to this market. Many entrepreneurs, despite their great desire, cannot start their business on the Internet. There are many reasons for this phenomenon. The main problem faced by online entrepreneurs are the costs that exceed the budget for starting the business or result from it from incorrect estimation of working time (Flis et al., 2009). The increase in expenses is largely influenced by the costs of hardware and software, marketing and advertising, costs resulting from the employment of necessary employees, rental costs (if the entrepreneur does not have its own storage space), or costs resulting from the purchase of all kinds of machines (infrastructure) enabling, for example, sorting or packing specific packages if the company distributes shipments.

Business activity conducted on the Internet due to the specificity based on the use of the Internet and websites, in addition to the above-mentioned costs, faced by many enterprises, also involves costs related to permanent access to the network, hosting package, or registration of an Internet domain name.

Hosting packages are usually purchased by enterprises in the form of a monthly or annual subscription. Server services are the foundation of the functioning of Internet enterprises. Often, entrepreneurs try not to use their servers and use free hosting or buy the aforementioned subscription. The reluctance of the owners of the company directed against the use of their own servers is justified by the huge costs of purchasing the appropriate equipment, service, software, or the costs of suitably qualified personnel. In addition, legal and security issues are a major obstacle in using your own server (Flis et al., 2009). Of course, the larger the company, the higher all the costs and responsibilities for proper server management.

With the high demand for the lease of server resources, many companies are emerging that provide such services combined with other hosting services. The offers of such companies are often very extensive and differ in terms of parameters and configuration options (Dobrowolski,

2013). It is worth noting that often hosting offers are incomprehensible to an ordinary entrepreneur, so it is important to use only trusted hosting sources and not be fooled by deceptively attractive offers of free and little-known hosting.

Taking into account the uniqueness of providing hosting services for companies that engage in this activity, in order to facilitate their work, the so-called dedicated servers. These servers refer to the service of remote destination by a given enterprise of computers for use by a given user. A dedicated server is equipped with a complete hardware specification and all strictly defined services. All hardware and operating system is solely conditioned by the client's decision, is subordinate to the client and constitutes a private desktop server, providing an ideal solution for entrepreneurs who have strictly defined requirements and their main work is carried out on the network (Hosting365, 2021).

Dedicated servers are aimed at large enterprises due to the cost of their purchase, which does not mean that an individual cannot purchase such a server if it is necessary. Dedicated servers are by nature very advanced solutions and to manage and use them requires a huge amount of knowledge. Dedicated servers are also characterized by a lack of flexibility and configurability during use.

A VPS (Virtual Private Server) server is much easier to use than a dedicated server and is also much cheaper. Thanks to its ease of use, it can be aimed at both novice domain users and more advanced users. In addition, the VPS server, thanks to its affordability and service, is intended for both private and corporate websites that are characterized by a large volume and which are visited by a large number of Internet users. The advantage of this server is also that access to all hardware and server tools depends on the purchased package, therefore it can be adapted to the changing needs of the organization (RapidDC, 2021). If organization's needs for server access increase, organization can purchase an additional package. Each server may be tested within a period of time determined by the organization providing such services, in order to check it against specific requirements (Sprint Data Center, 2022).

Dedicated servers, like VPS servers, are an alternative to hosting in the era of website development. It happens that hosting itself is too unattractive, and the solutions it offers are currently insufficient for enterprises, which may result in inefficient and unstable work. Therefore, enterprises should use hosting that uses dedicated or VPS servers or purchase access to the described servers themselves.

The advantage of using dedicated servers and VPS servers is that in the event of any failure, improper work performed by the server, or during damage, the manager of this server, i.e. the company that provides the server, is responsible for the repair.

3. Cloud server

In addition to shared hosting, VPS server and dedicated server, entrepreneurs or individuals can also use the cloud (cloud server), i.e. a remote server that can be used in different places around the world. Cloud computing is a service of remote sharing of software resources, e.g. system software and hardware resources for disks, networks or servers for data storage and processing (Krok, 2017). The resources used are configurable and therefore used as needed. Access to all data and files is possible anywhere and at any time from any device that has access to the Internet. Due to the functionality of cloud computing, it is treated as the most promoted direction of development by the IT industry.

Cloud computing is also independence in relation to the replacement of equipment, no need to transfer data or reinstall. Cloud computing is able to guarantee unlimited resources because it has gigantic computing power with the ability to store huge amounts of data (Fulmański, Wojczyk, 2014a). Despite the many benefits from the use of cloud computing, in Poland, purchases of cloud services used via the Internet by enterprises employing 10 or more people (excluding from the financial sector) is a small percentage compared to, for example, the Scandinavian countries, which are leaders in this category (Figure 1).

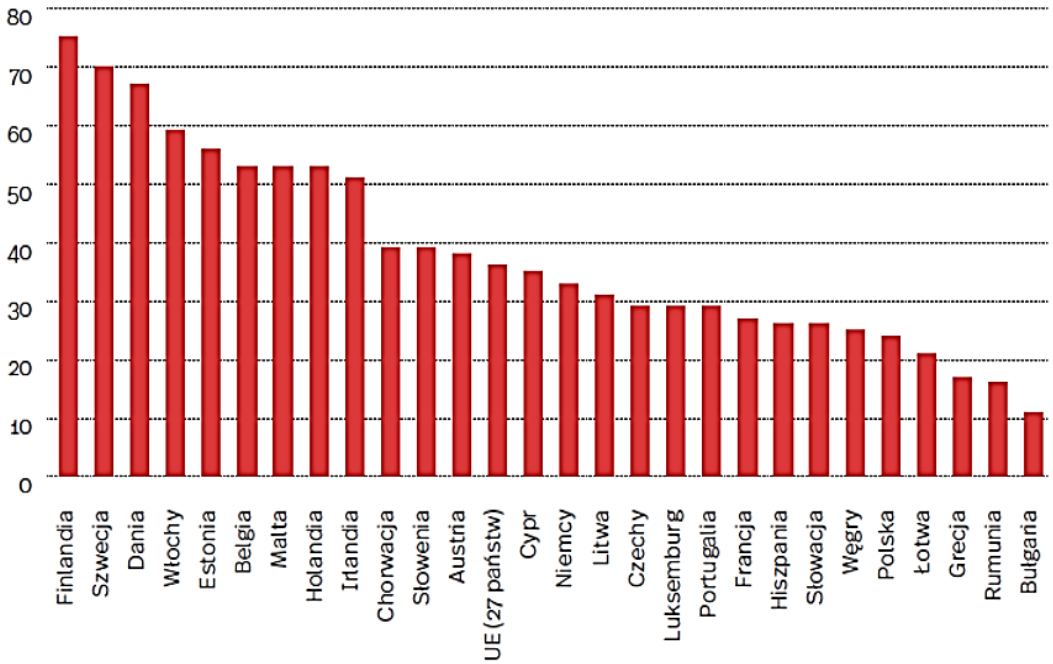

Figure 1. Percentage of enterprises that have purchased cloud computing services among companies employing 10 or more people (excluding the financial sector).

Source: https://300gospodarka.pl/news/chmura-si-big-data-europa-firmy-pie, 22.01.2023.

The situation is similar among Polish local government units (LGUs). Research conducted in 2021 for the purposes of the doctoral dissertation shows that these units currently use cloud computing in their daily activities in a very small percentage. Local government units are slowly

implementing the technology to the processes carried out in their structures. This requires time and commitment as well as the implementation of individual stages. Activities carried out by local government units using technology include:

- chmura obliczeniowa
- bramki biometryczne
- czytniki linii papilarnych
- urządzenia, aplikacje i platformy korzystające z Internetu Rzeczy
- czytniki linii papilarnych
- systemy profilowania
- karty dostępu
- weryfikacja tożsamości dla kontroli dostępu.

Some activities are carried out much more often than others, however, local government units more and more often make their functioning dependent on information technology (Figure 2).

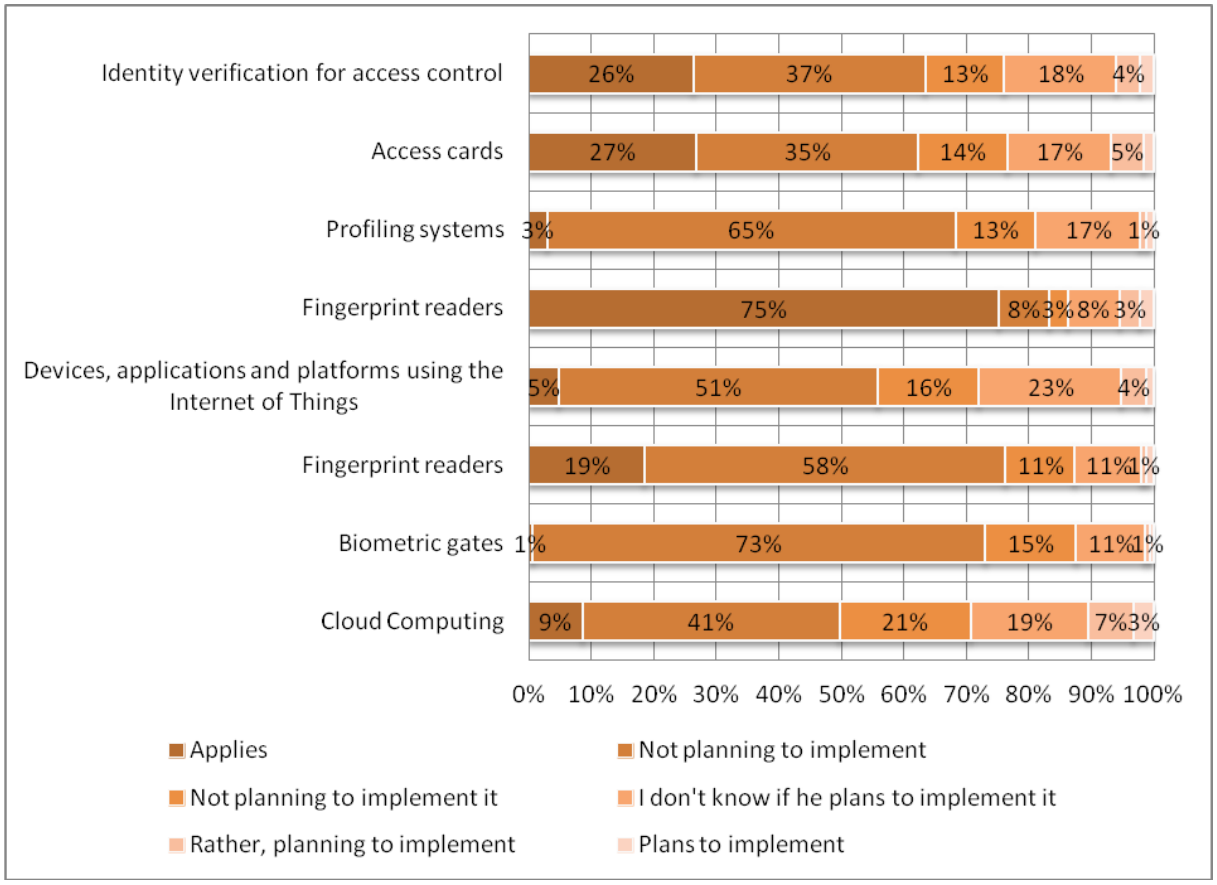

Figure 2. Technologies used by local government units or being in implementation plans.

