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Contemporary challenges
in the performance
of organisations

**Współczesne wyzwania
organizacji**

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FOREWORD

Dynamic changes in the environment of economic organisations significantly affect their functioning. On the one hand, these changes create opportunities for economic entities, bringing more opportunities and perspectives for their development, while on the other hand, they impose certain limitations and may pose a serious threat. The variability of changes in time and space creates a constant need for organisations to adapt to such a changing environment. This adaptability involves both the rapid identification of changing conditions and the development of appropriate development strategies. The nature of changes, their direction, and the intensity of their impact mean that the adaptation processes cover many aspects of the reality: economic, socio-cultural, political, legal, and technical. The decisions undertaken not only affect the competitive position of the organisation, but also trigger specific consequences in the further and closer environment. The organisation's interaction with its environment means that the strategies should assume attention not only to the achievement of economic success, but also to social relations and the natural environment. This publication from the series Silesian University of Technology. Scientific Papers. Organization and Management Series. Contemporary management is concerned with such challenges faced by organisations in the modern world. The authors of 44 articles from numerous Polish research centers focus on a number of issues in the field of organisation, management, and decision-making strategies in organisations in the broad sense. The papers presented in this issue concern: human resources management, strategic management, quality management, knowledge management, intellectual property management, production management, information management, organisational culture management, health care management, financial management, international management, risk management, environmental management, service management, issues of multidimensional consequences of the COVID-19 pandemic, implementation of artificial intelligence and IT technologies, development of renewable energy sources and smart cities, aspects of sustainable social development and corporate social responsibility.

Joanna Rydarowska-Kurzbauer

AN OVERVIEW OF THE DEVELOPMENT OF RENEWABLE ENERGY SOURCES IN POLAND

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Purpose: The main purpose of the article is to gather important pieces of information from different sources of renewable energy sources in Poland. That may lead to further scientific research.

Design/methodology/approach: The article is cognitive in nature and the basic research methods are the analysis of reference works and surveys. The reference work studies cover the analysis of national and foreign works.

Findings: The studies presents the actual approaches for each kind of renewable energy sources. The presented overview is based on aggregation of data from actual reports and other scientific sources. It is base for further exploring of the research topic.

Research limitations/implications: The surveys discussed in this article may contribute to further empirical studies, including but not limited to initiating works to improve the renewable energy sources.

Practical implications: The practical implications of studies entail the possibility to use them to improve application of renewable energy sources in proper places and using proper facilities.

Originality/value: The main value of this article is aggregation of data for renewable energy sources. The presented overview is base on actual data.

Keywords: photo-voltaic; forecast; renewable energy sources

Category of the paper: General review, Research paper.

1. Introduction

The continuity of energy supply as an aspect of energy security ensures economic development and quality of life. Nevertheless, it cannot be ignored that the rapid development of world economies has been accompanied by irrational exploitation of natural resources, which, in turn, has caused severe disruption to the ecological balance and precipitated the

depletion of nonrenewable resources. In addition, the emission of greenhouse gases (mainly carbon dioxide) has increased due to the combustion of fossil fuels, which causes a severe imbalance in the natural environment, such as the greenhouse effect (Bednarczyk, 2021).

The currently observed significant changes in the world's energy sector make it necessary to adequately reconstruct local and regional development views. It applies primarily to Poland, where when the world is experiencing an increasingly advanced energy evolution, most of the energy produced is still obtained from non-renewable sources, including geographically concentrated large professional thermal power plants (over 70 percent of electricity in 2019) (Śleszyński, 2021).

Energy has been an important, influential factor in countries' economic and political policies and bilateral relations and the formation of legal rules as soon as it began to occupy its irrevocable place in human life. There are different types of energy - a diversity that was not present when energy was first discovered - due to the reduction of typical energy resources and environmental concerns today. Countries with energy sources elaborate on some energy policies and implement them. On the other hand, some countries with limited possibilities in terms of energy sources develop new roles for themselves in energy and play essential roles in leading world policy to not fall out of the world order (Shahzad, 2021). Environmental fossil fuels were the source of as much as 83 percent of the energy consumed in Poland in 2020. This value is five times greater than the energy obtained from RES. Poland is in the infamous first place in Europe regarding securing energy from fossil fuels (Niekurzak, 2021).

The photovoltaic market in Poland is going through a development boom. At the end of 2020, Poland was in first place in the European Union regarding the growth rate of photovoltaic power. The photovoltaic capacity installed in Poland at the end of 202 was 3936 MW, which means an increase of 2463 MW year on year and translates into an increase of 200 percent year on year. It should be taken into account that the main driver of growth are prosumers. Thus, according to Solar Power Europe, in 2020, Poland was in fourth place in terms of increasing the installed PV capacity in the European Union.

This article is structured as follows. The Introduction covers the topic and the outline of solutions. The next part deals with the basics of renewable energy sources in Poland. In the next part, the scope is on the photovoltaic market in Poland. Then the discussion is presented in turn. The last parts are Conclusions and References.

1.1. Related work

The proposed topic is a significant part of global politics. The connection between renewable energy sources and sustainable economic growth is substantial (Yikun, 2021), in Europe (Włodarczyk, 2021) or in South Asia (Aner, 2021). The area of interest is extensive, which may cause additional problems to be solved. There are many methods to be applied in the field of interests, e.g., multi-criteria method (Ulewicz, 2021), stochastic scheduling (Faraji, 2021), multi-objective optimization (Ullah, 2021), AI (Boza, 2021).

As a part of the European Union, Poland is involved in all the situations which appear in the EU countries. That causes some problems but also gives opportunities. The main problem of all renewable energy sources is integration into European (and each country's) grids (Hammons, 2008). Also, the consumption of renewable energy in economic sectors in the whole EU countries is essential (Tutak, 2022), and also by households (Piekut, 2022).

Also, as a separate country, Poland has many specific aspects for renewable energy to be solved. First of all, the support scheme for renewable resources should be known (Wysocki, 2022) or other support mechanisms (Mazurek-Czarnecka, 2022). After the support mechanisms are defined, it is necessary to plan and declare settlement conditions (Śleszyński, 2021; Szyba 2021). It is also important to include determinants of the energy development in Poland (Bednarczyk, 2021). The potential of renewable energy resources (Niekurzak, 2021).

The modernization processes of energy consumption are also in the scope of the paper (Sobocińska, 2022). The modernization processes also meet barriers (Juszczak, 2022). Those topics are a part of local governments' policies (Rakowska, 2021) or sustainable development policy (Serowaniec, 2021). The local society may treat renewable energy sources as truth or myth in its opinions (Woźniak, 2022).

As was shown, the problem of renewable energy sources is widely spread in the scientific field of interest. Above mentioned articles show the importance of the topic and define the scope of the presented paper. The specific aspect of Poland will be shown in the other parts of the article.

2. Renewable energy sources in Poland

Technological development is inevitably related to the increasing demand for energy. In addition, the dwindling resources of fossil fuels meant a need to obtain power unconventionally - i.e., renewable energy sources (RES). Russia's war with Ukraine and the consequent lack of coal and gas supplies from Russia have shown how unfavorable the situation of countries dependent on energy imports is. Figure 1 shows the percentage dependence of individual European countries on energy imports in 2020. It can be noted that Poland is in the group of countries whose dependence on energy imports is 80,01-97,56%.

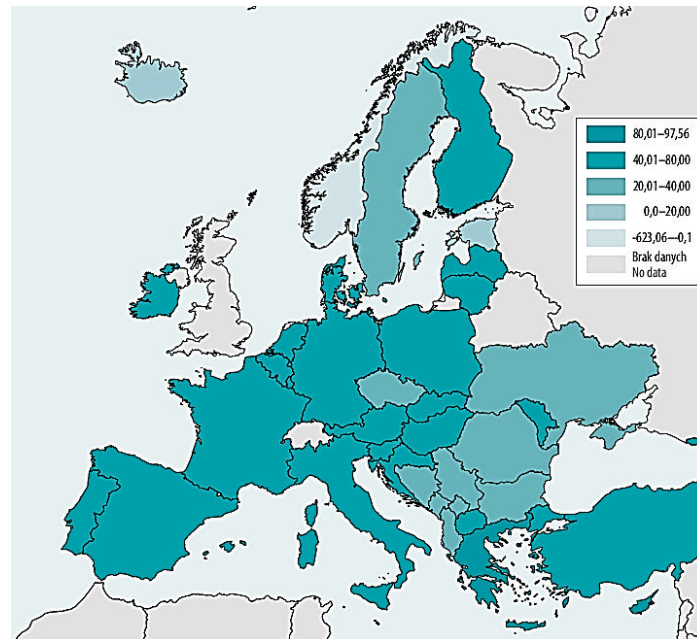


Figure 1. Dependence on energy imports in 2020.

Source: (Energy, 2022).

Renewable energy sources, i.e., those whose use is not associated with their long-term deficit. The RES resource is renewed relatively quickly - these are the so-called renewable raw materials. Renewable resources include: sun, wind, water, biomass, biogas, biofuels, and nuclear energy in a closed fuel cycle (Seroka, 2022).

Renewable energy sources include:

- solar energy (also known as solar radiation energy), which has the most significant energy potential, is mainly used to generate electricity and heat,
- wind energy,
- hydro-power,
- geothermal energy,
- biomass energy,
- energy from sand.

In Poland, in 2021, according to the Energy Market Agency, electricity production was the highest in the history of Poland and amounted to 179,4 TWh. The electricity demand was also record-breaking, reaching 180,3 TWh. Energy production in 2021 from RES was the highest in the history of Poland and amounted to 30 TWh. The structure and division of energy production sources in Poland in 2021 are presented in (Figure 2). The share of renewable energy sources in Poland's total energy production decreased to 16,7% compared to 2020, when it was 17,7%. Wind energy was responsible for more than half (54%) of RES production, the share of biomass was 15%, and photovoltaic was 13%. Within ten years, production from RES increased by 80% - from 16,8 TWh in 2012 to 30.4 TWh in 2021. Apart from photovoltaic, wind farms' most significant increase in production was observed (an increase of 250% in a decade) (Raport Transformacja energetyczna, 2022).

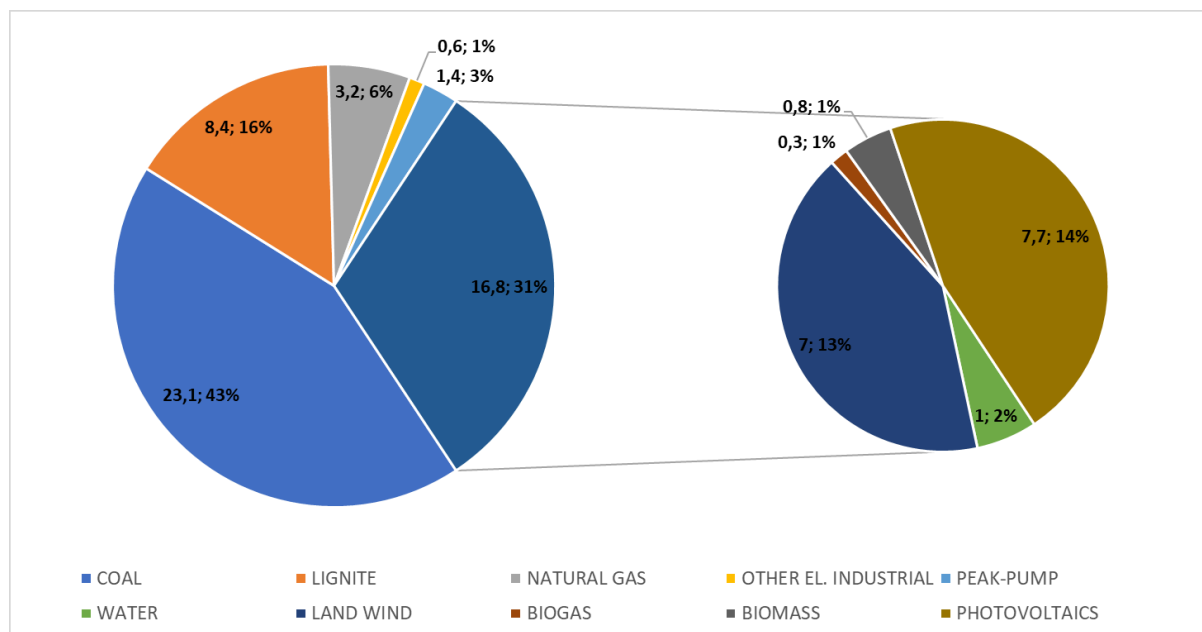


Figure 2. Share of the capacity of energy sources in Poland in 2021.

Source: (Raport Transformacja energetyczna, 2022).

In Poland, the actual legal act regulating the development of renewable energy sources is the Act of 20 February 2015 on renewable energy sources. This act adjusts to the Polish legal system Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the use of energy from renewable sources, amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. The goals behind the entry into force of the RES Act were primarily (Raport Polska energetyka, 2022):

- increasing energy security and environmental protection as a result of the effective use of renewable energy sources rational use of renewable energy, taking into account the implementation of the long-term economic development policy of Poland,
- fulfillment of obligations resulting from concluded international agreements and increasing innovation and competitiveness of the national economy,
- shaping mechanisms and instruments support the production of electricity, heat or cold, or agricultural biogas in installations of renewable energy sources.

The European Union's climate and energy policy, including its long-term vision of striving for EU climate neutrality by 2050, significantly shapes the national energy strategy. In 2014, the European Council maintained the direction of combating climate change and approved four targets for the 2030 perspective for the entire EU, which, after the revision in 2018 and 2020, are as follows:

- reduction of greenhouse gases (GHG) emissions by at least 55% compared to 1990 emissions,
- at least 32% share of renewable sources in gross final energy consumption,
- increase in energy efficiency by 32,5%,
- completion of the internal EU energy market.

The above objectives are the EU's contribution to implementing climate agreements. Of crucial importance for current policies and actions is the so-called Paris Agreement. It results in the need to stop the increase in the average global temperature below two degrees Celsius compared to pre-industrial levels and keep it no more than 1,5°C. During the 24th conference (COP24) in December 2018, during the Polish Presidency, the so-called Katowice climate package implemented the Paris Agreement. The transformation resulting from the Paris Agreement must be fair and solid is essential. The goal of the state's energy policy is energy security while ensuring the competitiveness of the economy and energy efficiency and reducing the impact of the energy sector on the environment with the optimal use of its energy resources.

Energy security means the current and future satisfaction of customers' needs for fuels and energy in a technically and economically justified manner while maintaining environmental protection requirements. The present and future guarantee of the security of the supply of raw materials, production, transmission, and distribution of energy, i.e., the complete energy chain, is essential. The fuel cost is hidden in every activity and product produced in the economy. Therefore energy prices translate into the competitiveness of the entire economy. At the same time, emissions of pollutants from the 2nd energy sector impact the environment. Thus creating the energy balance must be carried out with due regard to this aspect. Poland's energy policy until 2040 (PEP2040) sets the framework for the energy transformation in Poland. PEP2040 considers the scale of challenges related to the adjustment of the national economy to the EU regulatory conditions associated with the 2030 climate and energy goals, the economic recovery plan after the COVID pandemic, the European Green Deal, and the pursuit of climate neutrality as possible. PEP2040 describes the state and conditions of the energy sector. Then, three pillars of PEP2040 were identified, on which the eight specific objectives of PEP2040 were based, along with the activities necessary for their implementation and strategic projects.

Poland's energy transformation will be based on three pillars:

1. Just Transition - it will mean providing new development opportunities for regions worst hit by the harmful effects of the transition while providing new jobs and building new industries. Individual energy consumers will also participate in the transformation, as they will be shielded from the increase in energy prices and encouraged to actively participate in the energy market.
2. Zero-Emission Energy System - will be implemented through the implementation of nuclear energy and offshore wind energy, increasing the role of distributed and civic power while unambiguously ensuring energy security through the temporary use of energy technologies based, among other things, on gaseous fuels.
3. Good Air Quality - will be implemented through the departure from fossil fuels, thanks to investments in the transformation of the heating sector, electrification of transport, and promotion of passive and zero-emission houses, using local energy sources.

PEP2040 includes eight specific objectives:

1. optimal use of own energy resources,
2. expansion of the generation infrastructure and electricity network,
3. diversification of supplies and growth of the network infrastructure of natural gas, crude oil, and liquid fuels,
4. development of energy markets,
5. implementation of nuclear energy,
6. development of renewable energy sources,
7. development of district heating and cogeneration,
8. improvement of energy efficiency.

The PEP2040 adopted several detailed indicators, which were considered as a measure of the achievement of the objective:

- no more than 56% of coal in electricity generation in 2030,
- at least 23% RES in gross final energy consumption in 2030, item implementation of nuclear energy in 2033,
- reduction of GHG emissions by 30% by 2030 (compared to 1990),
- reduction of primary energy consumption by 23% by 2030 (compared to PRIMES forecasts from 2007).

PEP2040 determines the appropriate distribution of energy sources in general production in individual countries. An in-depth analysis is necessary to understand the detailed conditions for individual RES. Its purpose is to define the needs and requirements of separate energy sources.

3. A detailed overview of renewable energy sources

3.1. Wind energy

Wind, i.e., the kinetic energy of moving air, has been used by man for centuries primarily as mechanical energy in windmills or wind pumps. The renewable nature of wind seems obvious. You can never talk about its long-term deficiency or complete exhaustion. Wind farms are most often built on farms located on land or offshore - at sea or in river deltas. Therefore, we can talk about the following:

- onshore,
- offshore.

The leading countries using wind energy are China, and the United States (Energy, 2022). In 2021, the capacity of Chinese wind farms increased by 170%. In Europe, the UK is leading the way, investing primarily in offshore wind energy, i.e., offshore. Other countries, i.e., Sweden and Germany, focus on onshore wind energy. Poland is in the 12Th position.

In July 2021, the European Commission presented a 2030 renewable energy target of 40%, up from the current 32%. This means that to achieve this ambitious target, the EU will need to double its annual wind capacity from 15 GW to 30 GW per year. According to WindEurope data, wind currently meets 16% of electricity demand in Europe, and in many countries, much more: Denmark - 48%; Ireland - 38%; Germany - 27%; Portugal - 24%; Spain - 22%. The IEA predicts that by 2027 wind will become Europe's number one energy source. In 2021, the leaders in the field of onshore wind farm installations were Sweden (2.1 GW), Germany (1.9 GW), Turkey (1.4 GW), and France (1.2 GW). Notably, the realistic scenario developed by WindEurope indicates that nearly 90 GW of new onshore wind capacity will be installed in Europe in 2022-2026, i.e., an average of 17.4 GW per year (Energy, 2022).

The figure 3 presents the wind energy zones in Poland.

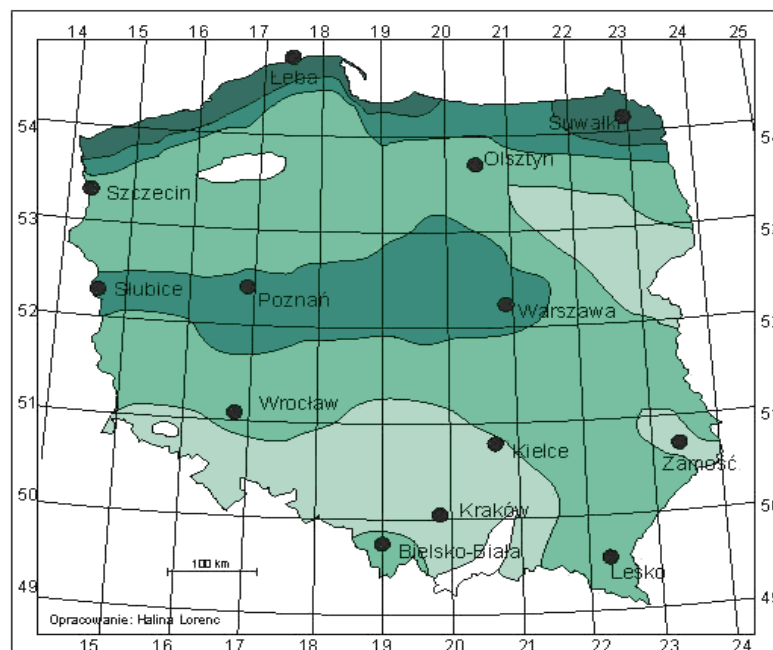


Figure 3. Wind energy zones in Poland.

Source: Raport Transformacja energetyczna w Polsce. Edycja 2022.

Energy generated from wind is considered clean energy because there is no emission of harmful pollutants during its generation. This is not the only benefit of wind energy development. The development of wind energy will directly translate into the competitiveness of the domestic economy in the international arena, will contribute to a decrease in energy prices, and will additionally generate new jobs.

Starting in 2016, Poland has faced numerous barriers preventing the dynamic development of onshore wind energy. These include, for example, the distance rule, the rules for agreeing on the connection of investments to the national power system, or the issues of assessing the impact of projects on the environment. All problems related to the role of the local community in the investment procedure are also significant. By the EU target binding for Poland, a 55% reduction in emissions in 2030 compared to 1990 will require over 18 GW of onshore wind power.

The development of onshore wind energy in Poland is also supported by the results achieved by the industry this year. In January, wind energy satisfied Poland's energy needs at the level of 30-35%, and in February, almost 50%. Moreover, the analyzes carried out by the Jagiellonian Institute clearly show that the share of onshore wind energy significantly reduces the price per 1 MWh on the Day-Ahead Market. As indicated by the Agency Energy Market, in December 2021, 5 new wind installations with a total capacity of 151,94 MW were built, and in the entire In 2021, 48 new wind installations with an installed capacity of 1071,75 MW appeared.

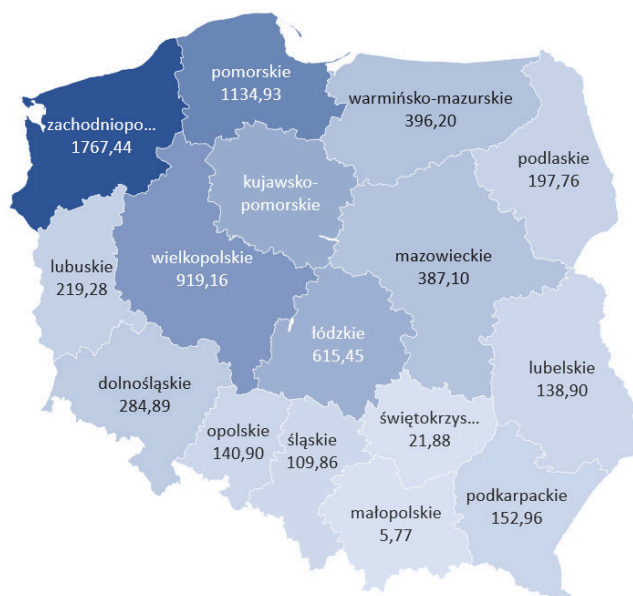


Figure 4. Power of energy in wind farms in individual voivodeships as of 31.12.2021.

Source: Raport Transformacja energetyczna w Polsce. Edycja 2022.

The advantages and disadvantages of wind energy are presented in the table 1.

Table 1.

The advantages and disadvantages of wind energy

Cons	Pros
breaks in the operation of windmills - performance fluctuations depending on weather conditions	no harmful emissions
a threat to the life of bats and birds, especially in the case of improperly located wind turbines	short construction time
intervention in the landscape (large area occupied by wind farms)	low operating costs
low efficiency of a single windmill (approx. 2-4 MW)	possibility of running a business (e.g., growing cereals) in the vicinity of windmills
noise (concerns older structures)	

Source: Own study.

3.2. Water energy (hydro-power)

Hydro-power is nothing more than the economically used mechanical energy of flowing water. At present, hydro-power is usually converted into electricity. Water energy can also be used directly to drive machines. In Poland, water energy has a very long tradition. It can be divided into the so-called large and small hydro-power (SHP).

The principle of operation of hydropower plants is simple and consists in damming up water using dams. The dammed water finds its outlet in pipes and hits the turbines at high speed, causing the blades to rotate. Kinetic energy is thus converted into mechanical energy. It then goes to a generator that converts it into electricity. The next and last element of the entire process of electricity production in a hydroelectric power plant is the transfer of the generated electricity to the power grid.

Water energy is an element of the energy industry of every country. Hydro-power plants can be built both on rivers and at sea. Due to the source of energy, power plants can be divided into:

- inland water power plants (river),
- power plants that obtain energy from sea waters (e.g., tides, waves),
- power plants using both inland and seawater.

In hydro-power, the following types of power plants are distinguished (Mikulski, 1998):

- hydro-power plants (EW): run-of-the-river (RRP) or reservoir (RP),
- hydro-power plants with a pump unit (PU-P),
- pumped-storage power plants (PSP), also known as pumped storage,
- tidal power plants (TP).

Hydro-power in Poland includes all hydro-power plants that use the natural flow of rivers, regardless of the method of obtaining the head, power, and size of the head. Renewable energy sources do not include pumped-storage water power plants and run-of-the-river power plants with a pump unit due to the need to purchase energy for pumping from other sources (Matuszek, 2005).

Due to their size, power plants can be divided into (Mikulski, 1998):

- large hydro-power plants with a capacity of over 10 MW,
- small hydro-power plants (MEW) with a capacity of 1MW - 10 MW,
- mini hydro-power plants with a capacity of up to 1 MW,
- micro hydro-power plants with a capacity of less than 200 kW.

However, taking into account the height of water drops, i.e., the differences between the upper level of the water reservoir and the lower one, large power plants can be divided into:

- low-head hydro-power plants (up to 15 meters),
- hydro-power plants with an average head (between 15 and 50 meters),
- high-fall hydro-power plants (above 50 meters).

The potential of hydro-power is evenly distributed throughout the country. About 68% occur in the Vistula river basin, while in the Oder basin, about 17% (Insolation, 2022). Rivers with high energy potential include the Vistula, Dunajec, San, Bug, Odra, Bóbr and Warta.

The advantages and disadvantages of hydro-power are presented in the table 2.

Table 2.

The advantages and disadvantages of hydro-power

Cons	Pros
the use of hydro-technics harms the migration of fish - although the use of fish passes in hydro-technical facilities, the natural process of their migration is disturbed	water energy is an ecological source of energy
the need to interfere with the environment during the construction of a hydroelectric power plant	free kinetic energy and low cost of electricity production - kinetic energy are generated by water that naturally flows in riverbeds. However, after the construction of a hydro-technical facility, renewable energy is very cheap to obtain
high costs associated with the construction of the power plant - unfortunately, the initial investment in a renewable source of water energy is much more expensive than other ecological power plants	the need to use dams to protect against floods - with an appropriate water drop, water damming is used, simultaneously allowing you to regulate the level of rivers. This is very important, especially in the event of a flood wave
work noise	the ability to store energy - a source of renewable energy, which is water, not only produces electricity for current needs but also allows energy storage
changes in water levels that may generate landslides	
siltation of rivers, which is very undesirable from the point of view of creatures living in water	

Source: Own study.

3.3. Solar energy

Solar energy is unlimited by the availability of resources, it reaches the Earth through solar radiation. It is then processed in a photovoltaic, photo-chemical, or photo-thermal conversion process. Solar energy comes to the Earth in the form of solar radiation. It is readily available energy. Unfortunately, the flux density getting to the Earth depends on the geographical location, season, and time of day. In Poland, the Institute of Meteorology and Water Management researches solar radiation. The PN-B-02025 standard shows that the average value of total radiation intensity for Poland during the year is 993,5 kWh/m². The best solar conditions exist on the Szczecin and Central Coasts and in the east of Poland - Zamojszczyzna, Polesie, etc. The map of Poland's insolation is shown in figure 5.

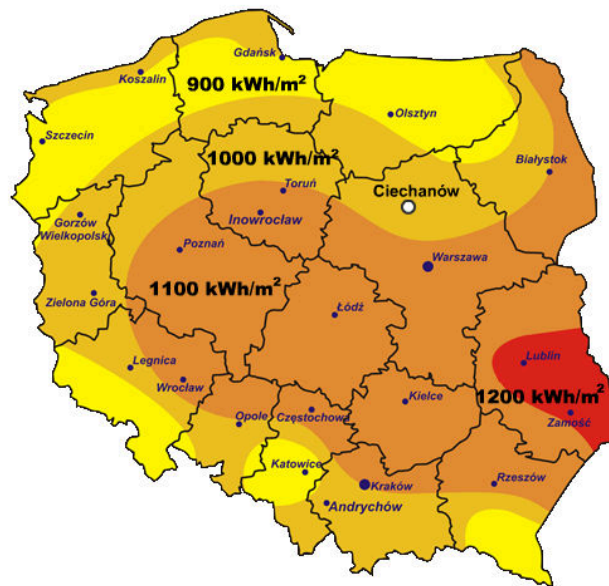


Figure 5. Insolation in Poland in 2021.

Source: Insolation, 2022.

Solar energy can be used in three ways:

- Photo-chemical conversion, i.e., the change of solar radiation energy into chemical energy. It is not widely used in technology but occurs in living organisms. The efficiency of this process is estimated to be around 19-34%.
- Photo-thermal conversion - direct change of solar radiation energy into thermal energy. Depending on whether additional energy sources are used for further distribution of the obtained power, passive photo-thermal conversion and active photo-thermal conversion are distinguished. In the case of dynamic photo-thermal conversion, the flow of the heat carrier is carried out using pumps powered by additional energy sources. In contrast, in the case of passive conversion, the heat carrier flow takes place by convection.
- Photovoltaic conversion - it is used in photovoltaic cells. These are devices that directly convert solar energy into electricity. The exchange is possible thanks to the use of semiconductor p-n junctions. The photon that strikes the silicon wafer is absorbed by the silicon, knocking the electron out of its position and causing it to move. This movement is the flow of electric current.

The advantages and disadvantages of solar energy are presented in the table 3.

Table 3.*The advantages and disadvantages of solar energy*

Cons	Pros
relatively high cost of devices	unlimited energy resources (solar radiation) - it can be obtained even when it is raining or cloudy
cyclical and uneven use (available energy depends on the time of day and year)	photovoltaic installations have a negligible negative impact on the natural environment due to the lack of pollution with waste and combustion products
problems with storing more electricity	the universality of this technology means that it can be installed almost anywhere by selecting the appropriate modules
the value of the intensity depends on the angle of incidence of the sun's rays	the possibility of direct conversion into various forms of energy (heat, electricity)
quite low efficiency of photovoltaic modules	no need to use fuel and transport energy
the dependence of solar radiation on atmospheric pollution, cloud cover	surplus energy can be collected and sold to external suppliers
	low operating costs
	lack of mechanical devices for processing electricity and noise related to their operation
	allows to significantly reduce the emission of harmful greenhouse gases into the environment because it is a zero-emission source
	allows you to significantly reduce the emission of harmful greenhouse gases into the environment because it is a zero-emission source

Source: Own study.

The following types of photovoltaic installations are distinguished:

- micro-installations - i.e., installations with a total installed capacity not exceeding 50 kW. These are the so-called prosumer installations. The total capacity of micro-installations amounted to approx. 6 GW;
- small installations - installations with a capacity of 50 kW - 1 MW. The power of facilities installed in Poland reached a value of over 1,5 GW;
- photovoltaic farms - over 1 MW - the total installed capacity has been estimated at almost 200 MW.

In Poland, the largest share in the photovoltaics market is held by micro-installations, which in 2021 accounted for less than 80% of the power installed in photovoltaics. In the entire power structure of renewable energy sources, in 2022, photovoltaic installations account for over 50% (Fig. 7). The total installed capacity of photovoltaics in Poland at the end of July 2022, according to the data of the Energy Market Agency, amounted to 10,586 GW.

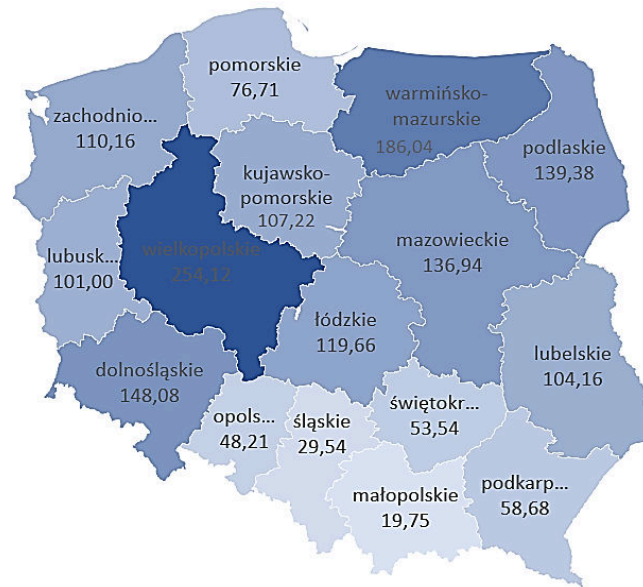


Figure 6. Installed power in photovoltaic installations in individual voivodships as of the day 31.12.2021.