Source: own study based on conducted research.

Only 9% of LGUs use cloud computing in their work, only 3% of units plan to implement and 7% rather plan to implement cloud computing. The situation is similar in the case of devices, applications and platforms using the Internet of Things. 5% of the surveyed LGUs use

the indicated IT technology, 1% plan to implement it, and 4% rather plan to implement it. Similar values were obtained by profiling systems (3% use, 1% plan to implement, and 17% rather plan to implement). Most of the surveyed local government units informed about the use of technology for Internet services, which include, among others. e-mail or social media. This was indicated by 75% of local government units, 27% use access cards and identity verification for access control (26% of surveyed local government units), as well as a fingerprint reader (19% of local government units). The non-use or moderate use of some technologies probably depends on the implementation costs or many disadvantages of the indicated technologies, e.g. associated with the emergence of threats to privacy (Figure 3).

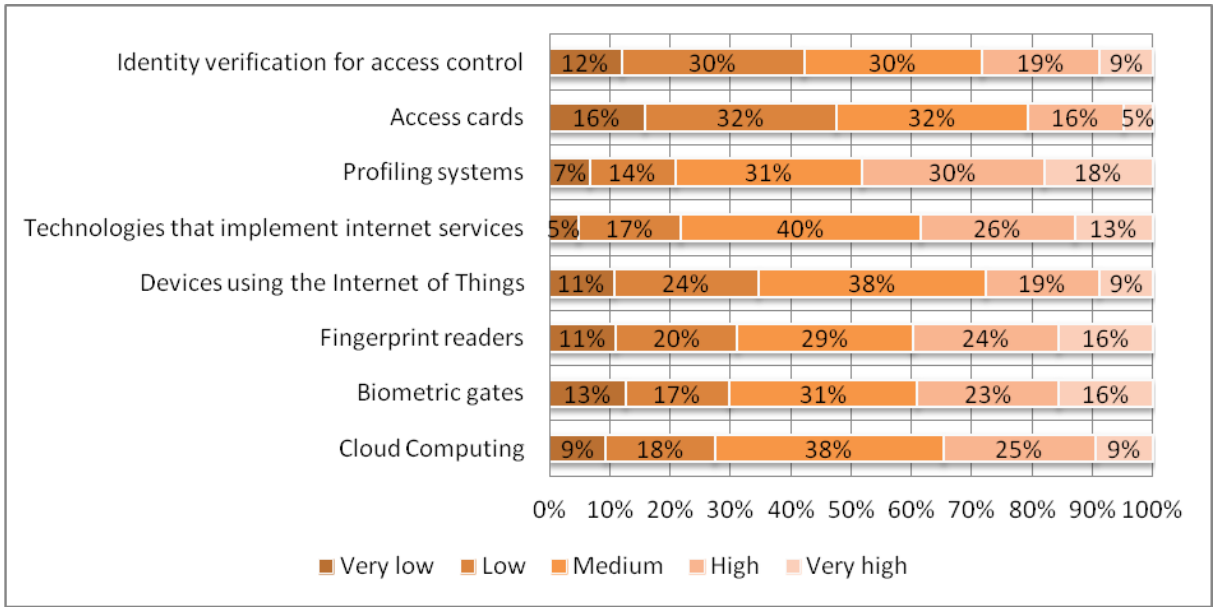

Figure 3. The risk of emerging threats to privacy as a result of the use of information technologies.

Source: own study based on conducted research.

Respondents of local government units recognized that the use of cloud computing carries a very low risk of data loss, as indicated by 9% of respondents. 18% considered it a low risk of the occurrence of a threat, and 38% considered it a medium-low risk. In turn, 9% considered cloud computing as a very high risk and 25% as a high risk. High risk was also recognized in the case of profiling systems (18% and 30%, respectively), and in the case of technologies that provide Internet services (13% and 26%). Devices using the Internet of Things described below in the article were considered a very high threat to data by 9% of the respondents and 19% of the surveyed LGUs considered a high risk.

Dedicated servers, VPS servers, hosting, computing clouds, or other information technology goods in the form of computer memory or external drives, in addition to many advantages for efficient functioning, also have disadvantages directed against the data stored in them. These devices are safe in their design and are only a convenience for users, but you can not always count on their stability and certain security limits. Failure of any of these tools may affect their functionality. In cloud computing, all data is outside the organization's headquarters, and their exact location is unknown. There are also no uniform legal regulations for clouds.

There are no clear rights and obligations of the suppliers of this tool (Fulmański, Wojczyk, 2014b).

Dedicated servers, VPS or hosting are provided by other organizations, which are taken care of by the guardian of a given server, i.e. the company providing such services. Your computer's memory can be exploited by cybercriminals and your external drive can be completely damaged or stolen. In addition, any data is also exposed to disclosure or falsification, it can also be damaged or completely lost. No data is completely safe anywhere. In addition, when it comes to servers provided by other organizations, there is a concern about confidentiality and privacy of data and the risk of dependence on the provider. There is also no certainty what will happen to the data after the end of cooperation with the service provider.

The lack of full responsibility of suppliers for data is another disadvantage of information technologies used to store them. Bankruptcy or breakdown regulations indicate that the service provider is not at fault for what happens with data. In addition, the United States has a better developed infrastructure of servers for data storage, which in turn may result in a high risk of dependence on non-European suppliers (Jeffery, Neidecker-Lutz, 2010). It turns out that there are also many doubts related to the guarantee of complete security and privacy of data on external servers and drives. The risk of theft, destruction or misuse largely depends on technology, and thus also on the growing knowledge of all the possibilities of obtaining this data by unauthorized persons, i.e. on the growing knowledge of security breaches. It should also be remembered that people who have access to this data and are able to commit certain offenses in this aspect for their own benefit are also dangerous in terms of data management.

4. Artificial intelligence

Artificial intelligence, as another aspect of modern reality that plays an important role in the functioning of the economy, affects the privacy and security of processed data. Technology supported by artificial intelligence gives new opportunities to organizations that use it. It facilitates the implementation of undertaken activities, supports the processes taking place in organizations, proves a competitive advantage and enables faster exchange of information. Artificial intelligence is able to collect and analyze all acquired data in a very short time, combine them, personalize information and make personalization. Artificial intelligence (AI) has been and is often used by science fiction writers. Science fiction is something that can be identified with a certain indicative plan for the future. By imagining what the future might look like, humanity somehow drives and sets the course of action in order to realize the dreams of modern economies. Artificial intelligence that humanity knows today was named and defined in 1955 by the American computer scientist John McCarthy, and then propagated. The Universal Encyclopaedia defines artificial intelligence as a field of science that is

responsible for studying the mental behavior of people, as well as the mechanisms of their formation, and then, using computer systems and programs, reproduces the examined behavior and thus maps human thinking. Artificial intelligence's scope of activity includes robotics and artificial life using fuzzy logic, evolutionary calculations and neural networks (PWN, 1996a). Artificial intelligence creates models of intelligent behavior and programs that simulate these models (Figure 4).

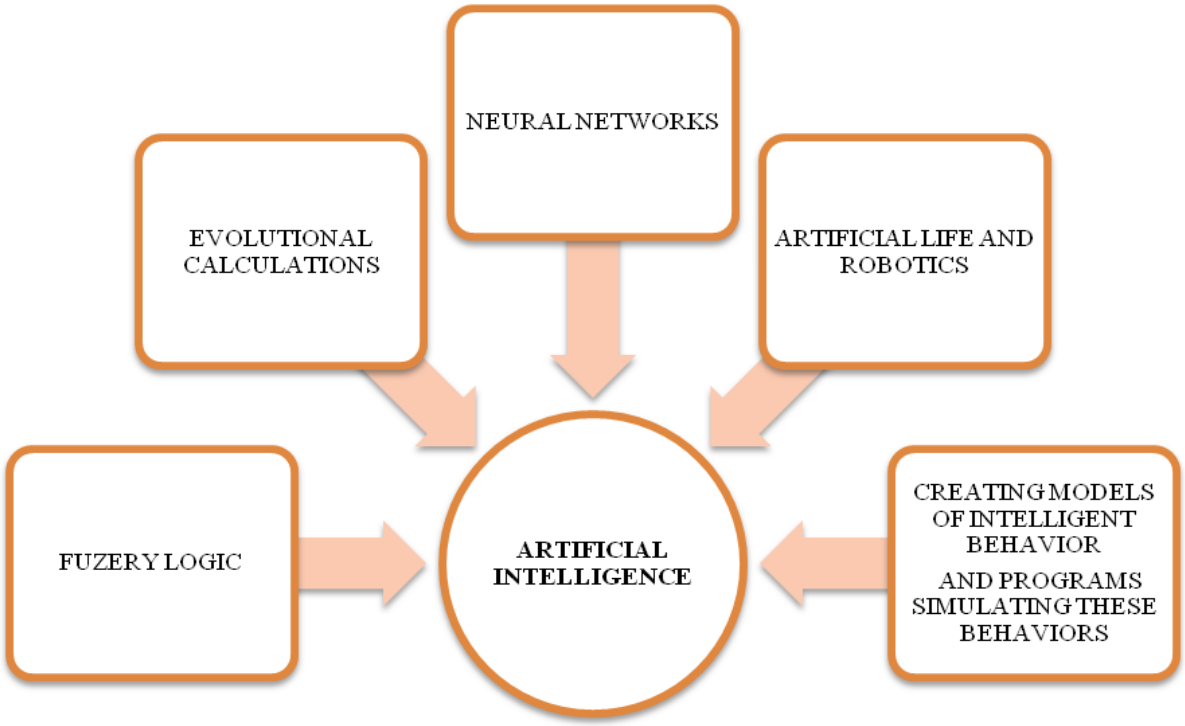

Figure 4. The essence of artificial intelligence.

Source: own study based on Mała encyklopedia PWN (1996). Warszawa: PWN, p. 344.

In the past, man was considered the only thinking being, and intelligence as a feature proper to humans and animals, but more often to humans. The PWN Encyclopaedia creates intelligence as the sum of psychological mental skills that enable a person to effectively use the acquired knowledge in the face of emerging tasks and situations (PWN, 1996b).