Source: Own study.

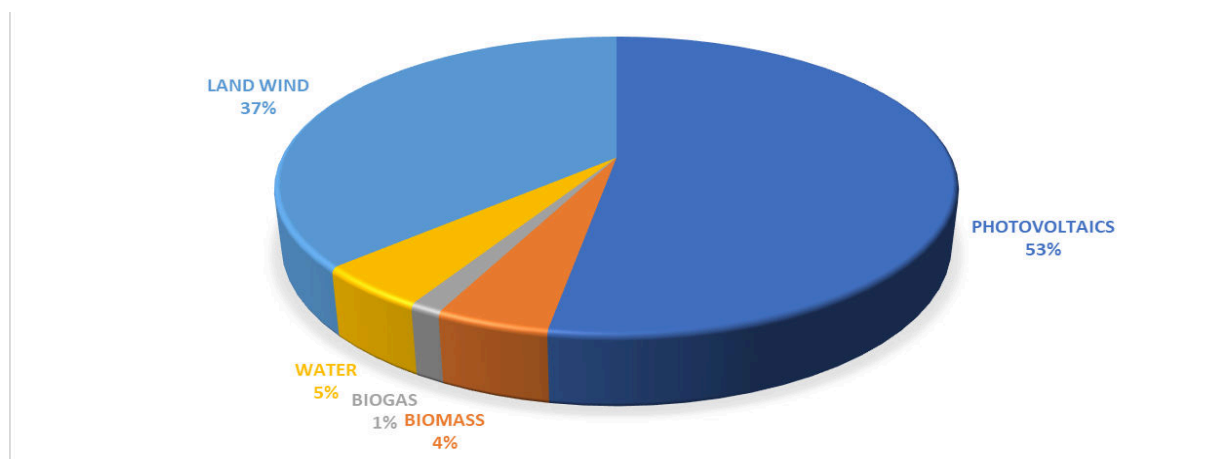


Figure 7. Share of the capacity of energy sources in Poland in 2021.

Source: Own Study.

The development of the photovoltaic market in Poland is highly dynamic. At the end of 2021, Poland was ranked second in Europe with an increase in installed capacity of 3,7 GW. In Europe, the most significant increase was recorded in Germany, which recorded an increase of 5,3 GW (Fig. 8).

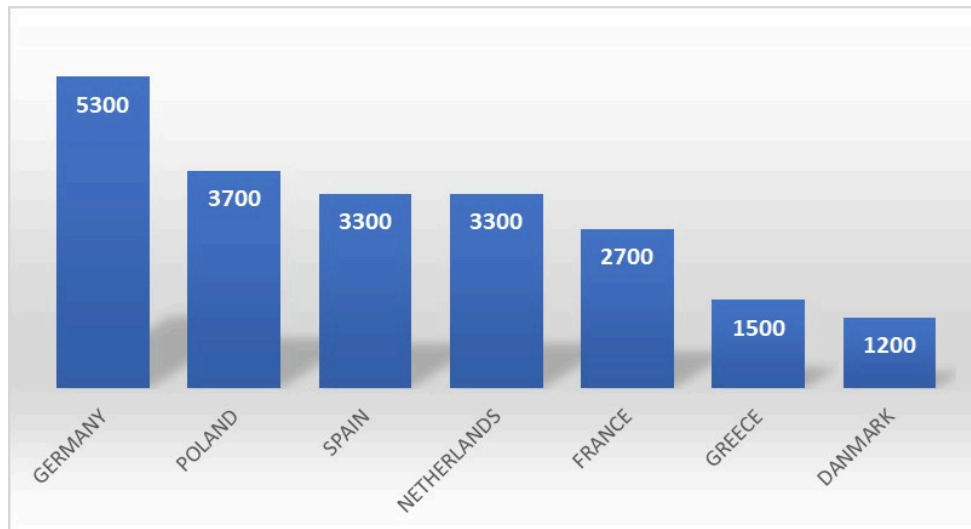


Figure 8. Increases in installed capacity in individual countries in 2021.

Source: Own study.

The installed capacity of photovoltaics in Poland is mainly due to prosumer micro-installations, which account for about 76% of all installations in the country. 2021 was a record year for new connections of prosumer photovoltaic installations. According to ARE, at the end of 2021, it amounted to over 845,000 units, which means an increase of over 89% compared to 2020. Such an increase was mainly due to the change in the settlement system from net metering to net billing. The "Clean Air", "My Electricity", and "My Heat" programs also provided great support for prosumers. Since 2018, there has been a noticeable increase in the installed photovoltaic capacity in small RES installations, while other renewable sources remain almost constant. Since 2019, new additions have reached several hundred megawatts per year in photovoltaics.

At the same time, since this year, PV has been indisputably in first place, and its outlook for the coming years is also optimistic.

The key market segment that uses small installations is business prosumers or self-producers of energy from RES. These include any company or enterprise that, thanks to its own RES installation, produces electricity for its own needs, thus reducing the cost of purchasing energy from the grid.

Table 4.
The largest photovoltaic farms in Poland in 2022

Localization	Power	Year of commissioning	Owner
Zwartowo	204 MW	2022	Stigma Sp. z o.o.
gm. Brudzew	69,999 MW	2021	ZE PAK
gm. Witnica	64,600 MW	2021	Alternus Energy Group
gm. Wielbark	62 MW	2022	Energa Wytwarzanie
Stępień (gm. Braniewo)	58 MW	2022	Wento
Żydowo/Polanów	29,999 MW	2021	Better Energy
Postomino	29,961 MW	2021	Better Energy
Bogucice	8,054 MW	2022	SOLAR-R
Borki Wielbarskie	7,987 MW	2021	Energa OZE
Jaworzno	5,000 MW	2020	Tauron
Prochowice	4,677 MW	2021	EWG Elektrownie Wiatrowe
Czernikowo	3,770 MW	2015	Energa OZE

Source: Own study.

3.4. Biomass energy

According to the content of the amended Art. 2 point 3 of the Act of 7 June 2018 on renewable energy sources, the term biomass should be understood as: "The biodegradable part of products, waste or residues of biological origin from agriculture, including plant and animal substances, forestry and related industries, including fisheries and aquaculture, processed biomass, in particular in the form of briquettes, pellets, torrefied and biochar, as well as the biodegradable part of the industrial or municipal waste of plant or animal origin, including waste from waste treatment installations and waste from water treatment and sewage treatment, in particular sewage sludge, following the provisions on waste in the scope of qualifying part of the energy recovered from the thermal treatment of waste".

Biomass is an attractive alternative to coal, mainly due to the lower amount of pollutants produced. It is characterized by a zero balance of CO₂ emissions and lower emissions of sulfur dioxide, carbon monoxide, or nitrogen oxides than fossil fuel combustion. Biomass can be used in three ways (Janowicz, 2006):

- combustion in boilers (straw, pellets, wood chips, wood),
- cooperation with conventional energy carriers (coal, gas, and others),
- combustion of products resulting from the processing of biomass (biogas, biodiesel, etc.).

The following types of biomass are most often used for energy purposes:

- wood of low technological quality and waste,
- sewage sludge,
- municipal waste,
- animal excrements (manure, liquid manure and slurry are the raw material for biogas production),
- straw, cake, and other agricultural waste,
- energy crops (including seaweed grown specifically for energy purposes).

The advantages and disadvantages of biomass energy are presented in the table 5.

Table 5.

The advantages and disadvantages of biomass energy

Cons	Pros
low energy value	biomass is safe for the environment
dioxin emission	low costs
emission of nitrogen oxides during the combustion of biofuels	unlimited access
reducing biodiversity risk	independence from weather conditions
	products from which biomass is produced can also be grown on wasteland
	many biomass fuels - such as wood and plants - can be regenerated

Source: Own study.

In the European Union, the energy industry must use biomass as fuel. However, due to the insufficient supply of this green fuel in Europe and its high prices, the practical consequence of these regulations is the import of biomass from Asia or Africa, which naturally negates the benefits of reducing emissions. Biomass is also imported in Poland, mainly from countries such as Russia, Ukraine, Hungary, Bulgaria, and Latvia (about 85% of biomass comes from imports). Biomass in Poland has excellent potential for development, which should not be neglected. Poland has a solid agro-sector; unfortunately, it is difficult to discuss a particularly favorable situation regarding soil quality. Because in Poland, the most fertile chernozems (I valuation class) occupy only 0.75%, while 40% of soils belong to class IV, 23% to class III and V, and 11% to class VI lands. Therefore, it is necessary to fertilize lower-quality agricultural land to obtain high yields.

This situation may therefore be beneficial for producers of energy crops, which, as we already know, do not require high-quality land (soils with low valuation are used for biomass crops - class V and VI). In addition, biomass in Poland can be obtained from the forest, agricultural and production waste, or garbage. The most effective model for the operation of biomass energy is its use, especially in local heating. However, to make biomass the leading source of green energy in Poland, systemic support is necessary, thanks to which it will be possible to build local logistic chains covering producers and recipients. Installed capacity in biomass power plants in individual voivodeships as of 31.12.2021.

Biogas can be used for energy purposes locally by coupling the generated fuel with a biogas burning unit or, after cleaning, introduced into the gas network and, after transmission, further used for energy purposes.

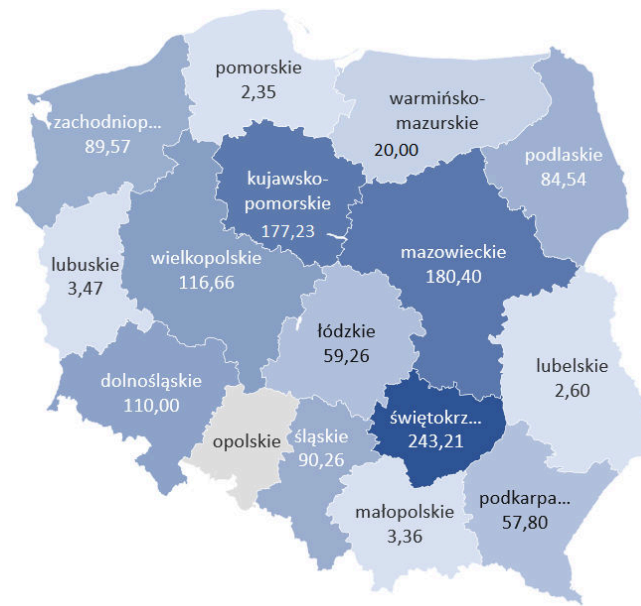


Figure 10. Installed power in biomass power plants in individual voivodships as of 31.12.2021.

Source: Own study.

3.5. Energy from biogas

Biogas is a gas from processing organic compounds contained in biomass. It is a secondary source resulting from biomass processing using various processes. The most common biogas production technique is methane fermentation, where in anaerobic conditions, physicochemical processes supported by methane bacteria decompose organic matter into gaseous form.

Biogas is a combustible gas, so it can be used as a fuel to drive a gas turbine to produce electricity, as a fuel used in a boiler to generate heat, or, more often, as a fuel for a cogeneration system engine, where electricity and heat are produced in one process.

Biogas can be compressed adequately after cleaning and used as fuel for motor vehicles in transport. Such solutions are well known in Sweden, as well as in Germany and Austria.

Biogas can be characterized as:

- Composition of biogas - The volumetric composition of biogas strongly depends on the type of biomass from which it was produced, and it consists only of components made of organic matter. Biogas (raw) consists of approx. 50-65% methane (CH_4), 30-45% carbon dioxide (CO_2) and other components in trace amounts such as water vapor (H_2O), hydrogen sulfide (H_2S), nitrogen (N_2), hydrogen (H_2), oxygen (O_2).
- Mass of biogas - Knowing the volumetric composition of biogas, we can determine the mass of biogas with a high approximation. Under normal conditions (pressure and ambient temperature respectively 1013,25 hPa and 273,15 K), the mass of biogas is approx. 1,2 kg/m.

- Calorific value - The calorific value of biogas results directly from the methane content in the biogas. A typical biogas has a calorific value of 19-23 MJ/m^3 . Knowing the calorific value and biogas production, we can determine the amount of primary energy generated in a given time unit, and then, after taking into account the efficiency of the primary energy conversion system in the final one, we can determine the amount of electricity and/or heat that can be produced. Assuming conversion efficiency at the level achieved by cogeneration systems (CHP) currently on the market, we can obtain approx. 2,2 kWh of electricity and approx. 8 MJ of heat from one m³ of biogas.
- Other parameters of biogas - colorless, odorless. It consists of combustible and non-combustible gases; only methane gives energy gain.

The following types of biogas can be distinguished:

- landfill biogas - it is created from the decomposition of organic compounds stored in landfills;
- sewage biogas - it is produced as a result of the decomposition of organic compounds of sewage sludge;
- municipal biogas - it is made as a result of the decomposition of organic compounds of biodegradable municipal waste (e.g., collected leaves from parks);
- agricultural biogas - is produced as a result of the decomposition of raw materials of agricultural origin.

The list of advantages and disadvantages of biogas is presented in the table 6. And the power installed according to the use of biogas is shown in figure 11.

Table 6.

Advantages and disadvantages of biogas

Cons	Pros
methane is a rather dangerous gas due to its instability	it is 100% clean energy
biogas production technology still causes large heat and energy losses at the production stage	for this biogas production, methane-fermentable organic waste is first used
biogas is a fuel that is difficult to produce on a large scale	getting rid of organic waste and distributing fertilizer ingredients
	reduces the amount of soil and water contamination

Source: Own study.

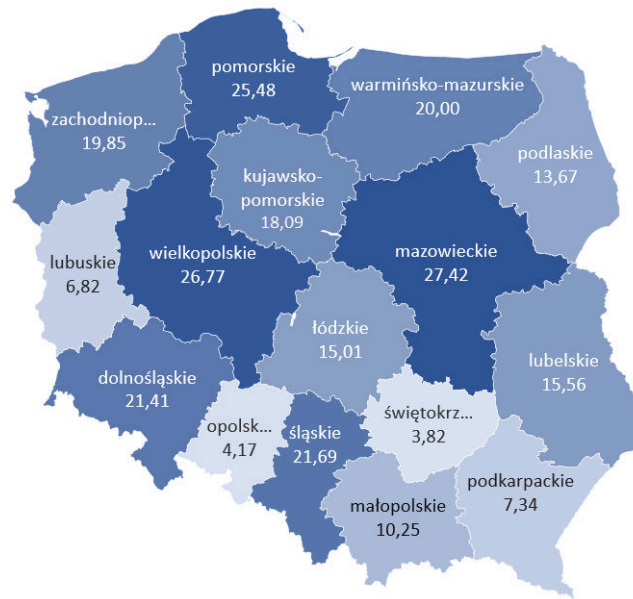


Figure 11. Installed capacity in biogas power plants in individual voivodeships as of 31.12.2021.

Source: Own study.

4. Discussion

The presented types of renewable energy sources in Poland differ from each other. The differences lie in the technologies used, the complexity of generating installations, and the availability (conditions) of particular energy sources. A careful selection of RES is needed. It depends on organizational and technical issues.

Each renewable energy technology has its advantages and disadvantages. As part of the investment implementation, it is necessary to include them in the implementation project. The development of individual RES in Poland is still ongoing. The most common is photovoltaics and obtaining energy from wind and water, partly due to technology and issues related to terrain and weather conditions.

The development potential of RES is growing along with the energy crisis in Europe and the world. Reviewing the RES development potential in Poland is the starting point for forecasting the development of these energy sources.

5. Conclusions

The article presents an overview of Poland's types of renewable energy sources. Analyzing individual RES's potential, advantages, and disadvantages allows you to familiarize yourself with the subject and is a starting point for further research.

Analyzing technological conditions and implementation possibilities of individual energy sources is essential in determining the further development of unique technologies and the possibility of creating a prognosis of their development potential.

The direction of further development of this publication is determined by creating forecasts for using particular RES in the future, considering the guidelines of the European Union.

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DECISION-MAKING SUPPORT SYSTEM FOR TERRITORIAL COMMUNITIES

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Purpose: The main aim of the study is to build a decision support system for the development of territorial communities.

Design/methodology/approach: The study includes linear multifactor regression for agro-industrial complex. The module for optimizing garbage collection consists of clustering garbage collection points using the k-means algorithm and the salesman's task to find the shortest path. The method of hierarchy analysis was used to choose the direction of development of territorial communities. For the development of tourism, PLS-PM modeling was used.

Findings: The system of decision support for the development of territorial communities has been implemented. The results of the program experiment were analyzed, and the scientific and practical significance of the developed program was shown. The study helps managers to make decisions for the development of territorial community. The separate components of the functioning of the decision support system which consists of four parts (modules) are analyzed. Each module can be used separately if necessary. Therefore, the methods of operation for each part were described using UML diagrams or a simple visualization of the steps of an algorithm or method.

Originality/value: The added value of the article is the support in the decision-making process of leaders for the development of local communities.

Keywords: territorial community, decision support system, mathematical model.

Category of the paper: Research paper.

1. Introduction

Today, several foreign countries are in the process of profound changes in the system of regulation of public relations. In terms of prospects for local development, decentralization has become an effective way to change the essential characteristics of society. The experience of

developed countries shows that the main prerequisite for successful community development is the unification of territories and resources, in which the state creates the necessary conditions for community development, and they must choose the priorities they need. Therefore, the question arises for each community "Which sector of the industry from the available resources can bring the most benefit to the community?".

Let us consider this issue on the example of the development of territorial communities of Ukraine, as in Ukraine there is also a tendency to decentralize power and unite several settlements, thus forming a prosperous territorial community. To effectively implement certain regional or local policy steps, community political forces need to have a few required skills. Such several managerial characteristics includes the ability to form compliance and unity between goals. Prioritization of tasks and activities at different levels of government of local governments (central, regional, and local) or executive authorities is also an important element of the above. This element plays an important role both in addressing key development challenges and in achieving long-term strategic goals.

Capable united territorial communities should be the main contenders for an effective system of government in Ukraine. Therefore, when creating new territorial communities with new legislative and financial functions, the relevant authorities have several responsibilities. They should form and explain to the newly created community the main priority areas of development, determine its route, and announce the means and methods needed to overcome it. The stage of creating new territorial communities also has several challenges, among which are the following:

- difficult adoption by the newly formed community of general priorities for the provision of basic services to its residents. This is since before the merger, each body had its own management methods and priorities;
- lack of understanding of the management and use of new resources available after the merger (land, territorial, budget);
- increasing the number of members of government with whom you want to coordinate certain management decisions.

Given such complications, the question of proper planning of the development of the territorial community is critical. The adopted strategy should include all the existing advantages of the united territorial community (natural, material, territorial, etc.). Then, with the proper organization of government work, you can achieve the most effective level of local development.

Over the last decade, a number of works have been devoted to solving the problem of development of territorial communities, which are based on the construction of efficient algorithms using natural systems (swarm algorithms, etc.) for various applications. Feldmann and Foschini (2012) used the problem of graph partitioning to construct balanced trees. Such mathematical models are also used for clustering problems (Alzate, Suykens, 2010).

Successful development of the regions requires certainty and the presence of consolidating ideas about the future. These are important needs of business and society, which are met through the mechanism of territorial socio-economic planning, especially strategic planning. Borbasova (2020) considered the concept of strategic management and described the differences between strategic and current management on the example of management of branches of the social bloc. The essence of management of territorial economy of the region, and questions of realization of life support and social service of the population, improvement of territorial economy, acquisition by it of new qualitative characteristics of higher level is investigated also.

On the example of Latvia, Lonska (2021) analyzed the structural scheme of assessment of the territorial state of development, developed earlier, assessing the territorial state of development of statistical regions of the country. The analysis showed that it is impossible to draw unambiguous conclusions about the level of their development, as each region of Latvia has its own quality or essence of development.

Filippetti, Sacchi, (2013) and Oates (2006) revealed a wide range of issues, including the study of the essence of the concept of "decentralization of public power", its types and forms, principles of implementation, evaluation of decentralization models, an algorithm for reform, and more. At the same time, some issues remain unresolved in both theoretical and methodological aspects, and therefore necessitate further research and finding ways to solve problems in this area.

Thoening (2006) analyzed the development and current state of reforms of state and local self-government in France and Germany.

Thus, the results of the analysis allow us to conclude that the development of territorial communities is a very important topic. This will better shape local budgets and improve the country's economy.

2. Materials and methods of research

The decision support system consists of four elements: agro-industrial (Bihun, Lytvyn, Oleksiv, 2022), optimization of garbage removal (Bihun, Lytvyn, 2022), choice of direction of development and tourism development (Bihun, Lytvyn, Oleksiv, 2021).

The structure of software for the decision support system of territorial communities consists of three categories: system programs, applications, and tools.

System programs include those that play a supporting role, such as the operating system. In our case, the operating system was Windows 11 Pro, version 21H2.

Tool systems, in other words, programming systems, provide the creation of new programs for the computer. In our case, for the garbage disposal optimization module, it was the Python programming language, the programming environment - PyCharm Community, because

Python has many useful libraries for working with data analysis, machine learning and others (Lutz, 2003). The C# programming language and the Windows Forms application programming interface were chosen to build the development direction selection system, as it is convenient for writing graphic applications and easy to use (Sells, 2003).

Applications are programs that directly provide the necessary work, such as building tables or databases, processing information arrays, and so on. In our case, such programs are Excel and SmartPLS.

3. The results of the study of the decision support system for the development of territorial communities

3.1. Building a decision support system for the development of territorial communities

All modules (elements) of the proposed decision support system: agro-industrial (Bihun, Lytvyn, Oleksiv, 2022), optimization of garbage removal (Bihun, Lytvyn, 2022), choice of direction of development and tourism development (Bihun, Lytvyn, Oleksiv, 2021) are written in those programs that best suited their functions and capabilities.

The diagram of components (Fowler, 2004) of decision support system is presented in figure 1.

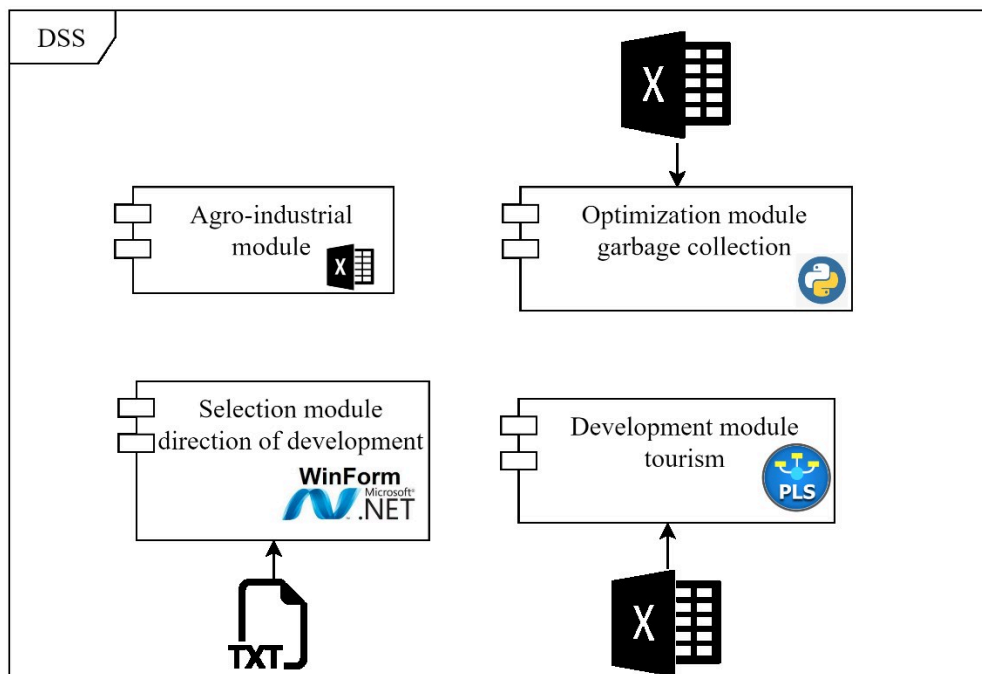


Figure 1. Diagram of components of decision support system for the development of local communities.

The block diagram of the decision support system for the development of territorial communities is presented in figure 2.

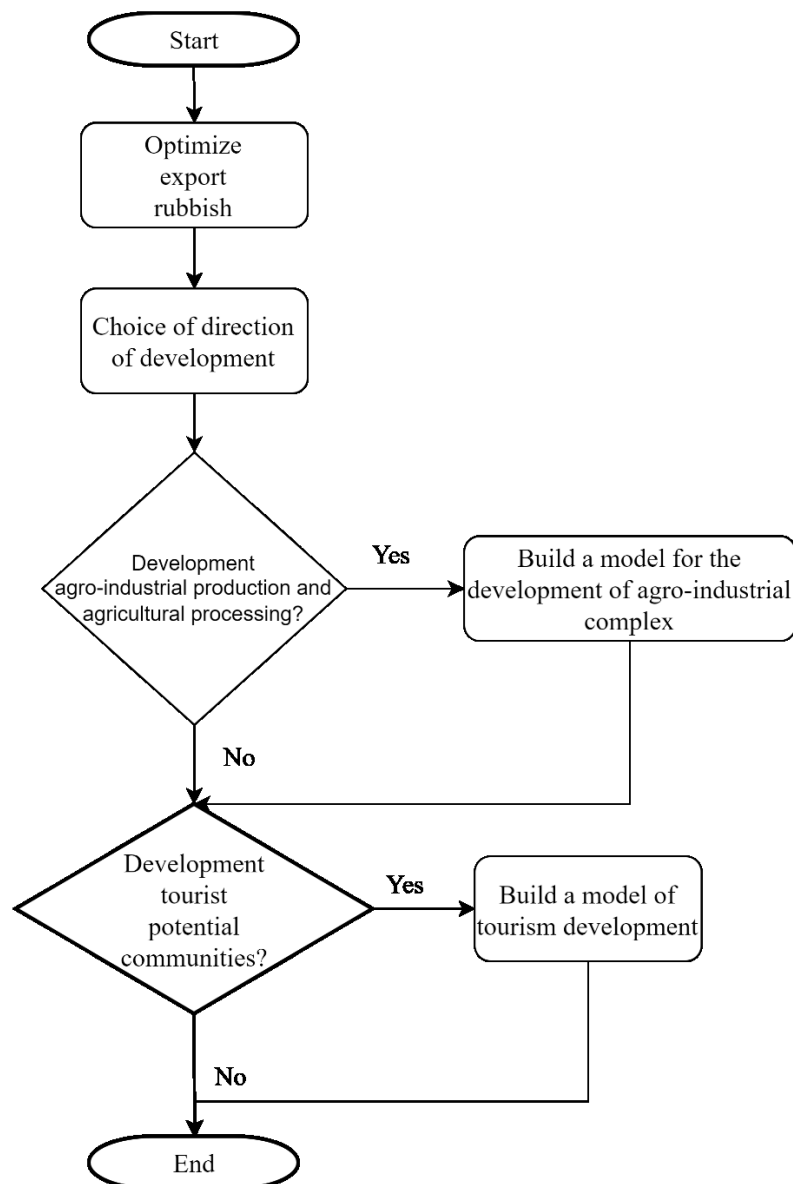


Figure 2. Block diagram of decision support for the development of territorial communities.

All modules can be used separately for any territorial community, except agricultural, as it depends on whether the community has agricultural land.

First, an algorithm for optimizing garbage collection is used. Then the direction of development of the territorial community is chosen. If in the process of calculation, the direction "Development of agro-industrial production and agricultural processing" is chosen, then the agrarian model is used, which analyzes the factors that affect the agro-industrial complex. If the direction "Development of the tourist potential of the community" was chosen, then we build a model of tourism development. Since there are several areas of development, both modules - tourism development and agro-industrial complex – can be used.

The first step in building a decision support system for the development of local communities is to optimize garbage collection. Next is the choice of direction of development. Depending on the calculated direction, the agro-industrial module (Bihun, Lytvyn, Oleksiv, 2022) or the tourism development module (Bihun, Lytvyn, Oleksiv, 2021) will be used (or both, depending on the number of selected areas). So, in the beginning we need to have data on landfills. To verify the decision support system, we will choose the Solonitsy settlement territorial community. First, it is necessary to import data that represent the location of garbage collection points. The tonnage of the garbage truck is 10 tons. The capacity of garbage collection points and their coordinates are given in the table (Table 1).

Table 1.
Capacity and coordinates of garbage collection points

Number	Position x	Position y	Garbage collection capacity
1	2	4	1,5
2	2,2	5,2	1
3	3,3	2,3	1,5
4	1,5	6	2
5	5,2	8	1
6	8	12	2
7	10,1	16,7	1
8	15	21	1
9	18	19,7	1,5
10	19,7	24	2
11	22	22	2
12	23,1	27	1
13	26	18,4	1
14	29,2	23,8	1,5
15	39	17,1	1
16	37,8	21,9	1
17	42,1	27,8	1
18	46,2	30,1	1,5
19	48	36,2	1,5
20	51,4	34,6	2
21	54,4	38	2

Source: own studies.

Using the algorithm of optimization of garbage removal, we get the result, which is visualized in figure 3.

That is, first, all garbage collection points are divided into the optimal number of clusters, which are highlighted in red. Next, we found the optimal route between clusters, which is indicated by green dotted arrows. After that, the first and last points in each cluster were found and dummy points were added, which were eventually deleted. Next, the optimal route within each cluster is constructed. The proposed location of landfills is any permitted location on the route represented by the green dotted arrows. The length of the shortest path by one garbage truck according to this algorithm is 23 km. The garbage truck must be unloaded 3 times.

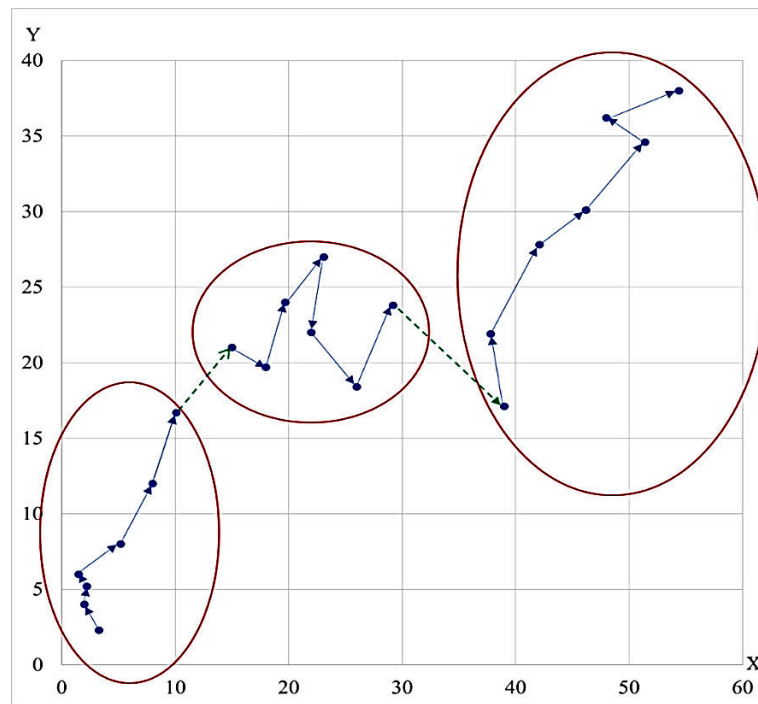


Figure 3. The result of clustering and the shortest way to collect waste.

To choose the direction of development, it is necessary to import data on available resources for the local community. The result is shown in table 2.

Table 2.

Available resources and their scales in Solonytsivska settlement territorial community

№	Resource	Scale: 1 - very little or very unsatisfactory, 9 - very much or very satisfactory, 2-8 - intermediate results
1	Minerals, oil, gas	1
2	Cultural heritage	4
3	Brownfields and Greenfields (investment attractive areas of the region)	3
4	Natural and recreational resources	5
5	Railway connections	3
6	Forests	7
7	Lakes, ponds, rivers	4
8	Tourist potential	7
9	Agricultural lands	8
10	Industrial enterprises	4
11	Land plots for individual development	5
12	Workforce	5
13	Recreation areas	4
14	Schools	7
15	Cultural institutions	5
16	Health care facilities	8
17	The level of medical care	4
18	Leisure networks	3
19	Creative cultural industry	4
20	Centralized water supply and sewerage	8
21	Sports infrastructure	6
22	Level of public activity	5

Cont. table 2.