The escalation of information technology and the Internet is undoubtedly responsible for the development of artificial intelligence. Thanks to its functionality, AI has found application in many aspects of human life. In addition to practical use, it is also used in many branches of the economy, e.g. in logistics and transport, and in some fields of science, mainly medicine, security or economics. The task of artificial intelligence is to reduce human work, limit it or replace it completely in some duties. It is also about increasing human comfort and helping in everyday activities.

There are many ways to use artificial intelligence and information technology in organizations. Also, local government units in many aspects use the opportunities offered by digital reality.

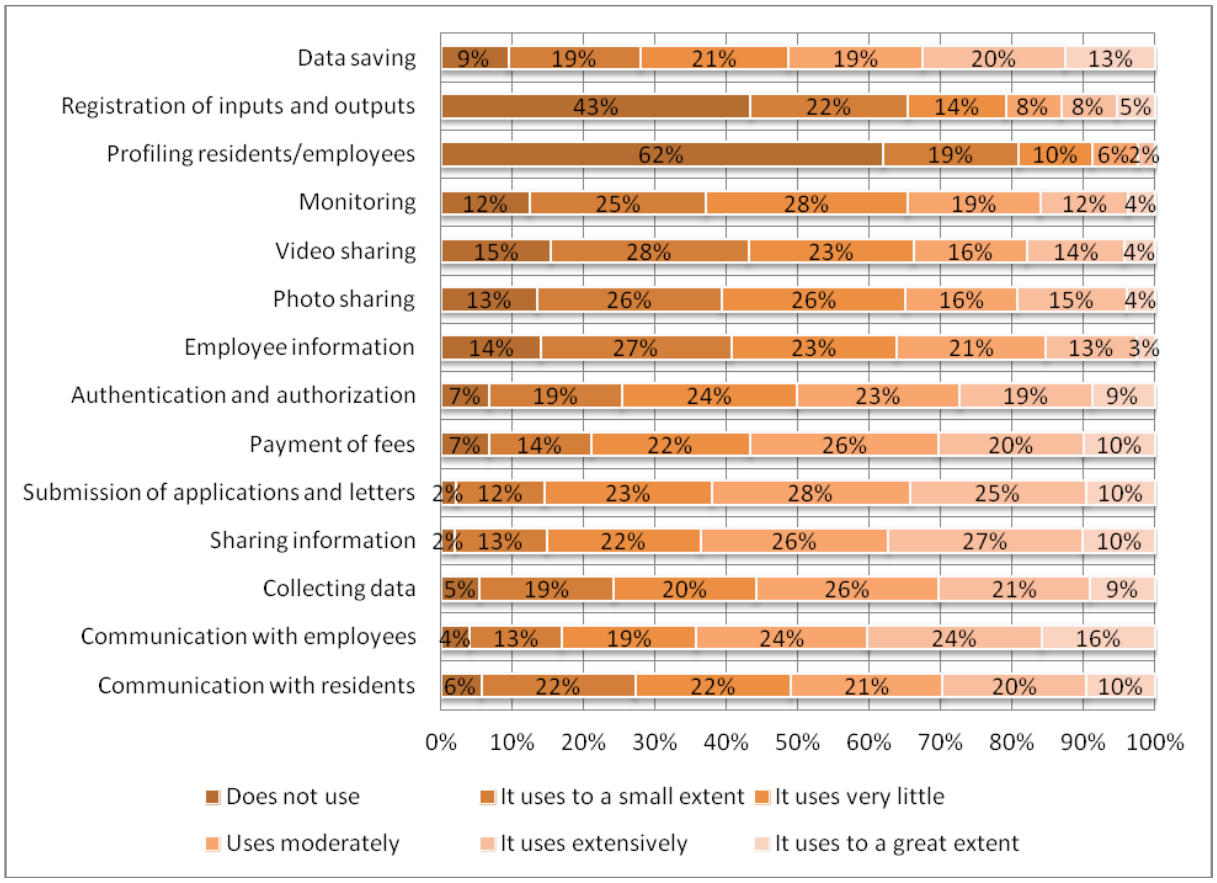

Figure 5. The use of information technology in the implementation of processes in local government units.

Source: own study based on conducted research.

Research shows that local government units use information technology and artificial intelligence to communicate with employees. 16% of the respondents use technological novelties to a large extent, and 24% to a large extent. Similar indicators were obtained for communication with residents, activities related to data collection, information sharing, submission of applications and letters, payment of fees, or authentication and authorization. In addition, LGUs use technology for monitoring (4% of LGUs in a very large scope, 12% in a large scope and 19% in a moderate scope). Profiling of employees and residents is not used on a large scale among LGUs, but already 6% of LGUs use profiling to a moderate extent, and 2% to a large extent, which may raise concerns in connection with further development of technology.

5. Internet of Things

Most information technologies that combine with artificial intelligence are focused around the Internet of Things (IoT). Iot is a technology that affects most devices through sensors and

connecting devices to one computer network. Thanks to this, all devices can communicate with each other using a common language, collect, process and exchange data. Typically, such devices are controlled using a smartphone via Bluetooth. The Internet of Things is used in the main sectors of the national economy in industry, transport, trade, health, care, science, education, administration and other services (Atzori et al, 2010).

IoT enables remote control of devices to improve comfort, but a huge number of devices is an area of activity that is related to the issue of with IoT security. Devices operating as part of the Internet of Things pose a risk of hacking and using devices in a cyberattack, e.g. to cause property damage or steal data, both in private life and in modern organizations. In a broader scope, IoT can also contribute to attacks on industrial infrastructure related to hybrid warfare, attacks on automation or activism regarding, for example, environmental pollution.

Modern technology also means smart cities, unmanned aerial vehicles and modern monitoring systems used by enterprises and formations designed to protect the safety of people and property, and to maintain public safety and order.

Unmanned aerial vehicles were created to monitor and control and filming objects, although they are currently also used in agriculture, medicine or transport, as internal transport of organizations or as a means of transport for distributing parcels. Unmanned aerial vehicles are also to be an Intelligent Transport System to innovatively and seamlessly control cities. Drones will increasingly have the task of checking traffic volumes, controlling air quality and weather, and supervising whether road users comply with the regulations. Unmanned aerial vehicles are also part of modern monitoring, which, in addition to maintaining security, consistently monitors and controls the public, including employees of organizations.

Information technology has also found application in face scanning at shop windows and sending offers of products according to interests, remembering products viewed, verifying any choices made on the Internet, locating and observing. Creating large sets of customer and market data and analyzing this data to obtain valuable insights undoubtedly helps to gain a competitive advantage.

Another product of technology and artificial intelligence that is unique to humanity are robots. It is thanks to AI that robots can behave and perform certain functions similarly to humans. Robots created on the basis of models of intelligent behavior are able to create their own artificial intelligence, make decisions and use their own language incomprehensible to humanity (Rocha, 2018). Artificial intelligence is many times superior to human intelligence, which is why its further development may cause many negative consequences. Robots answer questions and imitate humans. Currently, there are also humanoid robots that closely resemble humans, and one of them, Sophia, currently holds the citizenship of Saudi Arabia. However, there is a fear that robots will take the places of existing employees of the organization or limit their privacy.

Artificial intelligence is a very interesting field of science that exceeds the current cognitive boundaries and encourages the creation of artificial beings that are increasingly intelligent. The continuous development of this technology may cause a huge step forward towards the realization of the visualized future, but it may also turn out that it will lead to a certain revolt of machines, the disappearance of human intelligence resulting from not performing activities carried out so far, in which machines will replace people, and to the complete dependence of man from the use of technology. The dense number of connections between devices also makes it easier for cybercriminals and cyberspies. Devices powered by Internet networks are constantly collecting, transmitting and analyzing data, which consists of building a user profile (Zawierucha, 2021).

When analyzing the issues of artificial intelligence and technology development, it should be noted that the future is not and probably will not be a clear and specific extrapolation of current experiences related to information technologies. Nevertheless, it will increasingly make the functioning of a person and an organization dependent on technological possibilities and set the rules for the competition of enterprises.

6. Summary

Improper use of data by other people, intimidation, spying, constant monitoring can make people helpless in the face of technology and data managers, and consequently lead to all kinds of manipulation. The manipulation of the technology user is also based on the addiction of man to technology. Thanks to information technology, many aspects of life are changing dramatically. This also applies to the functioning of modern enterprises that are increasingly dependent on technology. Unfortunately, this is also a huge milestone for entry into virtual and augmented reality controlled by global corporations and governments.

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THE IMPACT OF CSR ON STOCK EXCHANGE QUOTATIONS AND PROFITABILITY IN THE POLISH BANKING SECTOR

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Purpose: This article analyses the relationship between the inclusion of the CSR policy in the bank's strategy and the level of stock exchange quotations and financial results (achieved profitability ratios), based on the example of Poland.
Design/methodology/approach: The article examined whether socially responsible banks obtain better stock exchange quotations and show higher profitability (improvement of profitability ratios). Secondary data used in the article concern 9 banks. The analysis period covers the years 2009-2019, in which the WIG-RESPECT index was calculated. The control group consists of four banks, two of which did not join the analyzed index, while two more only joined it after 6 or 7 years.
Findings: The study leads to the conclusion that CSR has a positive impact on the level of quotations and an improvement of the financial ratios of banks classified as socially responsible compared to the control group. However, just belonging to the group of banks perceived as socially responsible does not guarantee success in the form of higher quotations and an improvement of financial ratios.
Research limitations/implications: The sample for comparison is small, and the adopted control group is not fully homogeneous. The study only covered one country and therefore does not take into account the institutional differences between various economies and banking systems. The proposed directions for further research are to find an answer to the question whether the banks that introduced the CSR policy into the strategy with delay improve their results.
Practical implications: Banks should include CSR activities in their strategy, as they may bring benefits in the form of increased market quotations and profitability ratios. Exchange investors should take into account the involvement of banks in CSR activities, as they may affect the effectiveness of bank operations and, consequently, the level of their market valuation.
Social implications: Since socially responsible banks receive better market ratings and improvement of profitability ratios, it is expected that their activity in this area will develop, which will bring social benefits.
Originality/value: A comparison was made of the market valuation and financial ratios of banks, broken down into declaring and not declaring activities in the area of CSR.

Keywords: banks, stock exchange quotes, profitability ratios, CSR.

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

1. Introduction

Banks are key institutions for the functioning of the economy (Scholtens, 2009) because, as intermediaries between savers and investors, they co-decide on the allocation of resources in the economy (Moufty et al., 2021). They play an important role in the context of sustainable economic development for at least two reasons. Firstly, they decide what type of activity the enterprises will receive financing for, and one of the criteria for granting a loan may be the borrower's compliance with the principles of sustainable development. Secondly, the banks themselves can focus their business strategies and organizational culture in line with the recommendations of corporate social responsibility (CSR) (Nizam et al., 2019; Dedu et al., 2021).