23	Street lighting	3
24	Public transport	3
25	Logistics development	5
26	Efficiency of household waste management	3
27	Condition of roads	4
28	The state of engineering networks	4
29	Quality of mobile and internet coverage	6
30	Centralized water supply and sewerage (reverse)	9-8+1=2
31	Level of public activity (reverse)	9-5+1=5
32	Road condition (reverse)	9-4+1=6
33	Quality of mobile and internet communication coverage (reverse)	9-6+1=4

Source: own studies.

After applying the module for choosing the direction of development, we obtain a list of priorities, which is given in table 3.

Table 3.

Global priorities of alternatives (level 3)

Identifier of alternatives	Alternatives (directions of development)	The value of global priorities
a1	Creating a favorable investment climate	0.075
a2	Forming a positive community image and marketing	0.072
a3	Development of community tourism potential	0.081
a4	Development of agro-industrial production and agricultural processing	0.074
a5	Improving land management and their efficient use	0.062
a6	Transition to innovation-oriented and high-tech production, development of clusters and industrial parks, creation of a coworking center, youth business incubator, technology park	0.070
a7	Development of culture and sports	0.072
a8	Comprehensive development of children and youth	0.066
a9	Creating conditions for housing investment	0.069
a10	Preservation of historical identity and cultural traditions	0.060
a11	Modernization of the coal and oil industries. construction of modern mines	0.059
a12	Construction and reconstruction of water supply and sewerage networks	0.059
a13	Increasing the level of public activity and social cohesion in the community	0.061
a14	Repair of roads and roadside infrastructure	0.063
a15	Improving, expanding, improving the quality of communication and the Internet	0.060

Source: own studies.

Thus, the highest priority is direction a3 – the development of tourism potential of the community. That is what you need to focus on. If you need to choose several areas of development, for example, three areas, the following areas will be:

- a1 – formation of a favorable investment climate,
- a4 – development of agro-industrial production and agricultural processing.

If we implement all three areas of development, we can apply the module of tourism development and agro-industrial module. To apply the tourism development module, it is necessary to isolate indicators, find the necessary statistics and import them into the program. To apply the agro-industrial module, it is necessary to import into the system statistics of agricultural development in previous years to identify factors of production.

3.2. Operation of individual decision support system modules

Garbage removal optimization module

This module uses a correlation-regression model, which was built (Bihun, Lytvyn, 2022) for the agro-industrial complex. Since correlation and regression analysis is the construction and analysis of economic and mathematical models in the form of equations and tables – the agro-industrial module consists of a single component - Microsoft Excel - a spreadsheet for working with spreadsheets and data analysis. The use of Microsoft Excel spreadsheet allows you to create not only a correlation-regression model, but also to make predictions about the general indicators of the economic process and determine the development of enterprises in the future.

To model the algorithm of the agricultural module, we use UML (Unified Modeling Language) activity diagram (Fowler, 2004), which is presented in figure 4.

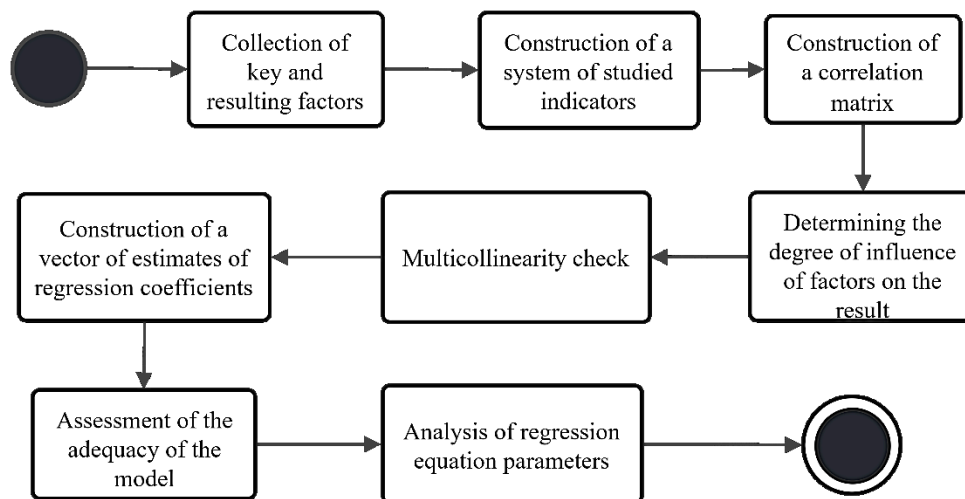


Figure 4. Activity diagram for correlation-regression analysis for agro-industrial complex.

In other words, it is a set of steps that need to be taken to build a correlation-regression model. The result will be a mathematical regression model, as well as an assessment of the adequacy of the model. All steps are taken by the researcher.

When adding or changing factors, as well as when new statistics appear, it is necessary to re-list all the steps of the algorithm.

Garbage removal optimization module

To model the garbage collection module (Bihun, Lytvyn, 2022) we use UML (Unified Modeling Language) precedent diagram (Fowler, 2004), which is presented in figure 5.

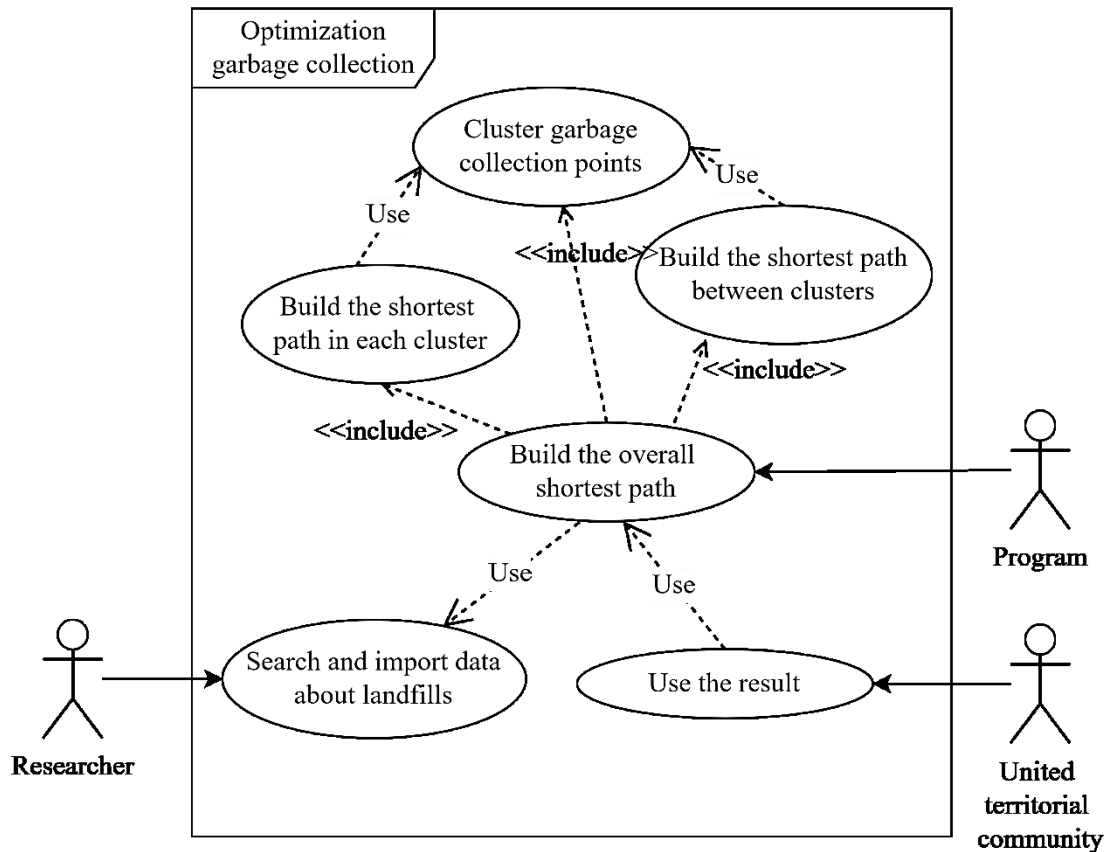


Figure 5. Garbage collection precedent diagram.

First, the researcher finds data on the location of landfills and their capacity. This data is then imported into a program that calculates the shortest garbage collection path. This result can be used by the local community to optimize garbage collection.

Module for choosing the direction of development

To model the module for choosing the direction of development, we also use the diagram of precedents (Fowler, 2004), which is presented in figure 6.

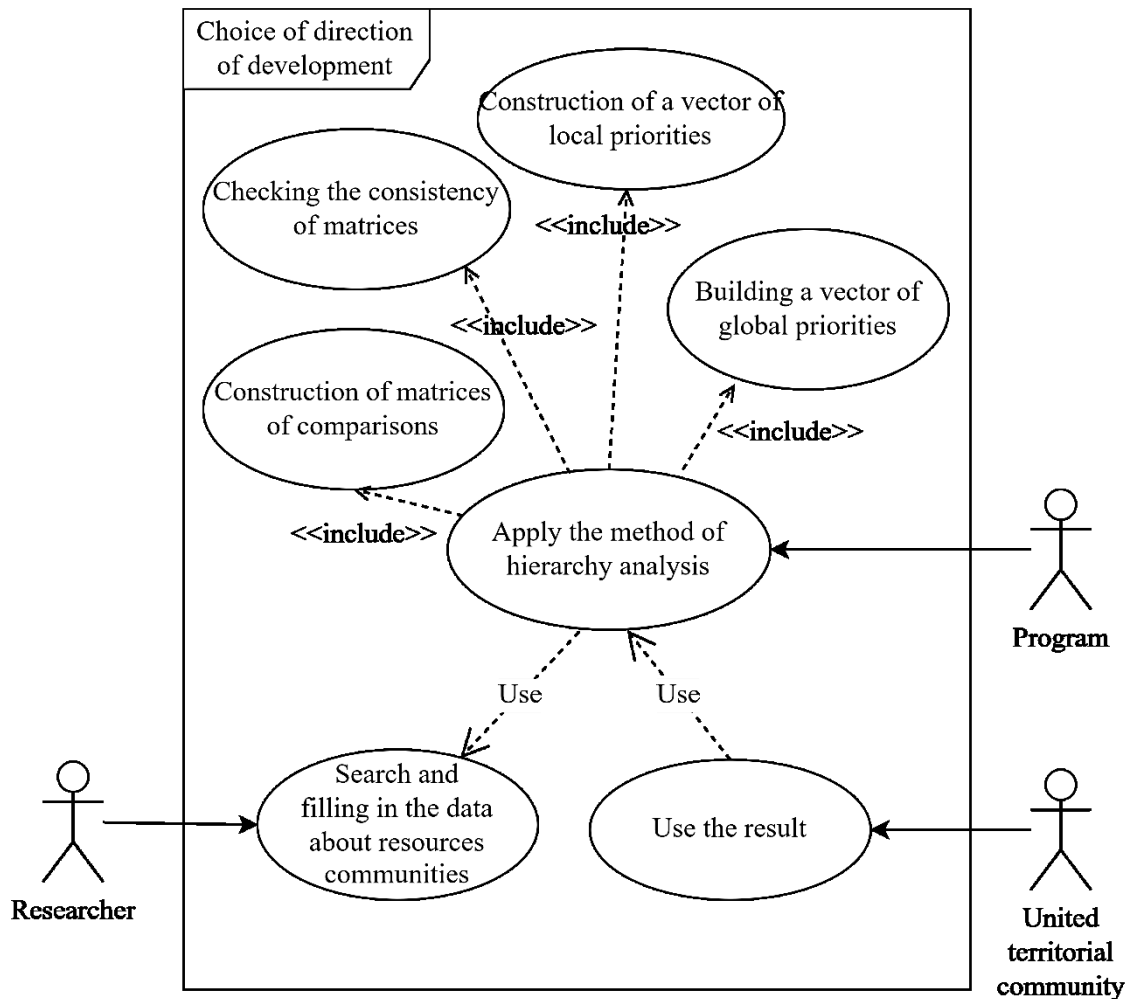


Figure 6. Diagram of precedents of the module for choosing the direction of development.

First, the researcher finds and fills in the data on the available resources of the territorial community on a scale: 1 – very little (if the number) or very unsatisfactory (if the state), 9 – very much (if the number) or very satisfactory (if the state), 2-8 – intermediate results. Then the data is used by the program to build matrices of pairwise comparisons and construct local and global priority vectors. At the end of the program gives a list of priorities of operational objectives. The united territorial community can choose one goal (the first from the list, which has the highest priority) or several (respectively, the first from the list of the highest priorities) to implement the development of the territorial community.

Tourism development module

The stages of PLS-PM modeling for the tourism module (Bihun, Lytvyn, Oleksiv, 2021) are presented in figure 7.

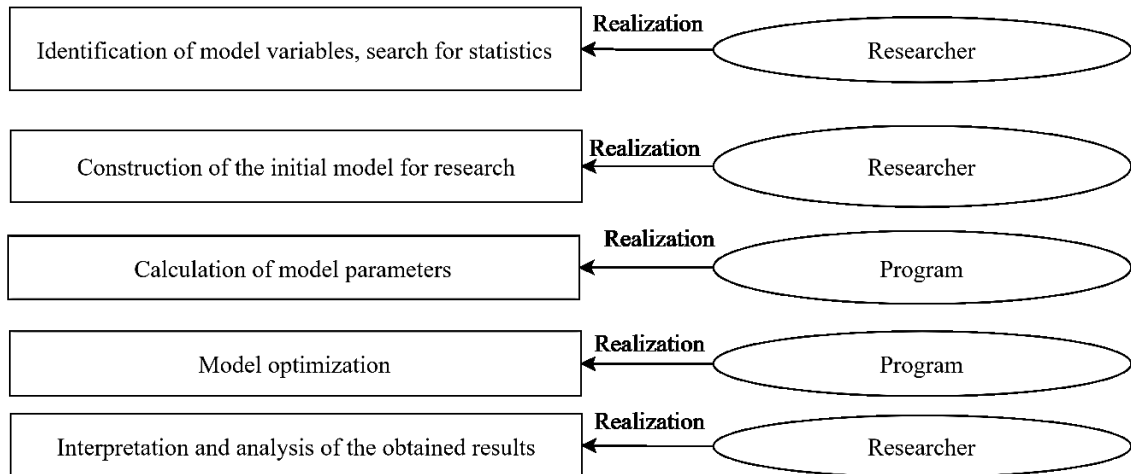


Figure 7. Stages of PLS-PM modeling.

Therefore, some steps cannot yet be automated programmatically. These steps need to be done by the researcher. The program calculates the parameters of the model and optimizes the model. The researcher needs to identify variable models, find the necessary statistics, and then build an initial model. In the end it is necessary to interpret the result by the researcher.

To model the algorithm of the tourist module, we use the block diagram of the algorithm PLS-PM, which is shown in figure 8.

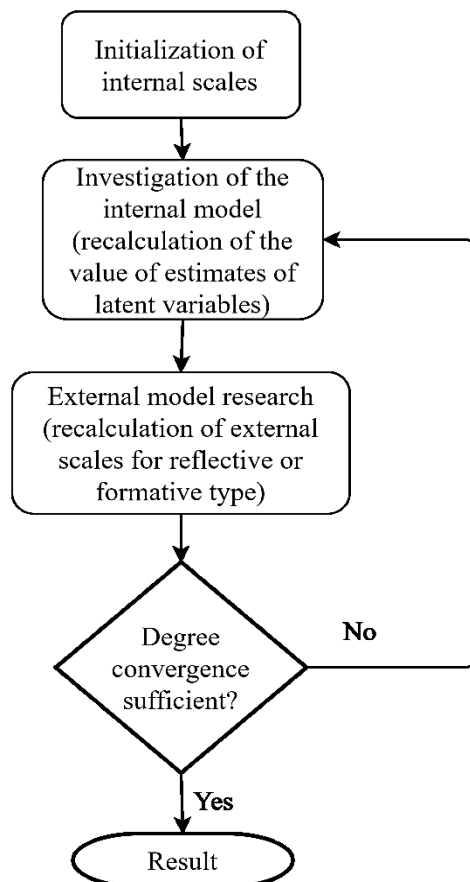


Figure 8. Block diagram of the PLS-PM algorithm.

SmartPLS program was used to implement the algorithm. First you need to initialize the internal scales. Next, the cycle is the recalculation of internal and external weights, which will be carried out until the degree of convergence is sufficient. Then we get the key factors that characterize the level of tourism development.

4. Discussion of the results of building a decision support system for the development of the territorial community

Analysis of the results of the software experiment will be allocated for each module separately:

- the result of the garbage collection optimization module will be a streamlined list of clusters and coordinates of garbage collection points, i.e., the garbage collection route, the reduction of which shows a reduction in costs allocated to the operation of the vehicle and reduce the total time spent on one route;
- the initial result of the module of choosing the direction of development will be the operational-strategic goal (or several goals if desired) of the territorial community, which best characterizes the development of the community based on its available resources;
- for the tourism module, the result will be data on key factors that characterize the level of tourism development, and the improvement of which will lead to positive changes in the tourism industry of the local community;
- the result of the agro-industrial module will be data on key factors, the regulation of which can have a positive impact on the growth of the economic component of the territorial community.

The scientific and practical value of the developed software can be divided according to the modules:

- the proposed module of optimization of garbage removal allows to facilitate the formation of financial solutions for the united territorial communities in the field of solving the problems of garbage collection and disposal in a certain area. This is possible due to the integration into the study of modern methods of machine learning in the section "learning without a teacher", one of which is the method of clustering, which is called k-average. To optimize the construction of clusters, namely their number in the area, an improved method of k-means was used, which includes consideration of the priority of garbage removal from certain clusters.

- the strengths of the agro-industrial module are that on the basis of representative economic indicators of the agricultural sector, key factors have been identified, the regulation of which can have a positive impact on the growth of the economic component of territorial communities. An important step in building a mathematical model is to consider the specifics of agriculture. Remember that natural conditions are an extremely important factor in production. That is why we need strategic planning that would formulate and implement community development strategies based on continuous monitoring and evaluation of change.
- the tourism development module allows to analyze the main factors influencing the development of the tourism industry, based on the PLS-PM model. This analysis can be used to successfully solve the problems of sustainable development of the tourism industry of local communities.
- the module of choosing the direction of development allows to prioritize the directions of development of territorial communities based on their resources, which allowed to analyze in detail these resources, as well as their impact on the direction of development of the territorial community.

5. Conclusions

The system of decision support for the development of territorial communities has been implemented. The results of the program experiment were analyzed and the scientific and practical significance of the developed program was shown. The separate components of functioning of the decision support system which consists of four parts (modules) are analyzed:

- development of the agro-industrial sector,
- tourism development,
- optimization of garbage removal,
- choosing the direction of development.

Each module can be used separately if necessary. Therefore, the methods of operation for each part were described using UML diagrams or a simple visualization of the steps of an algorithm or method.

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BARRIERS IN THE ORGANIZATION DESIGN PROCESS

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Purpose: identifying barriers that occur at each stage of the organization's design process.

Design/methodology/approach: the research project uses literature analysis and interviews with experts. The research was based on the opinions of managers and experts related to the design of the organization. A questionnaire was used to collect opinions.

Findings: research results show the fundamental importance of gathering information in the process of designing an organization. The respondents also pointed to the barriers related to the use of internal experts and to tensions and conflicts between project stakeholders. The research confirmed the hypothesis about the different intensity of barriers at different stages of the organization design process.

Research limitations/implications: research findings indicate the need for a deeper investigation of the information gathering process in the organization's diagnosis and design process.

Practical implications: the results indicate that in the designing process of the organization particular attention should be paid to problems related to information gathering. The article synthetically discusses the recommended methods of obtaining information.

Social implications: research results can be helpful in the implementation of improvement processes in profit and non-profit organizations.

Originality/value: emphasizing the role of qualitative information in shaping organizational solutions. The research results can be used by practitioners, consultants and other researchers.

Keywords: organization design, organizational structure, design process, qualitative information gathering methods.

Category of the paper: research paper, general review.

1. Introduction

Designing an organization is the process of defining system components, defining the functions of these components, and establishing relationships between them. The result of the design process should be a system enabling a smooth implementation of the strategy and proper adaptation of the organization to the environment. In designing the organization, situational conditions should be taken into account, i.e., the subject of activity, the company's strategy,

organizational culture, stakeholder expectations and many other factors. A well-designed organization answers a number of important questions. What organizational units should be distinguished in order to achieve strategic goals? How will these units be related to each other? What roles should we assign to members of the organization? How to coordinate work between separate units?

Designing an organization is based on specific assumptions. N. Stanford lists five such assumptions. 1. The basis for design should be a business strategy consistent with the operational context (environment). 2. Designing requires a holistic view of the entire organization. 3. Designing an organization is about the future, not the present. 4. Designing an organization involves a significant use of resources. 5. Designing an organization is a fundamental process, not a set of corrective actions (Stanford, 2007, pp. 8-19). In practice, the fulfilment of these assumptions encounters a number of barriers related to a widely understood design process.

There are two different interpretations of the design process in the theory of organization. According to the first one, designing an organization comes down to the decision-making process (Nadler, Tushman, 1997). According to the second interpretation, the design process represents the sequence of activities related to shaping the components of the organization model (Burton, Obel, DeSanctis, 2011). Regardless of the adopted interpretation, this process includes two phases - organization diagnosis and basic design.

The aim of the article is to show the importance of barriers in the process of designing an organization. Based on the analysis of the literature on the subject and interviews with experts and practitioners, six typical barriers in the design process were identified. Barriers are understood here as certain limitations, difficulties or challenges. The study assumes that the occurrence and intensity of these barriers are related to specific stages in the process of designing an organization. Therefore, three interrelated research hypotheses were formulated:

H1 - the intensity of barriers at different stages of the organization design process varies.

H2 - obtaining the necessary information, communication problems in the project team and the use of experts' knowledge are barriers characteristic of the initial stages of design (organization diagnosis).

H3 - the complexity of the conducted analyses, difficulties with the selection of appropriate research methods and techniques, as well as tensions and conflicts between project stakeholders are barriers characteristic of the basic design phase.

2. Methods

The research was based on the opinions of people directly related to the design of the organization. The subjects were divided into two groups. The first group consisted of people holding managerial positions in enterprises (202 people), the second group were people holding the positions of external experts (56). In total, 258 people were surveyed, including 51% of respondents with technical, 33% with economic and 11% with humanities education. Out of 258 respondents, 76% were men and 24% were women. Two groups were dominated by people with relatively extensive experience in designing an organization; in the first group, people with seniority over 5 years accounted for approx. 76%; in the second group, people who acted as external experts in more than 5 projects of the organization accounted for approx. 62% of all 56 respondents. Opinions were expressed by people employed in 185 enterprises of various size and operating in various industries. Out of the surveyed enterprises, 45% are companies with 10 to 49 employees, 27.5% are companies with 50 to 249 employees and 27.5% - more than 249 employees. The dominant activity of the surveyed enterprises was services (39.4%), production (37.2%) and trade (23.4%). The vast majority of these enterprises are companies with their headquarters in the region of south-east Poland¹.

The aim of the research was to identify barriers in the organization design process. As mentioned in the introduction, the issue of design in the theory of organization is considered in two ways. In one of these approaches, design is treated as a decision-making process. We can also find such a general approach to design in engineering sciences. For example, E.V. Krick in the process of technical design, lists the following stages: problem formulation (general problem definition), problem analysis (problem definition with the necessary details), search for solutions (gathering a certain number of variants), decision (evaluation of the collected variants and selecting the best one) and documentation, i.e., the development of detailed documentation for the selected variant (Krick, 1975, p. 129). Based on this approach, five stages of designing an organization were formulated. The research tool was a questionnaire, which listed the following stages in the design process:

- I. Identification of the organizational problem.
- II. Analysis of the situation and formulation of the project goal.
- III. Development of variants of organizational solutions.
- IV. Assessment of variants and selection of the optimal variant.
- V. Detailed design of the selected variant.

¹ The presented results are a fragment of broader research, which for the purposes of this article has been supplemented and expanded (Stabryła, 2014).

Respondents were asked to assign at least one of the above-mentioned stages to the following statements:

- A. Obtaining the necessary information is critical in the stage/s.
- B. The high complexity of the analyses carried out is characteristic of the stage/s.
- C. Problems with communication in the project team most often occur in the stage/s.
- D. Tensions and conflicts between project stakeholders emerge at stage/s.
- E. Difficulties with the selection of appropriate research methods and techniques occur in the stage/s.
- F. Using the knowledge of external experts is the best in the stage/s.

The task of the respondents was to assign the stages of the design process (I, II, III, IV or V) to specific barriers (A, B, C, D, E and F). The respondents could assign more than one stage to a given barrier. As a result, a specific "map" was created, reflecting the distribution of challenges related to the implementation of subsequent stages of the design process in terms of the distinguished categories.

3. Results

The respondents most often assigned one or two stages to the statements given in the questionnaire (65% and 25% of all indications, respectively). It is interesting that in the case of the statement referring to the importance of obtaining the necessary information (barrier A), eight respondents mentioned all of the five distinguished stages of the design process. These indications are fully understandable due to the importance of information in the diagnosis and design of an organization. In most cases, however, the respondents tried to point to the dominant connections. The list of indications of all the people surveyed is shown in Table 1.

Table 1.
Distribution of indications of all respondents

Barriers	Stages in the design process					Sum
	I	II	III	IV	V	
A. Information gathering	175	126	51	36	29	417
B. Complexity of analyses	31	107	105	63	65	371
C. Team communication	50	60	77	122	61	370
D. Tensions and conflicts	37	40	80	144	76	377
E. Choice of methods	44	105	76	69	64	358
F. Use of experts	72	69	82	61	110	394
Sum	409	507	471	495	405	2287

Source: own study.

The collected data show that the greatest problems with obtaining the necessary information (A) occur when identifying an organizational problem (stage I) and analysing the situation and defining the project's goal (stage II). The complexity of the necessary analyses (B) is revealed

most strongly during the stage consisting in examining the situation and formulating the project's goal (II) and during the development of variants of organizational solutions (stage III). Communication problems in the project team (C) are most pronounced in the stage related to the assessment and selection of the optimal variant (IV). The fourth stage of the design process was also indicated most often in the category described as tensions and conflicts between stakeholders (D). In terms of difficulties with the selection of appropriate research methods and techniques (E), the most frequently indicated stage was the second stage of the design process, i.e., the analysis of the situation and formulation of the project's goal. On the other hand, in terms of the use of experts' knowledge, the last stage (V), i.e., a detailed design of the selected variant, was most often indicated.

The data presented in Table 1 can also be read differently, i.e., taking into account the number of indications of barriers at individual stages of the design process. In this way, we obtain information on the significance of the categories of barriers adopted in the research with regard to each stage. This data allows us to conclude that:

- in the stage of identifying an organizational problem (I), the most important thing is obtaining information (A): 42% of 409 responses out of all the barriers listed, other barriers do not play a dominant role (except for category F, which means the need to use experts),
- at the stage of analysing and formulating the project's goal (II), the most important thing is also obtaining information (A): 25% of 507 indications in all categories of problems, but also factors B and E play an important role, i.e., the complexity of the analyses and the selection of methods,
- in the stage of developing variants of organizational solutions (III), the most important factor is the complexity of the analyses (B): 23% of all 471 indications, but also tensions and the use of experts (F) as well as tensions and conflicts (D),
- at the stage of variant assessment and selection of the optimal variant (IV), the tensions and conflicts between stakeholders (D) are the most important: 29% of 495 indications; communication in the project team is also relatively important (25%),
- at the stage of a detailed design of the selected variant (V), the most important thing is to use the knowledge of experts: 27% out of 405 indications, as well as tensions and conflicts between the project's stakeholders (19%).

As mentioned above, the research was conducted in two groups of respondents. Therefore, the question arises to what extent the distributions of managers and experts' answers are consistent with each other. Pearson's correlation coefficient was adopted as a measure of agreement. The critical value of the r coefficient in the one-sided test (we test the hypothesis of positive r) is 0.805 at the level of 0.05 for $df = 3$ ($df = n - 2$, where n is the number of observations, in our case equal to the number of stages in the design process). The values of the correlation coefficients between the summary indications of managers and the summary indications of experts are shown in Table 2.

Table 2.

Values of correlation coefficients between the indications of experts and managers from the perspective of barriers

Barriers	<i>r</i>
A. Obtaining the necessary information	0.991
B. High complexity of the conducted analyses	0.932
C. Problems with communication in the project team	0.848
D. Tensions and conflicts between project stakeholders	0.994
E. Difficulties with the selection of appropriate research methods and techniques	0.965
F. Using the knowledge of external experts	0.622

Source: own study.

Based on the data in Table 2, we find that the agreement between the indications of managers and experts is high and not accidental (at the significance level of 0.05) for categories A, B, C, D and E. However, in the case of category F, there are no sufficient grounds ($r = 0.622 < 0.805$) to conclude that the agreement is not coincidental.

4. Discussion

With regard to the first research hypothesis (H1) put forward in the introduction, it can be stated that the intensity of the identified barriers at different stages of organization design varies. These differences, however, are not large, which seems to be justified by the complexity of the design subject. The organization is an open and dynamic system, it is influenced by many internal factors (organizational culture, number and attitudes of employees, technologies used, etc.) and external factors (customers, competitors, collaborators, etc.). Together, these factors determine the optimal configuration of organizational solutions. The above-mentioned barriers are visible at every stage of the design process and at the same time constitute challenges faced by those responsible for shaping the organization. Regardless of the design stage, the rank of these barriers based on the frequency of indications (last column of Table 1) is as follows: obtaining information (A), using experts (F), tensions and conflicts (D), complexity of analyses (B), communication in the project team (C), and the selection of methods (E). In the light of the data obtained, it is clearly visible that the most important thing in designing an organization is obtaining information.

Obtaining information plays a fundamental role in the first two stages of design, i.e., identifying the organizational problem (I) and analysing the situation and formulating the project goal (II). These stages relate, in fact, to the diagnosis of the organization. Information needed for a reliable diagnosis of an organization is often qualitative in nature, and obtaining it requires the use of appropriate methods. In practice, interviews, questionnaires, observations and document analysis are used to gather information (Swanson, 2007, pp. 107-120). Sometimes workshops are used (Harrison, 2005, pp. 21-22). Each of the above-mentioned methods comes in many varieties (Brewerton, Millward, 2001). Each of them has specific

advantages and disadvantages, and also requires specific skills. The synthetic characteristics of the information gathering methods are summarized in Table 3.

Table 3.

Methods of collecting information in the diagnosis of an organization

Name of the method	Characteristics of the method
Interviews	Directly asking questions to employees or people related to the organization. Requirements: formulating relevant questions, creating an atmosphere of trust, the ability to take notes. Advantages: allows you to study a wide range of problems, facilitates the understanding of complex situations, allows you to gain the trust of the respondents. Disadvantages: costs, subjectivism, difficulties in interpreting the answers, difficulty in developing a synthesis.
Questionnaires	Closed or open written questions. Requirements: precisely defined information needs, the ability to analyse data, preparing a questionnaire in a simple and transparent manner. Advantages: quantification of results, simultaneous testing of many people, low costs, possibility of multiple use, impartiality. Disadvantages: no direct contact, possibility of omitting important issues, difficulty in preparing a good questionnaire, possibility of misreading questions and giving incorrect answers, data may be misinterpreted.
Observations	The observer follows the work done by employees who are or are not informed about what aspect of their work is being examined. Requirements: choosing the right people at the right time, openness to new ways of doing work, the need to be on site, the ability to register data. Advantages: the observer has first-hand information about the work being performed, observations are made in the course of the work in progress, they can reveal a series of unexpected problems or a more effective method of performing the work. Disadvantages: difficulty in interpretation, selection of people and observation time, observer's attitude, necessity to conduct supplementary research, high costs.
Document analysis	The analyst examines, classifies and interprets the meaning of the information contained in the organizational documentation. Requirements: skills in classification, synthesis, selection and proper use of statistical methods, data interpretation. Advantages: organizational documentation is unambiguous, numbers and data are easier to understand, possibility of precise identification of problems. Disadvantages: difficulties in determining the validity of individual documents, reports can be biased, difficulties in quantification.
Workshops	Selected employees jointly discuss the problems of the organization with the participation of a moderator. Requirements: selection of employees representing different views and familiar with the system, appropriate qualifications of the moderator in managing the discussion. Advantages: useful in the analysis of particularly complex organizational problems, enables the exchange of views between the participants of the organizational system, allows for a better understanding of the causes of existing problems. Disadvantages: the need to involve employees at the same time, polarization of opinions, dominance of strong personalities.