The intangible nature of financial services, which hinders their measurement and comparison, speaks in favor of expanding the importance of CSR in banks' strategies. For this reason, it becomes important to maintain an appropriate reputation, depending on e.g. effective communication with customers (Walsh, Beatty, 2007). CSR policy may be an element of a differentiation strategy based on emphasizing the quality of products and services, customer orientation and building the image of a good employer in order to gain a sustainable competitive advantage (Sen et al., 2006).

Most authors point out that the reputation of the banking sector as a whole deteriorated during the 2008 global financial crisis. In the public perception, banks contributed to its creation, and during the crisis, they did not fulfil their obligations towards their stakeholders (Esteban-Sanchez et al., 2017). Although banks' efforts to build an accountable reputation for CSR have a positive effect on their results, the results of research on this issue are ambiguous, especially when it comes to the crisis period. Forcadell, Aracil (2017) found a negative relationship between CSR and financial results in the period after 2008, Esteban-Sanchez et al. (2017), while the research by Ganga et al. (2018) indicated the positive impact of CSR involvement on the financial performance of banks. Regardless of the profitability of CSR activities during the crisis, one of the ways to strengthen the credibility and confidence of stakeholders after the global financial crisis was the intensification of corporate social responsibility activities by banks (Miralles-Quirós et al., 2019).

This article analyses the relationship between the inclusion of the CSR policy in the bank's strategy and the level of stock exchange quotations and financial results (achieved profitability ratios), based on the example of Poland. The first part presents an overview of the literature on CSR, with particular emphasis on references to the banking sector. This review includes, inter alia, research results on the effectiveness and profitability of CSR activities. The following sections present the research assumptions, the method used and the results of the research. The originality of the undertaken research consists in comparing the financial results and stock exchange quotations of the banks declaring inclusion of CSR in their strategy with other banks. The article ends with the sections of discussion and conclusions.

2. Literature review

In search of a competitive advantage, more and more often enterprises reach for values consistent with CSR, trying to act as a good employer, citizen, neighbor. According to many authors, CSR, taking into account social and environmental goals as well as economic goals should become an element of the enterprise's strategy, because it is expected by the economic environment (Valeute 2015; Masoud, 2017; Suriyankietkaew, Petison, 2020).

One of the main reasons for the interest in CSR on the part of enterprises is the creation of an image-based reputation (Pérez, 2015; Engizek, Yasin, 2017), which is an important element of the differentiation strategy, mainly directed to customers (McWilliams, Siegel, 2011; Fatima, Elbanna, 2023). An appropriate image is also conducive to increasing employee satisfaction (Gond et al., 2010; Kolk et al., 2016) and other entities in the environment (Fombrun, van Riel, 1997; Jeffrey et al., 2019). This enables the improvement of the use of the enterprise's resources (better use of human resources, reduction of energy consumption and waste reduction, reduction of insurance costs, legal problems) (Maignan, Ferrell, 2001), contributing in the long term to the reduction of costs and risk (Saeidi et al., 2015). All of the above image effects should result in improved competitive position, market success and the possibility of achieving above average profit (Roberts, Dowling, 2002; van Marrewijk, 2003; Hsueh, 2014; Achi et al., 2022).

Building and managing reputation is especially important in the service sector due to the intangible nature of the offer. CSR activities can help build a strong reputation and better relationships with key stakeholders (Hillman, Keim, 2001; Kabus, Dziadkiewicz, 2022). Seen from this perspective, CSR programs can be treated as investments in reputation and relationships with stakeholders, in particular with customers (Narwal, 2007, McDonald, Rundle-Thiele, 2008, Ramzan et al., 2021). CSR initiatives targeted at customers have a significant impact on: the company's (brand) assessment, confidence in the value and quality of the service (product), which translates into intentions of buying (Bhattacharya, Sen, 2004; Mohr, Webb, 2005; Poolthong and Mandhachitara, 2009; Lécuyer et al., 2021), customer satisfaction and loyalty (Marin et al., 2009; Stanaland et al., 2011; McDonald, Lai, 2011; Mandhachitara, Poolthong, 2011; Perez et al., 2013; Muflih, 2021) and recommendations provided to other customers (Goyal, Chanda, 2017).

CSR activities contribute to the creation of a good image in the society, which creates favorable relations with all stakeholders. Good CSR performance, including investment in personnel, can provide increased ability to attract and retain valuable employees, increase satisfaction, motivation, morale, productivity, commitment and loyalty of existing employees, and reduce potential employment problems and costs (Branco, Rodrigues, 2006; Moufty et al., 2021). The accountability of banks to their shareholders helps to increase their confidence, making it easier to attract more investors, lenders and depositors, ultimately leading to improved long term financial results (Zhou et al., 2021).

The obtained reputation may translate into the higher earning potential of banks in terms of net interest income. Customers taking into account the bank's reputation resulting from, inter alia, CSR may be willing to accept a lower interest rate for their deposits if they come from a bank with strong CSR features (Wu and Shen, 2013). Some companies prefer loans from reputable banks, even if they have to pay higher interest rates on loans (Kim et al., 2005). A strong reputation for CSR may also allow banks to charge higher fees and commissions for additional services (Wu, Shen, 2013).

The above considerations indicate the need to invest in CSR as a way of building a bank's reputation. It should be noted here that not all authors share this opinion. Research by Ruiz and García (2020) on the example of Great Britain and Spain shows that the relationship between CSR and bank reputation is small (there may be a positive, negative or zero relationship between various CSR constructs and the bank's reputation). The reasons for this state of affairs were indicated by the instability of the financial system and the focus of CSR initiatives on restoring the lost reputation of banks (after the 2008 crisis), and not on real social problems. Other authors point out that CSR spending certainly improves public relations, but there is no certainty about the customer's reaction (Morrison, Bridwell, 2011).

One of the reasons why customers do not react to CSR initiatives may be insufficient communication. A critical prerequisite for reaping the benefits of involvement in CSR resulting in the expected customer behavior (increased loyalty, satisfaction, positive relay of information) is making customers aware of such activities and a customer understanding of the social issues in which banks engage (Fatma, Rahman, 2016; Cheung et al., 2020; Oyewumi et al., 2018). Research indicates that customers' ability to accurately identify companies' CSR activities is generally quite low (Bhattacharya, Sen, 2004). Therefore, banks should not only inform but also educate customers, making them aware of the importance of CSR activities (Pomering, Dolnicar, 2009).

The choice of methods and channels for the presentation of undertaken CSR initiatives and the selection of areas in which banks need greater visibility are the most important for the effectiveness of social marketing strategies (Hildebrand et al., 2011). These activities should be long-term and comprehensive, also covering the communication of all CSR activities. While initiatives directed at customers are rather visible to them, initiatives addressed to other stakeholders (i.e. employees, suppliers, investors) are less visible, and they also influence customer behavior (Pirsch et al., 2007; Fatma et al., 2014). The conclusions of the E&Y study (2016) indicate that disclosing CSR efforts (sustainability reports) brings the organization a better reputation, meeting employees' expectations, reducing incorrect information about the enterprise, improving social performance, increasing customer loyalty, etc. Other studies indicate that a higher level of CSR disclosure has a positive effect on the valuation of the company's shares (Mallin et al., 2014), and this effect is more visible in industries with a higher impact on the environment (De Klerk et al., 2015).

One of the basic strategic decision-making problems is the direction and scope of CSR activities undertaken. It is advisable to invest in activities that are closely related to the mission and value of the company and at the same time contribute to social development. The condition for the effectiveness of the message addressed to consumers is adjustment to their expectations and motivations as well as the adoption of an appropriate schedule of social initiatives and their appropriate promotion (Becker-Olsenetal, 2006).

Credibility plays an important role in the perception of CSR activities by customers. Research on banks in the EU and the US revealed a significant positive correlation between the internal social dimensions of sustainable development and banks' performance. An exception was the link between the environmental dimensions of sustainability and bank performance, as customers did not associate banking as an environmentally threatening sector. Customers may treat bank information on environmental activities as greenwashing (Brammer, Pavelin, 2006; Grougiou et al., 2014), i.e. a strategy according to which companies, in order to attract environmentally friendly investors and customers, disclose manipulated information (reporting CSR activities that they do not undertake or undertake to a small extent) (Saeed, 2021). The argument against undertaking a greenwashing strategy is that it may reduce the effectiveness of real CSR initiatives (Parguel et al., 2011), and the results obtained by Goss and Roberts (2011) and Lecuyer et al., (2021) indicate that efforts to manipulate stakeholders through greenwashing are likely to be ineffective.

CSR practices in particular sectors of economic activity are relatively “homogeneous” due to: regulations imposed by the state, influence of stakeholders, imitation of other organizations and unification of jobs in the sector. In pursuit of social legitimacy, organizations implement projects aimed at customers, communities and the environment, even though they involve costs and time (Khan et al., 2020). The scope of undertaken CSR activities depends on the decisions of managers whose task is to protect the interests of the corporation, taking into account the validity of the claims of various stakeholders (Donaldson, Preston, 1995; Maignan, Ferrell, 2004). Basically, managers act as shareholder agents as owners of the company, controlling the day-to-day operations of the enterprise and making all investment and financial policy decisions. As managers do not usually own the companies they manage, their interests do not always align with those of shareholders (Chakraborty et al., 2019). Part of the publication points out that CSR policy can be used by managers as a way to gain private benefits (such as personal reputation) and not to increase shareholder value (Barnea, Rubin, 2006; Barnea, Rubin, 2010; Chahine et al., 2019).

The scope of undertaken CSR initiatives depends on the intensity of competition and the financial situation of the organization. On the one hand, market competition drives company ethical behaviour, due to pressure from customers, competitors, or concerns about reputation. On the other hand, strong competition in the market reducing profitability may force companies to save on, for example, non-basic activities (including CSR expenses) in order to maintain profits (Shleifer, 2004; Forgione, Migliardo, 2020). When the level of competitive activities in

a given sector is high, a positive image related to CSR can improve the company's financial performance, while when the level of competitive activities is low, the lack of such activities (omitting CSR expenditure) may improve financial results (Kim et al., 2018).

It is pointed out in the literature that past profitability (availability of financial resources) and the company's social performance are positively related. Investing in social performance is also found to be positively related to future financial performance. This type of feedback is seen as a result of good organizational management (Waddock, Graves, 1997). Companies voluntarily engaging in CSR activities expect that it will bring them financial benefits. In addition, they not only build their image as socially responsible, but also profitable (having funds for social expenditure) (Aswani et al., 2021).

Some authors emphasize the importance of the economic approach, writing that CSR should have a business justification (Esken et al., 2018; Wagner-Tsukamoto, 2019). According to this group of authors, the actions taken can be treated as socially responsible only when they bring positive financial effects (Lantos, 2001). Proponents of the economic approach state that there is an optimal level of investment in CSR that maximizes profit while satisfying stakeholders (consumers, investors, employees and the community) (McWilliams, Siegel, 2001; Barnett, Salomon, 2012). This level can be determined by analyzing the costs and benefits of investing in CSR. Godfrey et al., (2009) suggest the existence of an optimal level of CSR from the point of view of limiting broadly understood risk.

Most meta-analyses indicate a positive impact of the implementation of CSR rules in an enterprise on its profitability (Orlitzky et al., 2003; Allouche, Laroche, 2005; Boaventura et al., 2012; Wang et al., 2015; Mikołajek-Gocejna, 2016; AidElMekki, 2020), with some of them having a small impact (Margolis et al., 2009; Gallardo-Vázquez et al., 2019). However, it should be pointed out that it is really a minority, but some studies show that the relationship between CSR and financial results may be neutral or even negative (Boyle et al., 1997; McWilliams, Siegel, 2000; Hirigoyen, Poulain-Rehm, 2015; Zhao, Murrell, 2016; Lee et al., 2018). According to Bruno and Lahouel (2021), discrepancies in the results obtained by individual researchers are the result of: discrepancies in the adopted definitions, differences in the selection of ratios, differences in the selection of databases, methodological problems in the correct selection of the sample, ignoring organizational differences and sensitivity to the time scale.

Discrepancies in the obtained results also occur in surveys concerning the banking sector. Most of them show a positive relationship between CSR and bank profitability. An example can be the research conducted in the USA, according to which there is a positive and significant correlation between financial results and CSR (Simpson, Kohers, 2002; Cornett et al., 2016; Miller, 2016). Research based on international comparisons covering a larger number of countries indicates that CSR of banks is positively related to financial performance in relation to traditional measures (including ROA and ROE) (Shen et al., 2016; Esteban-Sanchez et al., 2017; Wu et al., 2017). Weber (2017) found a positive relationship between sustainability

performance and bank financial ratios (i.e. total assets, net profit, ROA and ROE) of Chinese banks. However, there are also studies indicating the lack of a statistically significant relationship between CSR and financial performance, e.g. in the case of banks in Italy (Soana, 2011).

Attention should be paid to the two previously mentioned (Bruna, Lahouel, 2021) reasons for differences in the obtained test results, in the form of failure to take into account organizational (institutional) differences and sensitivity to the time scale (other reasons for differences in test results refer to the heterogeneity of definitions, adopted indicators and samples research.

An empirical study carried out by Belasri et al. (2020), based on an international sample of banks, made it possible to conclude that the CSR of banks is positively related to their effectiveness, and this relationship depends on the institutional context. CSR has a positive effect on the efficiency of banks only in developed countries, which have a high degree of stakeholder orientation and appropriate institutional features.

The study in Nigeria may argue the lack of a positive relationship between CSR and financial performance in developing countries. According to the researchers, the reason for the negative impact of CSR on bank results was the poor disclosure of actions taken by banks (Oyewumi et al., 2018). Other studies contradict the conclusion that in developing countries, banks do not benefit from applying CSR rules. Research in India (Maqbool, Zameer, 2018) shows the positive impact of CSR on financial results, socially responsible banks gain a competitive advantage in Jordan (Abu-Alkeir, 2021), and in Bangladesh the average rate of return on assets of socially responsible banks is higher than in other banks (Ahamed et al., 2012).

A very important aspect from the perspective of the impact of CSR on financial results is the difference between the long-term and short-term effect. Undertaking CSR activities is associated with incurring costs, which may have a negative impact on the financial result in the short term (Hillman, Keim, 2001). This effect is temporary, and in the long run, CSR activities should bring good reputation to banks and enable them to attract additional customers (Zhou et al., 2021). If the expected reputation can be built up, one can expect higher profitability of the resources involved, a better financial situation and a higher market valuation (Garriga, Melé, 2004). Therefore, CSR should be treated as a strategy that allows for higher returns in the long term, offsetting the costs incurred in the short term (Forgione, Migliardo, 2020).

Referring to the scale of operations, the research gives different answers to the question of what the impact of the size of banks is on the activities undertaken in the area of CSR. According to Forgione and Migliardo (2020), banks that dominate the market do not feel the moral pressure of public opinion to undertake social initiatives (they do not undertake a wider range of initiatives than smaller banks). In turn, the research of Cornett et al. (2016), indicates that the largest banks, to a greater extent than smaller banks, conducted socially responsible activities (e.g. lowering deposit fees, increasing services for low income communities.

Based on the results of the above mentioned research on the discussed issues, the article hypothesized that: **socially responsible banks obtain better market ratings and have a higher profitability (improvement of profitability ratios).**

3. Research metodology

All banks that meet three conditions at the same time were selected for the analysis: headquarters based in Poland, belong to the WIG-Banki index and have been listed on the Warsaw Stock Exchange since at least 2009. These criteria were met by 9 banks.

The WIG-RESPECT index, which has been listed on the Warsaw Stock Exchange since 19 November 2009, was used to distinguish socially responsible banks. This index functioned until the end of 2019 (since 1 January 2020, by a Resolution of the Stock Exchange Management Board, it has ceased to be published and was replaced with another index referring to CSR, covering all the largest companies listed on the stock exchange). Companies that wanted to be included in the WIG-RESPECT index underwent a three stage assessment, including an assessment of the liquidity of trading on the stock exchange, corporate governance practices and activities addressed to stakeholders as part of CSR, which were assessed from the perspective of environmental, social and economic factors (http://www.respectindex/…).

For the purposes of the analysis, the banks that were accepted into the WIG-RESPECT index at the beginning of its operation were accepted as socially responsible. The first two (Handlowy, ING) joined the index in 2009. Three more (MBank, Millennium, Santander Polska) joined the index in 2010. It was assumed that these banks implemented the CSR policy before joining the index of socially responsible companies.

The control group consists of the remaining banks that meet the adopted criteria. Two of them did not enter the WIG-RESPECT index at all (PKO BP and BOŚ). Two more banks joined the index, but only after several years of its operation (BOŚ in 2015 and Pekao in 2016). They were added to the control group, assuming that they had applied the CSR policy too briefly for its positive effects to be visible in the financial results.

An important additional piece of information about the banks forming the control group is the fact that they occupy the extreme positions in terms of total assets. In 2009, PKO BP and Pekao had the highest level of assets (in 2019, SantPL was promoted to second place ahead of Pekao). The two remaining banks belonging to the control group (BOŚ and Getin), both at the beginning and at the end of the analyzed period, had the lowest sum of assets among the 9 analyzed banks.

The research period covered the years 2009-2019, in which the WIG-RESPECT index was operating on the Warsaw Stock Exchange. The verification of the hypothesis was based on the available financial data of banks and stock exchange levels. The share prices of the analyzed

banking companies are the closing values at the last trading session in a given year. The index method was used in order to obtain comparability of data, in the case of stock exchange quotations, assuming the level of quotations at the end of 2009 (i.e. the year in which the WIG-RESPECT index appeared on the Warsaw Stock Exchange) as the base value. As part of the stock price analysis, a comparison of the banking sector index (WIG-Banki) to the entire market (WIG), the index of socially responsible companies and the index of the largest companies listed on the Warsaw Stock Exchange was presented. To analyze the differences between the banks accepted as socially responsible and the control group, a chart showing changes between the beginning and end of the analyzed period was used, as well as a tree diagram for changes in exchange rates of the surveyed banks in the years 2009-2019.

With regard to the profitability analysis, the basic profitability ratios ROA, ROE and ROAA were calculated on the basis of the annual financial statements of the companies for the years 2009-2019. The analysis began with changes in the levels of profitability ratios in individual banks between the beginning and the end of the analyzed period. As an initial method of analysis, a ranking approach was used, taking into account the positions of individual banks, and the arithmetic mean of the achieved financial ratios for the groups of banks being compared. To check how different the achieved financial ratios differ in the analyzed groups of banks, tree diagrams were used to change all the analyzed profitability ratios in the years 2009-2019. At the end of the research part, the principal component analysis method was used, which simultaneously took into account: the change in the stock exchange rate between the beginning and the end of the analyzed period and the average levels of ROA, ROE and ROAA ratios obtained by individual banks.

4. Results

The impact of CSR on stock exchange quotations

Changes in the level of quotations of banking companies should be considered amongst the entire market and its selected segments. In the years 2009-2019, the Polish banking sector improved its performance much slower (15.32%) than the overall market (44.63%) (Table 1). This could be the result of the financial crisis of 2008, which caused an increase in the share of non performing loans in the loan portfolio, as well as a decline in customer and investor confidence in the banking sector as "complicit" to the crisis. In the analyzed period, the WIG-RESPECT index (socially responsible companies) improved its quotation by 45.94%. Referring to the 5 banking companies that co-created it, it should be pointed out that compared to the sector index (WIG-Banks), they showed a much better improvement in quotations. Admittedly, two of them underestimated the RESPECT index (one of them recorded a 26%

drop in quotations, while the other grew by only 21.88%), they are, however, the smallest of the analyzed banks, with the lowest share in the index. The three remaining banks with higher shares in the index recorded increases in quotations in the analyzed period exceeding the increase in the RESPECT index (increases from 49.77% to 159.62%). Therefore, the banking sector companies raised the WIG-RESPECT index and did not lower it.

The performance of the banking sector in Poland should also be related to the WIG-20 index, which groups the largest companies. In the conditions of the Polish stock exchange, banks are relatively large economic organizations. In 2009, 5 out of 9 analyzed banks were included in the index of the 20 largest companies, three more constituted the "reserve" (they were considered candidates for the index). In 2019, 4 of the analyzed banks remained in the index, and two more were treated as reserve banks.

In the analyzed period, the index of the largest companies on the Warsaw Stock Exchange dropped by 9.99%. One of the reasons for the relatively weak growth of the banking sector in Poland is therefore the size of banks as economic organizations (their affiliation to the WIG-20) at a time when investors shifted their investment preferences to smaller companies.

The ten year period of the analysis seems to be enough to answer the question – Is there a visible effect of the increase in quotations and improved profitability of socially responsible companies compared to the control group? Considering the differences between the changes in the level of quotations of the analyzed banks, between 2009 and 2019 there is an advantage of the banks that joined the WIG-RESPECT index in the years 2009-2010 (the first five in Fig. 1). Quotations improved four out of nine banks (Table 2), all belonged to the group of socially responsible. At the end of 2019, all banks from the control group had lower quotations than at the end of 2009.