Source: own study based on Swanson, 2007, pp. 107-120 and Harrison, 2005, pp. 21-22.

Obtaining information, communication problems in the project team and using the knowledge of external experts were recognized in the second hypothesis (H2) as characteristic barriers in the initial stages of design (organization diagnosis). This hypothesis was clearly confirmed with regard to obtaining information (175 indications for stage I, and 126 indications for stage II). As for the other two factors, their importance is less clear, but visible especially in the first stage of designing an organization, i.e., when identifying an organizational problem (use of experts - 72 indications, communication - 50 indications).

Referring to the third hypothesis (H3), we believe that the basic design applies to activities initiated after the diagnosis of the organization, i.e., including the stage of developing variants (III), the stage of variant assessment and selection of the optimal variant (IV), and the stage of detailed design of the selected variant (V). According to this hypothesis, the barriers

characteristic of these stages are the complexity of the analyses (B), difficulties with the selection of appropriate research methods and techniques (E) as well as tensions and conflicts between project stakeholders (D). Considering the cumulative indications for these three stages of design, one can only acknowledge the validity of the statement about the importance of conflicts and tensions between project stakeholders. This factor was indicated as the third one in the order of indications (377 times in total in stages III, IV and V), more indications were obtained by barriers related to obtaining information and using experts).

5. Summary

Summarizing the presented research results, attention should be paid to the most frequently indicated barrier in the process of designing an organization, which is obtaining information. Special attention should be given to the importance of "soft" factors in design, which, in practice, implies the need to collect qualitative information. In fact, an organization is defined by people's behaviour. How people behave depends on the recognized norms and values, the history of an organization and long-established habits. These, in turn, can change under the influence of mission and strategy, leadership, environment, and many other factors. The role of these "soft" issues in the design of organizational systems must not be underestimated. This is confirmed by numerous examples of organizations in which proposals for wide-ranging changes to structures and procedures without taking these factors into account lead to apparent changes. Therefore, when designing an organization, we emphasize the need to use qualitative methods of collecting information, the synthetic characteristics of which are presented in Table 1.

When designing an organization, we should remember that we shape the structures which, in turn, shape us. This fact indicates the great responsibility of senior management, but also the need to involve employees in the process of designing an organization. In the past, an important role in design was played by the pursuit of consistency, stability and even harmony within an organization. Looking to the future, we find that organizations which, in the conditions of radical changes in the environment, will shape structures only to ensure an artificial sense of internal stability, will become their own greatest enemies (Nadler, Tushman, 1999 p. 58).

Progressive digitization, the development of artificial intelligence, pandemics and armed conflicts accompanied by increasing complexity and unpredictability will force a change in the approach to organization design. Even so, it seems that the classic organizational design dilemmas remain valid today. How to maintain diversity (differentiation) while ensuring consistency (integration) of action? How to connect people, processes and operational units so that they are adapted to the environment and to the entire organization? How to make employees original and unanimous at the same time? Overcoming natural barriers in the complex design

process gives hope that organizations will not only be more efficient, but also become a better place for people to work.

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DEVELOPMENT OF THE HARD DRIVES IN A PORTABLE COMPUTER DEVICES

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Purpose: The aim of this article is to present the history of hard drive development over the last few decades. The structure and principle of operation of disks made in various technologies was also presented. Particular attention has been paid to SSDs (Solid State Drives) due to their dominant position in the market.

Design/methodology/approach: The article presents the possibilities of using mass storage devices. In the article we also covered the base structure of main mass storage computer device available commercially nowadays.

Findings: During the work we found connections and main differences between main types of mass storage computer devices and how they evolved during last 70 years.

Originality/value: Paper presents whole history of developing of mass storage devices. This approach may be helpful for engineers who work on designing and refining mass storage technologies.

Keywords: hard drive disk, solid state drive, mass storage.

Category of the paper: Research paper.

1. Introduction

The beginnings of designing hard drives date back to the 1950s. The disk was constructed by IBM on September 14, 1956. This disk was a 20 inch device in an IBM 305 RAMAC computer. It can be said that this drive ushered in the era of hard mass storage. To this day, hard drives are the best way to store data. They are magnetic type disks (Horowitz, Hill, 2019). They are installed in all types of computers, in mobile devices, laptops, PCs, servers, etc.

The hard disk contains a movable system with a sliding reading or writing head on a magnetic plate. So it is a mechanical device. For this reason, for the correct operation of the disk, the stability of the position without any shocks is essential. The computer devices that are most often exposed to shocks are laptops and various types of mobile devices. Each shock exposes the hard drive to irreparable damage and loss of functionality. This may result in the loss of data stored on the disk. Any such data loss can expose the user to significant costs.

The article presents the development trends of hard drives used in portable computers.

2. Design of hard drives and their development

A hard disk is made of a set of rotating plates or a single rotating plate, which are usually made of aluminum alloys, with a polished surface and covered with a magnetic carrier. There are heads next to the plates that enable data recording and reading. There is one read and write head assigned to each surface of the disc. The heads are placed on guides. They are in contact with the plate when they are at rest. However, they float during work. The distance between the head and the platter is stabilized thanks to the aerodynamic effect. This phenomenon is based on the production of a whirl of air resulting from the operation of the plates (Metzger, 2011).

In order to read or write data, the arm of the disk head is positioned at an appropriate distance from the axis of rotation of the disk. The first designs of this type of disk were equipped with a stepper motor. Technological advances related to the increase in the number of cylinders on a disk along with the need to increase the speed of the disks resulted in launching of many other solutions. They used the phenomenon of a strong magnetic field generated by a magnetic coil. As a result, the transition time between successive paths was reduced to less than 1 millisecond. There, the information is recorded on a disk by transmitting an electromagnetic flux through a recording head. This information can be read back in the opposite way. This is because the alternating magnetic field induces an electrical voltage in the head coil. Electronics on board of the hard disk control the movement of the heads and the rotation of the disk. It also prepares read and write processes on the command of the disk controller.

It is obvious that one of the most important features of mass storage devices is their capacity, i.e. the amount of data that can be stored on one indivisible medium. In magnetic type disks, the capacity depends on several factors. The first is the number of plates placed in a unit. The second is the technology of their implementation. The smoother the disk surface, the closer the read/write head can be placed, and thus the density of magnetic memory cells can be increased (Mueller, 2005). The rotational speed of the discs also has an indirect effect on the disks. For those with a lower rotational speed of 5000 rpm, the distribution of available capacities is greater. However, for drives that reach speeds of 7000 rpm, the maximum capacities available on the market are twice as small. This is probably because the

manufacturers, by focusing on the speed of operation in specific models, put the capacity in second place. Otherwise, the price could prevent the release of such models on the market.

The second most important feature is the speed of data transfer. It depends primarily and directly on the rotational speed of the platters and the size of the cache. The former is directly responsible for the speed with which access to a specific sector is made possible. Hence, the faster the platter's rotation speed, the faster the drive responds to commands (SSD and HDD, 2022). On the other hand, a larger and faster cache is needed to transfer and temporarily store larger data packets in this memory. Such temporary retention is needed so that data that is needed more often is not repositioned on disk, but in a faster cache (What is a cache, 2022). Hence, the larger it is, the more data can be processed simultaneously.

3. Hard drives evolution strategy

From the invention of the magnetic hard disk to the present day, engineers have made great strides in improving them both in terms of performance and price.

The history of the evolution of hard drives is as follows:

- September 4, 1956 - IBM's construction of the first 20-inch hard drive, named RAMAC 350, in the IBM 305 RAMAC computer.
- 1983 - the appearance of IBM PC/XT computers with mounted disks with a capacity of 5 and 10 MB,
- 1986 - development of the IDE (Integrated Drive Electronics) controller,
- 1987 - start of production of 3.5-inch drives,
- 2003 - hard drives produced at that time could collect from 60 to 500 GB of data, their platters rotated at a speed from 5400 to 15 000 rpm and had an average data transfer speed of 30MB/s - some servers and workstations used disks with rotational speeds of 15 000 revolutions per minute,
- 2006 - a new perpendicular recording technology was used, which made it possible to store over 1 TB of data on the disk; SATA and SAS (Serial Advanced Technology Attachment and Serial Attached SCSI (Small Computer Systems Interface)) have become a standard; USB sticks began to displace floppy drives,
- 2009 - production of disks with a capacity of 2 TB; the appearance of disks with a dynamic change in rotational speeds; the SATA 3 standard was developed for SSDs,
- 2013 - the first Ultrastar He6 disk with a hermetic housing and filled with helium is launched commercially. It reduced energy consumption by 49% in the category of watts per terabyte (WD releases 6TB, 2022),

- 2014 - the company Western Digital (WD) announces the release of new hard drives with a capacity of 10 TB filled with helium and with a new recording technology SMR (shingled magnetic recording) (Western Digital unveils, 2022),
- 2018 - Seagate announces a 16 TB hard drive thanks to the HAMR (heat-assisted magnetic recording) recording technology (HAMR Milestone, 2022),
- 2022 - Western Digital (WD) at its inaugural What's Next Western Digital event in San Francisco presented new 22 TB hard drives called Ultrastar DC HC570 and 26 TB called Ultrastar DC HC670. At the same time, it presented a path that will make it possible to achieve even higher capacities (Orchestrating, 2022).

Nowadays, the leading manufacturers of hard drives are: Seagate, Western Digital, Samsung, Hitachi, Fujitsu.

In the next chapter we will deal with disks made in the latest commercially available SSD (solid state drive) technology. It is a direct successor to magnetic hard drives. It is worth emphasizing, however, that the SSD technology has not replaced the magnetic technology, but is used alongside the latter, which gives enormous benefits and allows to use the advantages of both technologies and compensate for the disadvantages of each of them.

4. Solid state drive (SSD)

Solid state disks get their name from the part of physics that deals with solid-state physics. One of the most important parts of this branch of physics is the study of semiconductor properties and their application (Skorko, 1982). This is where the name and construction of SSD drives come from. That is because these disks do not contain moving (mechanical) parts, but their main data storage material is a semiconductor. In order to obtain the greatest possible capacity, FLASH type semiconductor memory chips are constructed (Wawrzyski, 2003), which are arranged in the disk.

This approach to construction allows the use of any connector for data transfer, and even to integrate such a disk directly with the motherboard (such solutions can be found in small laptops, where great emphasis is placed on their minimum physical size, especially thickness). However, due to backward compatibility with older motherboards, SSDs contain a SATA or ATA type connector.

Since the launching of the new solid state drive (SSD) technology, the massive development of this type of memory has begun. The constantly cheaper components lead to the production of more and more new types of SS (Solid State) memories with much greater capacity, which makes them more and more available and finding newer and newer applications. This trend is driving waves of applications and generating newer and newer product groups. Examples include: small earbuds, smart watches and sports bands (smartwatch and smartband), smart rings, smart glasses (the latter two, however, are not common today) and the like.

SSDs have a number of advantages that cannot be achieved with magnetic disks. First of all, these disks are extremely resistant to shocks and mechanical damage. They are also characterized by low power consumption. This is again due to the lack of mechanical components. The entire process of data storage in an SSD takes place at the level of the atom and electron shells, hence the energy needed for the operation of such a system is much smaller than that needed to power the moving head system, the disk and the electronics controlling them. For the same reason, SSDs are completely silent and generate no noise at all. Also, depending on the type of semiconductor used, they have a much wider operating temperature range than hard drives, i.e. from -40°C to 85°C .

Finally, it is probably the greatest advantage of SSD drives that should be mentioned, i.e. their data transfer speed. Due to the elimination of the need to physically move the head over the appropriate sector to write or read data, it has been possible to shorten the data access time many times over. Currently, the data transfer speed in semiconductor memories in the latest models reaches even 5000 MB/s! This means that the mass memory on which the operating system and user data are located is equal to and even beats the RAM operating memory with its speed. This creates, first of all, the possibility of creating smooth and fast-operating computer units (personal or for industrial applications), but also the possibility of creating fast and efficient servers and data centers.

Table 1 shows the storage media available on the market for data storage. You can easily compare these products with each other. Semiconductor storage media clearly exceed the data transfer speed compared to other media

Table 1.
Memory medias available at the market

Kind of memory	Memory card MicroSDXC	Memory card Compact Flash	Disk USB Flash Drive (Pendrive)	Hard drive HDD 3.5 inch	Disk SSD 2.5 inch	Disk SSD M.2
Manufacturer and the model of device	SanDisk Ultra microSDXC 32	SanDisk EXTREME CF 32	SanDisk Ultra Flair USB 3.0 FlashDrive	Seagate Barracuda ST1000DM010	SanDisk SSD Plus	WD_BLACK SN770 NVMe SSD
Size	15 x 11 x 1 mm	43 x 36 x 3,3 mm	6.6 x 42 x 13 mm	147 x 101 x 26 mm	7 x 100 x 70 mm	80 x 22 x 2.38 mm
Weight	2 grams	10 grams	About 30 grams	400 grams	100 grams	5,5 grams
Nominal capacity	32 GB	32 GB	256 GB	1 TB	240 GB	250 GB
Price	32 PLN	164 PLN	169 PLN	200 PLN	210 PLN	283 PLN
Price per 1 GB	1 PLN	5 PLN	0.66 PLN	0.20 PLN	0.88 PLN	1.1 PLN
Read speed	Up to 100 MB/s	Up to 120 MB/s	Up to 150 MB/s	Up to 210 MB/s	Up to 530 MB/s	Up to 4 GB/s
Write speed	30 MB/s (min 10MB/s)	Up to 85 MB/s	50 MB/s	Up to 100 MB/s	Up to 400 MB/s	Up to 2 GB/s
The maximum available capacity for this media type	516GB	128GB	512 GB	8 TB	2 TB	2 TB

Source: own work.

Apple was the first company to massively use SSD disks in its devices. It offered the possibility of mounting an SSD drive in place of standard storage media in laptops it produced. Lenovo was the first manufacturer to equip its series of products with SSD drives. In addition, there were no devices containing magnetic disks in the computers of these series. Asus was also a pioneer in applying the new SSD disk technology. These were low-cost, small mobile computers. SSD disks in these computers were permanently installed on the motherboard.

5. Solid state drive evolution strategy

SSDs have grown rapidly over the past few decades. At the beginning, their main disadvantage was the price. In addition, from today's perspective, we can say that this price was in no way disproportionate to their parameters. However, this is usually how the development of something good and useful looks like.

This is the story of the evolution of SSD storage drives:

- 1991 - the launch of the first SSD drive with a capacity of 20 MB, which cost \$ 1000 at the same time (The evolution, 2022),
- 2006 - Samsung introduces a 32 GB SSD drive, which is built into their computer models: Sens Q30PLUS Samsung Note PC and Sens Q1 ultra-mobile PC, (Leading the transition, 2022),
- 2016 - Samsung introduces a 16 TB SSD called PM1633a (Westlake, 2022),
- 2018 - Samsung has created a 30 TB SSD called PM1643 (Snoch, 2022),
- 2022 - a 30 TB drive from Samsung can be purchased for PLN 40,000.

6. Security of data contained on solid state drive disks

The new SSD hard drives are much more reliable than the previously developed magnetic drives. They are much more shock-resistant and guarantee effective work with the data. In modern computer systems, security and reliability issues take priority over other properties. Hence, in computer systems, SSD storage media are an ideal product that meets the needs of system users. No wonder that these drives have been used in large corporations, concerns and organizations for which reliability and security are priorities. Organizations such as the armed forces and governmental organizations should be mentioned in particular. It is worth mentioning that computers have been involved in hostilities for decades and have helped in these areas. SSD drives can meet the requirements of working in harsh military conditions and are therefore widely chosen by such organizations.

7. Summary

A significant reduction in the production costs of storage media is noticeable in comparison with the years of introducing individual types of storage media to the market. There is considerable interest in new storage technologies. Especially with SSD technology due to its high energy and transfer efficiency. The prices of storage media are highly dependent on the manufacturing technology, capacity and speed of data transfer. Hence, manufacturers, in order to ensure the availability of their products for as many users as possible, design the same types of carriers adapted to specific applications. That is, in certain models, they focus on speed, and on other models, capacity.