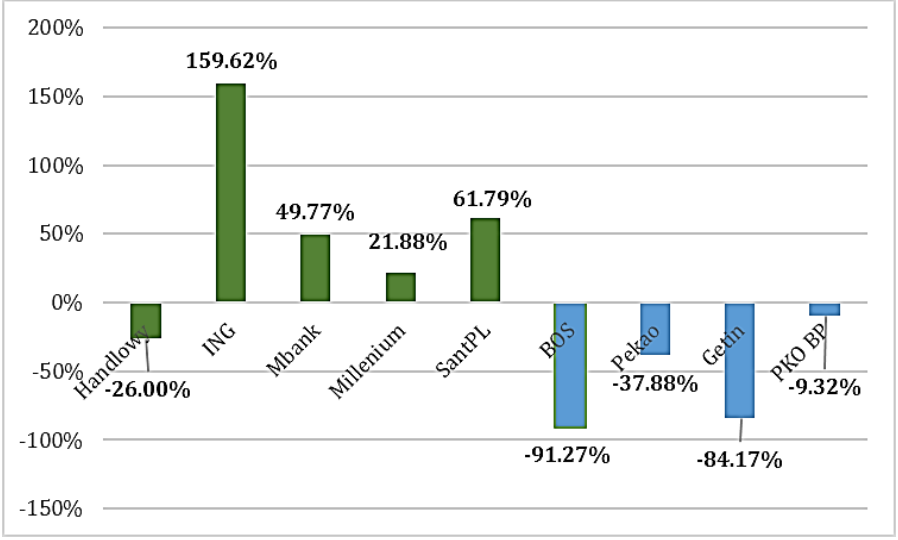

Figure 1. Change in the stock exchange rate of the surveyed banks in 2009-2019 [in %].
Source: own study based on data from the Warsaw Stock Exchange.

The only bank among those classified as socially responsible, whose quotations at the end of 2019 were lower than at the end of 2009, was Bank Handlowy. In terms of ranking, it was overtaken by PKO BP, which is not included in the RESPECT index (PKO BP recorded a lower decline in quotations than Bank Handlowy). However, it should be noted that the quotations of Bank Handlowy have dropped in the last two years (Table 2). In the entire analyzed period, it dropped below the quotations from 2009 only three times, which happened six times in the case of PKO BP.

The comparisons of the relative changes in the level of quotations of socially responsible companies compared to the control group, based on a comparison of the end and beginning of the analysis period, indicate a clear advantage of socially responsible companies.

The conclusions from the tree diagram for the exchange rate changes of the examined banks in the years 2009-2019 are not so clear (Fig. 2).

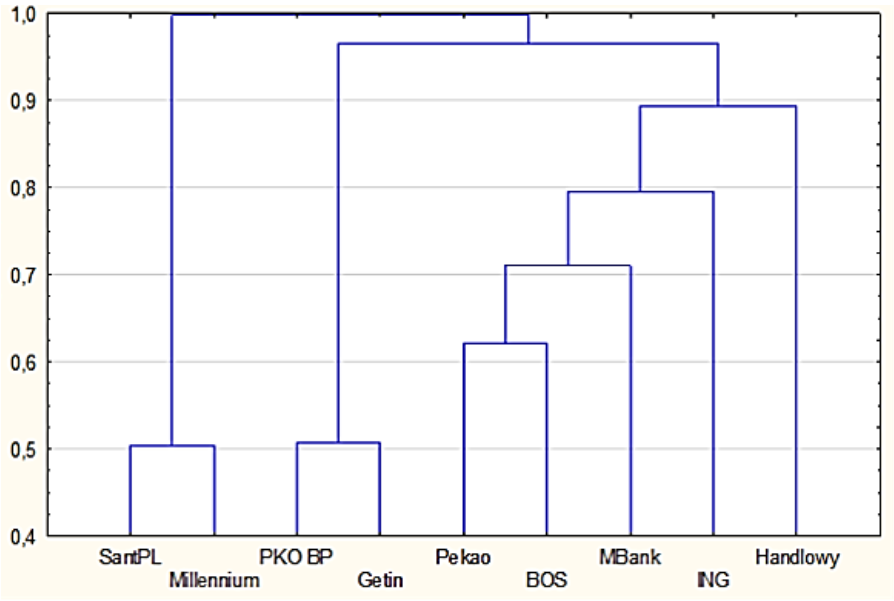

Figure 2. Tree diagram for changes in exchange rates of the examined banks in the years 2009-2019. Source: own study.

It shows that the closest proximity is shown by the quotations of two pairs of banks included in the control group, i.e. PKO BP and Getin (neither entered the WIG-RESPECT index), as well as Pekao and BOŚ (both entered the index with a long delay). Changes in the quotations of banks classified as socially responsible have much higher dissimilarity measures than other banks. The exception is the pair SantPL and Millennium, whose quotation fluctuations are the closest to each other among the 9 analyzed banks. The indication that membership of the WIG-RESPECT index could be one of the factors taken into account by stock exchange investors, on the basis of the tree diagram, is therefore slightly weaker (taking into account the low similarity of socially responsible banks) than the conclusions drawn from the comparison of quotation changes at the beginning and end of the period analysis.

The impact of CSR on profitability ratios

Based on the data concerning the beginning of the analyzed period (2009), it can be stated that in the case of the Polish banking sector, the statement about the relationship between the interest in CSR activities and the achieved profitability level is not confirmed. The two largest banks on the market that were assigned to the control group (PKO BP, which did not join the index, and Pekao, which joined the index in 2016), distanced most of the banks that decided to join the WIG-RESPECT index at the beginning of the analysis period. As indicated by the data (Tables 2-4), these banks in 2009 were ranked first and third (in the case of ROA), second and fourth (ROE) and first and second (ROAA).

We begin the assessment of the impact of CSR on profitability ratios in the banking sector with their changes between 2009 and 2019. ROA was improved by 4 banks, including 3 classified as socially responsible and one that did not belong to the RESPECT index (Appendix 1). In terms of ranking, socially responsible banks took the first two places and, respectively, fourth, sixth and seventh when it comes to improving ROA.

In the case of ROE, an improvement was recorded by four banks, including 2 classified as socially responsible (Appendix 2). In terms of ranking, socially responsible banks took the first two places and, respectively, fifth, seventh and ninth when it comes to improving ROE.

In the case of ROAA, an improvement was recorded by three banks, including 2 classified as socially responsible (Appendix 3). In terms of ranking, socially responsible banks were ranked first, third, fourth, fifth and ninth, respectively, when it comes to improving ROAA.

As the ranking approach only shows the advantage of socially responsible banks in the case of ROA but does not give clear indications in the case of other ratios, the average values of financial ratios for both groups of banks at the beginning and end of the analyzed period were calculated (Table 6).

Table 1.
Changes in selected stock exchange indices in the years 2010-2019 compared to 2009 [in %]

Index	Years									
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
WIG	18.77	-5.98	18.69	28.26	28.59	16.21	29.43	59.42	44.28	44.63
WIG 20	14.88	-10.22	8.13	0.51	-3.05	-20.74	-18.45	3.03	-4.69	-9.99
WIG Banki	17.93	-7.63	13.28	36.55	35.64	3.71	6.72	45.55	27.00	15.32
WIG RES-PECT	31.44	16.65	50.75	48.89	55.57	32.00	46.35%	79.05	62.47	45.94

Source: own study.

Table 2.
Change in the stock exchange rate of the surveyed banks in the years 2010-2019 compared to 2009 [in %]

Bank	Years									
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Handlowy	33.57	-3.00	40.43	50.00	52.79	2.71	9.13	16.97	-1.29	-26.00
ING	14.62	0.77	16.67	45.32	79.36	50.19	106.92	163.59	130.77	159.62
Mbank	16.92	-5.38	25.38	92.31	91.54	20.77	28.94	78.85	63.15	49.77
Millennium	2.08	-20.83	-7.92	50.00	72.92	15.83	8.13	86.25	84.79	21.88
SantPL	13.11	18.95	27.32	104.00	97.37	49.47	66.32	108.55	88.53	61.79
BOS	-5.88	-44.84	-63.24	-42.40	-58.33	-79.06	-86.92	-89.87	-90.99	-91.27
Pekao	10.70	-12.68	3.59	11.01	10.51	-11.26	-22.20	-19.91	-32.59	-37.88
Getin	28.49	-21.23	-68.49	-57.88	-79.22	-86.37	-88.38	-84.58	-98.10	-84.17
PKO BP	14.08	-15.47	-2.89	3.74	-5.89	-28.08	-25.95	16.61	3.87	-9.32

Source: own study.

Table 3.
Return on Assets (ROA) of the surveyed banks in 2009-2019 [in %]

Bank	Years									
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Handlowy	1.34	2.01	1.74	2.23	2.14	1.90	1.27	1.33	1.24	1.30
ING	0.99	1.17	1.26	1.06	1.11	1.04	1.04	1.07	1.11	1.08
Mbank	0.16	0.73	1.16	1.17	1.16	1.09	1.06	0.91	0.83	0.90
Millennium	0.00	0.69	0.92	0.90	0.94	1.07	0.83	1.02	0.96	0.95
SantPL	1.74	1.96	2.05	2.44	1.90	1.52	1.81	1.59	1.65	1.31
BOS	0.22	0.42	0.40	0.20	0.36	0.33	-0.24	-0.29	0.23	0.35
Pekao	1.85	1.89	1.98	1.96	1.76	1.63	1.36	1.31	1.33	1.20
Getin	0.95	1.02	1.85	6.55	2.08	1.29	1.19	1.78	1.04	-7.17
PKO BP	1.48	1.89	1.99	1.93	1.62	1.30	0.97	1.01	1.05	1.15

Source: own study.

Table 4.
Return on Equity (ROE) of the surveyed banks in 2009-2019 [in %]

Bank	Years									
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Handlowy	8.14	11.63	11.43	13.13	13.31	12.78	9.14	8.86	7.72	9.05
ING	12.18	13.32	13.72	10.23	11.14	9.95	10.55	11.96	11.90	11.44
Mbank	3.06	9.34	14.18	12.45	11.79	11.64	10.62	9.36	7.66	8.65
Millennium	0.05	7.97	10.17	9.79	9.99	11.29	8.48	10.10	8.76	9.07
SantPL	15.56	15.36	16.40	16.29	13.91	11.34	12.32	11.34	10.79	10.12
BOS	2.92	5.83	5.37	2.35	4.45	4.24	-3.48	-3.38	2.48	2.98
Pekao	13.18	12.49	13.62	12.64	11.89	11.33	9.79	9.95	10.64	10.03
Getin	8.29	9.64	18.26	31.11	12.39	9.92%	10.06	14.22	8.30	-188.32
PKO BP	11.31	15.04	16.67	15.29	12.83	11.74	8.59	8.83	8.58	9.57

Source: own study.

Table 5.
Return on Average Assets (ROAA) of the surveyed banks in 2009-2019 [in %]

Bank	Years									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Handlowy	1.74	2.51	2.18	2.85	2.69	2.34	1.60	1.69	1.64	1.68
ING	1.15	1.38	1.54	1.25	1.33	1.34	1.28	1.40	1.49	1.44
Mbank	0.26	0.97	1.48	1.43	1.46	1.40	1.31	1.22	1.16	1.23
Millennium	-0.01	0.87	1.41	1.13	1.20	1.38	1.04	1.39	1.30	1.27
SantPL	2.15	2.54	2.56	3.03	2.36	1.96	2.26	2.04	2.15	1.63
BOS	0.28	0.48	0.49	0.22	0.41	0.42	-0.27	-0.38	0.36	0.49
Pekao	2.21	2.26	2.40	2.40	2.13	1.97	1.60	1.64	1.46	1.55
Getin	1.01	0.97	2.11	8.40	2.11	1.70	0.23	1.82	1.43	-5.60
PKO BP	2.84	2.40	2.52	2.39	2.03	1.61	1.18	1.14	1.42	1.54

Source: own study.

Table 6.
Arithmetic means of financial ratios for the group of socially responsible banks and the control group in the years 2009 and 2019

Index	Bank group	Years	
		2009	2019
ROA	Socially responsible	0.846%	0.874%
	Control group	1.125%	0.745%
ROE	Socially responsible	7.798%	7.872%
	Control group	8.925%	7.645%
ROAA	Socially responsible	1.058%	1.208%
	Control group	1.585%	1.023%

Source: Own calculations based on Appendices 1-3.

For all analyzed financial ratios, the arithmetic means at the beginning of the analyzed period were higher in the control group (treated as a whole). The situation was reversed at the end of the research period. This was a consequence of the fact that all arithmetic means of ratios improved in the group of socially responsible banks (treated as a whole), while they deteriorated in the control group. The above comparison definitely supports the hypothesis about the positive impact of CSR activities on profitability (improvement of its ratios) in the Polish banking sector.

As the achievable changes in ratios depend on their initial level and taking into account that the beginning and end of the period in the study may only generate errors, a more detailed analysis was based on the evolution of the analyzed financial ratios over the entire period.

Tree diagrams were used to check whether socially responsible banks differ from the control group in terms of the achieved profitability ratios. The first of the diagrams concerns ROA.

When analyzing the tree diagram for ROA achieved in the analyzed period, on the one hand, it points out that two small banks from the control group show the highest level of dissimilarity to the analyzed group, which is especially visible in the case of Getin bank. On the other hand, the two remaining banks from the control group are very similar to each other and to the group of socially responsible banks. The greatest similarity is between Millennium and Mbank, two of the socially responsible banks.

The next diagram (Fig. 4) relates to ROE.

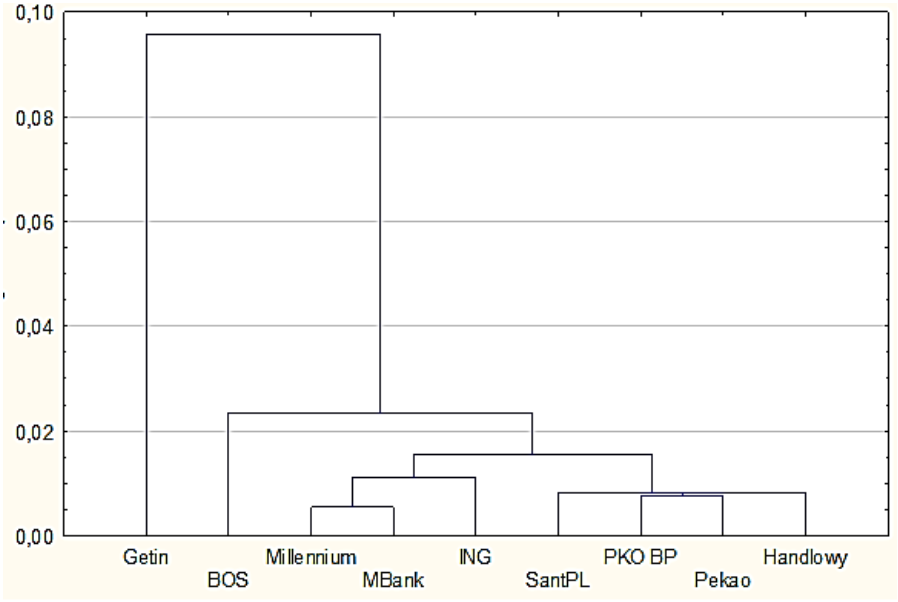

Figure 3. Tree diagram for ROA of the examined banks in the years 2009-2019.

Source: own study.

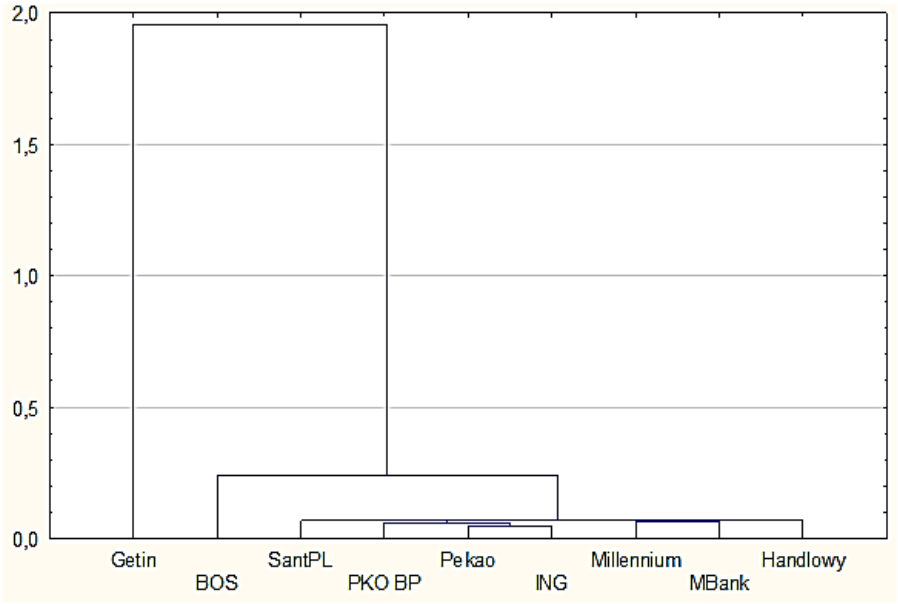

Figure 4. Tree diagram for ROE of the examined banks in the years 2009-2019

Source: own study.

The conclusions from the tree diagram in relation to ROE that are achieved by the analyzed banks are similar to those in the case of ROA. Again, the same two banks from the control group show the highest level of dissimilarity to the analyzed group (which is especially visible in the case of Getin bank). The two remaining banks from the control group are very similar to each other (with a greater similarity between Pekao and ING than between PKO BP and Pekao) and to the group of socially responsible banks.

The last tree diagram presented relates to ROAA.

As in the previous two cases, the ROAA achieved shows the highest level of dissimilarity to the analyzed group in the case of the same two banks from the control group (especially in

the case of Getin bank). The two remaining banks from the control group are very similar to each other and to the group of socially responsible banks. The results obtained are very similar to those of the ROA (the greatest similarity is between Millennium and Mbank, the second most similar is between banks from the control group – PKO BP and Pekao.

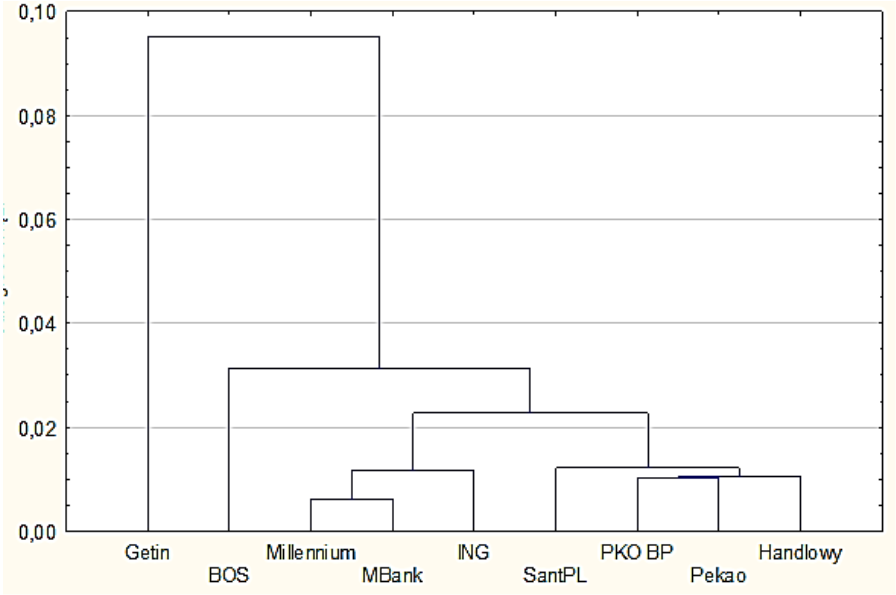

Figure 5. Tree diagram for ROAA of the examined banks in the years 2009-2019.
Source: own study.

To sum up, the tree diagram analysis for profitability ratios is ambiguous. Small banks belonging to the control group differ significantly from other banks. Their example could indicate that there is an impact of CSR on profitability ratios. However, this observation does not apply to the other two banks that form the control group – the profitability ratios they achieve are similar to those achieved by socially responsible banks. It should be remembered that the banks PKO BP and Pekao were the largest banks on the market in the analyzed period. Their size may be a factor determining the relative stability of their financial situation to a greater extent than undertaking CSR activities.

From the perspective of socially responsible banks, they are often more similar to PKO BP and Pekao than to one another (to other banks belonging to the WIG-RESPECT index since its inception). Thus, the analysis of tree diagrams shows the existing differences between financial results within the group of socially responsible banks. This confirms the differentiation within this group of banks, which was already noticed in the preliminary analysis based on the ranking method (a large range of positions taken in the statements concerning the improvement of financial ratios.

To summarize the considerations on the similarity between the analyzed groups of banks, and thus also to answer the question to what extent CSR activities affect the quotations and profitability of banks, the main component analysis method was used, for which the change of

the stock exchange rate between the beginning and the end of the analyzed period and the obtained average levels of ROA, ROE and ROAA. (Fig. 6).

Principal component analysis confirms the conclusions of the tree diagram analysis. On the one hand, two small banks belonging to the control group deviate the most from the other banks. On the other hand, the features of PKO BP and Pekao are closest to those of the two socially responsible banks (Handlowy and SantPL).

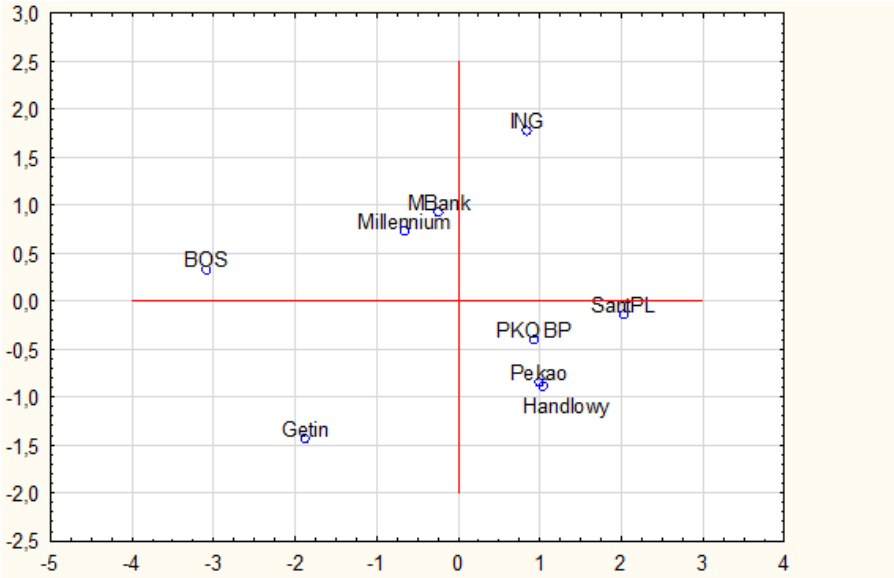

Figure 6. Principal component analysis and classification for the examined banks in the years 2009-2019.

Source: own study.

5. Discussion

The article contributes to the discussion on the connection of CSR activities with stock market quotations and profitability of enterprises, especially banking companies. On this basis, it can be used for discussion in a number of areas which have been alluded to in previous publications.

In the case of the Polish banking sector, it cannot be confirmed that banks with a strong financial position are more willing to invest in CSR in order to strengthen their reputation and emphasize the profitability of operations (having funds for social expenditure) (Aswani et al., 2021). The banks joining the WIG-RESPECT index in the years 2009-2010, treated as a whole, deviated from the banks in the control group in terms of profitability. This was mainly the result of the participation in the control group of the two largest banks on the market, having a relatively strong and stable financial position. An additional explanation for the slightly lower initial profitability ratios of socially responsible banks may be the effect of the short period,

i.e. before applying to the index of socially responsible companies, banks probably undertook cost generating CSR activities, which contributed to their lower results in the short term (Hillman, Keim, 2001; Zhou et al., 2021).

The results of the rankings indicate a significantly higher improvement in the stock exchange quotations of banks classified as socially responsible as compared to the control group. This advantage is much higher than the advantage in improving profitability ratios, especially visible in terms of ranking. This may indicate that investor decisions are more influenced by the improvement of the bank image that is related to CSR activities or by considering the composition of the WIG-RESPECT index when building investment portfolios (selection of socially responsible entities in the first place.

The difference between socially responsible banks and the control group would be even more visible if the control group did not include PKO BP bank, which did not join the WIG-RESPECT index, and recorded only a slight drop in prices. Its lack of interest in joining the index may confirm the hypothesis that the largest banks on the market are not interested in bearing the costs of CSR activities (Forgione, Migliardo, 2020). Based on the above observation, Pekao, the second largest bank by assets only joined the WIG-RESPECT index in 2016.

In the case of an improvement in financial results, the advantage of socially responsible banks over the control group is especially visible in changes in the arithmetic average levels of profitability ratios for selected groups of banks. This may indicate the building of a stronger organizational culture and more effective management methods in socially responsible banks (Waddock, Graves, 1997). If we treat the analyzed groups of banks as two separate entities, it can be concluded that belonging to the group of socially responsible banks brings the expected results in terms of improving long-term financial results (Zhou et al., 2021) and higher market valuation (Garriga, Melé, 2004).

However, it should be pointed out that the analysis of changes in profitability ratios in individual banks shows that they are highly diversified. For example, in terms of ranking, Santander PL, which belongs to the socially responsible group, came last in the ROE improvement ranking, and Millennium was the last in ROAA improvement. This indicates that just belonging to the group of socially responsible banks does not guarantee success in the form of improvement of all financial ratios.

The obtained results are admittedly not fully unambiguous, but they support the theoretical indications as to the inclusion of CSR in the strategy of banks.

Practical implications of the article can be related to managers in the banking sector and stock market investors. Banks should include CSR activities in their strategy, as they may bring benefits in the form of increased market quotations and profitability ratios. Stock exchange investors should take into account the involvement of banks in CSR activities, as they may affect the effectiveness of bank operations and, consequently, the level of their market valuation.

6. Conclusions

The article contributes to the debate concerning the impact of CSR practices on the financial performance and listing level of companies in the banking sector. The study confirms the results of most previous studies, pointing to the positive impact of CSR activities on the market valuation and on the financial results achieved in the banking sector (Simpson, Kohers, 2002; Cornett et al., 2016; Miller, 2016; Esteban-Sanchez et al., 2017; Weber, 2017). In this way, it contributes to both theoretical and empirical considerations.

Our study has some limitations in terms of any generalizing the obtained results. The sample for comparison is small, and the adopted control group is not fully homogeneous (two banks with a delay in entering the WIG-RESPECT index and two not interested in participating in it). The study only covered one country and therefore does not take into account the institutional differences between various economies and banking systems.

Admittedly, the period adopted for the study is ten years, so it allows to check the long-term effects, but only two of the banks from the control group operated for three or four years in the index, which does not allow for a full assessment of the results of including socially responsible activities in their strategy. Additionally, the analysis is based on comparisons of two groups of banks, one of which declares a long-term CSR policy, but we have not analyzed the actual CSR activities undertaken by individual banks (their scale and direction).

The proposed directions for further research are related to the above limitations. First of all, it is necessary to find an answer to the question whether the banks that introduced the CSR policy into the strategy with delay (joined RESPECT in the years 2015-2016) improve their results (will there be a positive long-term effect of CSR activities). This will enable the analysis of market quotations and financial results obtained by these banks in the coming years.

A promising direction for future research seems to be checking what specific CSR activities individual banks focus on and how these activities affect financial results and the level of stock exchange quotations. Such a study would mainly refer to the identification of standard (implemented in most banks) and specific (undertaken by individual banks) CSR activities, the evolution of directions and scale of spending funds on CSR and their assessment from the perspective of bank stakeholders.

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Appendix

Appendix 1.

Change in ROA of the surveyed banks in the years 2010-2019 compared to 2009 [in %]

Bank	Years									
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Handlowy	50.11	29.96	66.36	59.86	41.80	-5.59	-0.72	-7.15	-3.33	-30.16
ING	17.47	26.91	7.01	11.54	4.89	4.16	7.34	12.05	8.44	5.24
Mbank	355.61	618.50	628.00	619.67	578.35	555.39	467.29	417.24	460.65	295.11
Millennium	20 744.84	27 465.61	26 795.93	28 131.59	32 094.98	24 689.04	30 524.57	28 667.90	28 302.08	17 079.89
SantPL	12.69	17.95	40.28	9.31	-12.38	4.43	-8.57	-5.04	-24.53	-32.84
BOS	87.06	79.40	-9.82	60.83	50.53	-209.81	-229.78	5.21	56.93	75.03
Pekao	1.79	7.05	5.97	-4.89	-12.30	-26.70	-29.41	-27.99	-35.42	-42.52
Getin	7.48	95.87	592.72	120.07	36.58	25.62	88.32	9.72	-858.71	-61.55
PKO BP	28.18	35.01	30.98	9.68	-11.74	-34.04	-31.83	-29.12	-21.89	-21.59

Source: own study.

Appendix 2.

Change in ROE of the surveyed banks in the years 2010-2019 compared to 2009 [in %]

Bank	Years									
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Handlowy	42.88	40.45	61.32	63.61	57.11	12.38	8.89	-5.14	11.27	-15.47
ING	9.41	12.64	-15.99	-8.49	-18.26	-13.34	-1.78	-2.31	-6.04	-10.52
Mbank	205.57	363.91	307.52	285.73	281.02	247.66	206.45	150.74	183.10	104.66
Millennium	14 757.14	18 863.09	18 148.79	18 526.37	20 949.43	15 714.63	18 735.94	16 240.82	16 814.62	11 592.09
SantPL	-1.27	5.38	4.71	-10.60	-27.11	-20.80	-27.10	-30.66	-34.95	-41.78
BOS	99.55	83.81	-19.71	52.27	45.12	-219.07	-215.47	-15.31	1.99	11.95
Pekao	-5.23	3.35	-4.10	-9.82	-14.01	-25.71	-24.51	-19.27	-23.90	-29.74
Getin	16.29	120.18	275.13	49.39	19.64	21.31	71.45	0.04	-2370.82	0.73
PKO BP	32.97	47.37	35.20	13.45	3.80	-24.02	-21.94	-24.20	-15.40	-14.28

Source: own study.

Appendix 3.

Change in ROAA of the surveyed banks in the years 2010-2019 compared to 2009 [in %]

Bank	Years									
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Handlowy	44.28	25.03	63.65	54.37	34.64	-8.21	-2.85	-5.61	-3.41	-27.23
ING	20.77	34.59	9.31	16.16	16.66	11.41	22.15	30.32	25.30	23.85
Mbank	274.96	474.17	454.91	463.16	442.03	406.82	373.84	349.72	377.64	279.11
Millennium	-7 706.44	-12 422.14	-9 965.83	-10 593.45	-12 200.89	-9 214.82	-12 261.28	-11 497.51	-11 260.11	-7 565.81
SantPL	18.39	18.98	40.86	9.56	-8.74	4.91	-4.96	-0.15	-23.99	-29.44
BOS	69.78	72.73	-21.01	42.41	46.31	-195.45	-233.08	28.02	70.39	109.37
Pekao	2.38	8.75	8.75	-3.72	-11.05	-27.46	-25.76	-34.14	-29.89	-33.17
Getin	-3.65	109.82	733.73	109.34	68.74	-76.91	80.65	41.68	-656.25	-65.68
PKO BP	-15.39	-11.46	-15.96	-28.54	-43.37	-58.45	-60.02	-49.91	-45.71	-41.49

Source: own study.

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