In recent years, however, the development of computer memories of both technologies has reached the limits of its development. It is about cells that are shrinking, in which bits of data are saved, and which are getting closer and closer in size to the size of a single atom. This leads to the fact that in the next several years, magnetic and semiconductor technology will reach the limit where memory cells will no longer be able to become smaller. Hence, there is a need to invent other methods of storing information, which will be appropriate to the ever-increasing amount and intensity of its processing by people around the world.

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ANALYSIS OF ELECTRICITY FROM RENEWABLE SOURCES IN THE EUROPEAN UNION MEMBER STATES IN THE YEARS 2004-2020

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Purpose: The purpose of this paper is to present an analysis of electricity from renewable sources in the European Union countries. Analysis includes the quantity of electricity produced from renewable sources - Electricity (hydro, wind, solar, solid biofuels, all other renewables), the amount of renewable electricity used in Transport (Renewable electricity in road transport, in rail transport, in all other transport modes, compliant biofuels, non-compliant biofuels, other renewable energies), gross final consumption of energy from renewable sources in the heating and cooling sector (final energy consumption, derived heat, heat pumps), gross final consumption of energy from renewable sources (electricity, Transport, heating and cooling (European Commission, 2021)).

Design/methodology/approach: The article presents an analysis of the volume of energy obtained from renewable sources and its use, taking into account the list of volumes, changes in volumes in subsequent years, relative values and percentage change compared to the first period from which the data are available (2004) and compared to the period immediately preceding.

Findings: By analyzing the data, conclusions can be drawn regarding the level of share and its changes in relation to renewable sources in obtaining electricity, as well as its use in aspects such as Transport or heating and cooling.

Research limitations/implications: The problem that arose during the search for the necessary data was the lack of data from all European Union countries - as a result, the analysis includes data until 2020 (when the work was being written, data from 2021 was not yet available).

Practical implications: The results of the analysis can be used to assess the possibility of implementing the climate project by the EU Member States.

Social implications: Observing the behavior of society as a result of climate policy, it can be concluded that the community is aware of the need to achieve climate goals, and an increasing percentage of people reach for solutions such as heat pumps or solar panels.

Originality/value: The article analyzed electricity obtained from renewable sources.

Keywords: renewable electricity, renewable source, final gross consumption of energy from renewable.

1. Introduction

Over 75% of EU greenhouse gas emissions come from energy production and use. It became reasonable to develop the European climate policy and create the Green Deal for Europe project, where plans for systematic reduction of carbon dioxide emissions by the European Union Member States were presented to achieve carbon dioxide neutrality by 2050 as a long-term effect. Different options for reducing carbon dioxide emissions targets are determined based on the country's gross domestic product per capita. The proposed targets for 2030 would range from -10% to -50% compared to 2005 levels and would align with the overall target of reducing EU emissions by 40% (European Parliament, 2018).

The European Union strategy focuses on three main assumptions for the clean energy transition, which will help reduce greenhouse gas emissions: ensuring affordable and secure energy supply in the EU, creating a fully integrated, interconnected, and digital EU energy market, prioritizing energy efficiency, improving the energy performance of buildings and developing an energy sector based mainly on renewable sources. To achieve the EU's 2030 energy and climate targets, EU countries must establish their 10-year integrated national energy and climate plans for 2021-2030. The national plans outline how EU countries intend to address five critical areas: energy efficiency, renewable energy, reducing greenhouse gas emissions, interconnections, and research and innovation. This work aims to present an analysis of power obtained from renewable sources in the European Union in 2004-2020 based on the factors set by the European Union (European Commission, 2021).

2. Analysis of the electricity share and its components from a renewable source

Sources are presented in the second chapter of this work, electricity in 2004-2020. The following table (Table 1) shows gross electricity production by hydropower - Hydro, wind power - Wind, Solar, Solid biofuels, and all other renewables. The change in the level of individual electricity sources in 2020 compared to 2004 was as follows:

- Hydro - change from level 29209,01 to level 29677,23 (increase by 1,6%).
- Wind - change from level 4783,32 to level 32366,81 (increase by 576,66%).
- Solar - change from level 59, 41 to level 12392,04 (increase by 20759,27%).
- Solid biofuels - change from level 3116,97 to level 7132,70 (increase by 128,83%).
- All other renewables - change from level 1936,83 to level 7513,17 (increase by 287,91%).

The last column shows the percentage share of electricity from renewable sources in subsequent years: this value increased from 15,87% in 2004 to 37,48% in 2020, i.e., an increase of 136,17%.

Table 1.
Share of component parts electricity

Year	Hydro	Wind	Solar	Solid biofuels	All other renewables	Total (RES-E numerator)	Total (RES-E denominator)	RES-E [%]
2004	29209,01	4783,324	59,41	3116,97	1936,83	39105,54	246397,32	15,87%
2005	29309,81	5733,508	125,43	3489,56	2263,44	40921,74	249498,37	16,40%
2006	29180,54	6783,305	214,06	3883,32	2649,35	42710,57	253037,44	16,88%
2007	29259,99	8180,863	324,55	4098,63	3183,68	45047,72	255265,06	17,65%
2008	29202,98	9568,501	639,52	4572,56	3534,41	47517,97	256489,11	18,53%
2009	29308,17	10978,45	1212,72	4930,92	3945,42	50375,68	243900,77	20,65%
2010	29628,52	12442,35	1996,91	5587,45	4530,60	54185,83	254596,76	21,28%
2011	29632,79	13968,62	4066,08	5772,24	5012,31	58452,04	250862,61	23,30%
2012	29507,67	15574,03	6034,10	6196,93	5760,29	63073,01	250905,47	25,14%
2013	29516,8	17280,99	7231,68	6062,11	6439,40	66530,98	248539,13	26,77%
2014	29462,78	18995,78	8097,04	6080,29	6906,30	69542,18	243143,59	28,60%
2015	29663,73	21455,14	8672,24	6194,86	7262,37	73248,33	247004,01	29,65%
2016	29596,59	23384,59	8687,41	6223,37	7392,30	75284,26	249515,58	30,17%
2017	29462,59	25710,3	9280,45	6385,33	7459,23	78297,90	251732,87	31,10%
2018	29559,81	27524,33	9718,66	6556,53	7447,71	80807,04	251466,72	32,13%
2019	29509,63	29954,82	10643,44	6926,87	7460,78	84495,53	247887,04	34,09%
2020	29677,23	32366,81	12392,04	7132,70	7513,17	89081,95	237667,51	37,48%
Suma	500688,6	284685,7	89395,72	93210,61	90697,58			

Source: <https://ec.europa.eu/eurostat/web/energy/data/shares>.

The chart below shows the shares of renewable sources in subsequent years in 2004-2020.

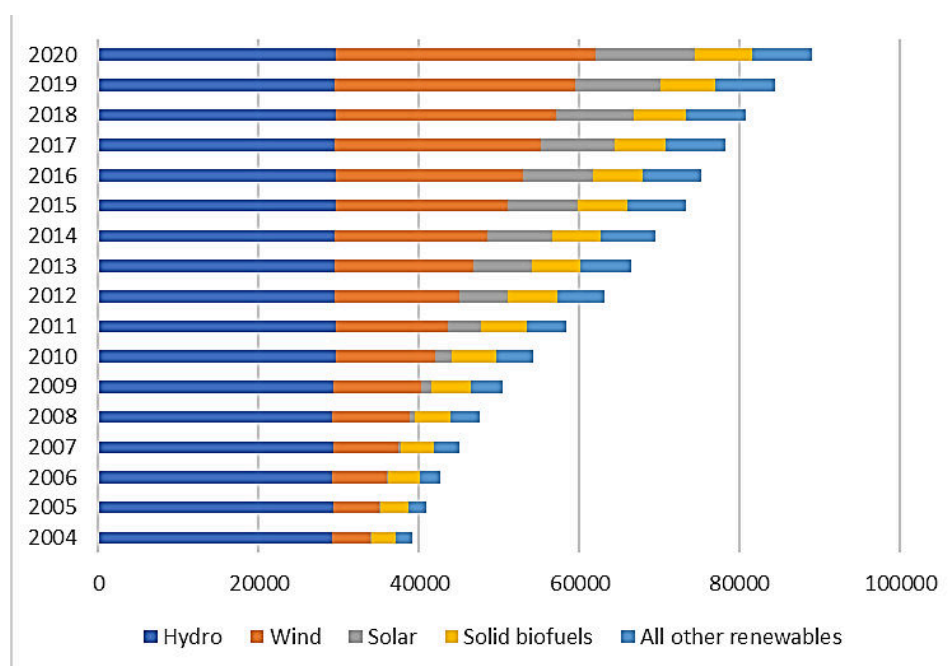


Figure 1. Quantitative share of electrical components in the years 2004-2020.

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

The chart presents a constant level of hydro share in electricity. However, taking into account the increase in the share of energy from other renewable sources, its percentage decreases, which is presented in Table 2.

Table 2.

Percentage share of individual electrical components in years 2004-2020

Year	Hydro	Wind	Solar	Solid biofuels	All other renewables
2004	74,69%	12,23%	0,15%	7,97%	4,95%
2005	71,62%	14,01%	0,31%	8,53%	5,53%
2006	68,32%	15,88%	0,50%	9,09%	6,20%
2007	64,95%	18,16%	0,72%	9,10%	7,07%
2008	61,46%	20,14%	1,35%	9,62%	7,44%
2009	58,18%	21,79%	2,41%	9,79%	7,83%
2010	54,68%	22,96%	3,69%	10,31%	8,36%
2011	50,70%	23,90%	6,96%	9,88%	8,58%
2012	46,78%	24,69%	9,57%	9,83%	9,13%
2013	44,37%	25,97%	10,87%	9,11%	9,68%
2014	42,37%	27,32%	11,64%	8,74%	9,93%
2015	40,50%	29,29%	11,84%	8,46%	9,91%
2016	39,31%	31,06%	11,54%	8,27%	9,82%
2017	37,63%	32,84%	11,85%	8,16%	9,53%
2018	36,58%	34,06%	12,03%	8,11%	9,22%
2019	34,92%	35,45%	12,60%	8,20%	8,83%
2020	33,31%	36,33%	13,91%	8,01%	8,43%

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

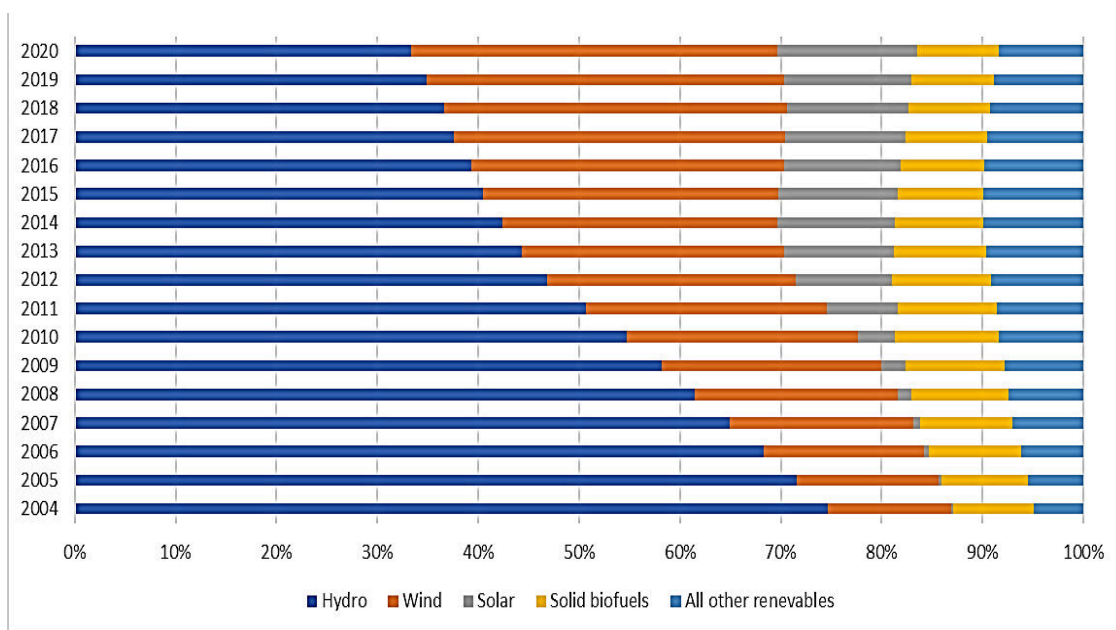


Figure 2. Percentage of electricity components.

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

Based on the presented chart, it can be concluded that Hydro's share in electricity decreased in subsequent years, from 74,69% in 2004 to 33,31% in 2020. It means a decrease of 55,40%. A significant increase in the share was recorded for wind: the change from 12,23% in 2004 to 36,33% is an increase of 197,04%. Solar 9056,88% achieved the most significant increase in percentage share - the share in 2004 was 0,15% compared to 2020: 13,91%. A slight change in the claim can be observed for Solid biofuels: an increase of 0,45% from 7.97% to 8,01%. A rise of 70,29% for All other renewables can also be seen: from 4,95% (2004) to 8,43% (2020).

Wind also showed a significant increase (an increase compared to 2004 by 576,66%). However, the overall share of Solar in total electricity remained at a lower level of -13,91% than wind – 36,33%. Not as high as in the case of elevators, the share of all other renewables slightly increased. In contrast, the percentage of solid biofuels increased until 2010, after which it slightly decreased and remained relatively constant.

The table below (Table 3) presents changes in the share of electrical components in subsequent years concerning the base year 2004.

Table 3.

Percentage change in the share of individual electrical components in 2020 compared to 2004

Year	Hydro	Wind	Solar	Solid biofuels	All other renewables
2004	-	-	-	-	-
2005	0,35%	19,86%	111,12%	11,95%	16,86%
2006	-0,10%	41,81%	260,32%	24,59%	36,79%
2007	0,17%	71,03%	446,31%	31,49%	64,38%
2008	-0,02%	100,04%	976,49%	46,70%	82,48%
2009	0,34%	129,52%	1941,35%	58,20%	103,71%
2010	1,44%	160,12%	3261,36%	79,26%	133,92%
2011	1,45%	192,03%	6744,35%	85,19%	158,79%
2012	1,02%	225,59%	10057,08%	98,81%	197,41%
2013	1,05%	261,28%	12072,95%	94,49%	232,47%
2014	0,87%	297,12%	13529,58%	95,07%	256,58%
2015	1,56%	348,54%	14497,80%	98,75%	274,96%
2016	1,33%	388,88%	14523,34%	99,66%	281,67%
2017	0,87%	437,50%	15521,60%	104,86%	285,13%
2018	1,20%	475,42%	16259,23%	110,35%	284,53%
2019	1,03%	526,23%	17815,88%	122,23%	285,21%
2020	1,60%	576,66%	20759,27%	128,83%	287,91%

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

The following table (Table 4) shows the share of electricity components change from year to year. It can be seen that only the percentage of Wind and Solar had an upward trend (smaller or larger), while the share of Hydro, Solid biofuels, and All other renewables recorded decreases (in the case of Hydro, seven times during the period under examination in the year: 2006, 2008, 2021, 2014, 2016, 2017 and 2020, for Solid biofuels once: in 2013 and once for All other renewables: in 2018).

Table 4.

Percentage change in the share of electrical components from year to year over the years 2004-2020

Year	Hydro	Wind	Solar	Solid biofuels	All other renewables
2004	-	-	-	-	-
2005	0,35%	19,86%	111,12%	11,95%	16,86%
2006	-0,44%	18,31%	70,67%	11,28%	17,05%
2007	0,27%	20,60%	51,62%	5,54%	20,17%
2008	-0,19%	16,96%	97,05%	11,56%	11,02%
2009	0,36%	14,74%	89,63%	7,84%	11,63%
2010	1,09%	13,33%	64,66%	13,31%	14,83%
2011	0,01%	12,27%	103,62%	3,31%	10,63%

Cont. table 4.

2012	-0,42%	11,49%	48,40%	7,36%	14,92%
2013	0,03%	10,96%	19,85%	-2,18%	11,79%
2014	-0,18%	9,92%	11,97%	0,30%	7,25%
2015	0,68%	12,95%	7,10%	1,88%	5,16%
2016	-0,23%	8,99%	0,17%	0,46%	1,79%
2017	-0,45%	9,95%	6,83%	2,60%	0,91%
2018	0,33%	7,06%	4,72%	2,68%	-0,15%
2019	-0,17%	8,83%	9,52%	5,65%	0,18%
2020	0,57%	8,05%	16,43%	2,97%	0,70%

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

3. Renewable electricity in Transport

The following table (Table 5) presents the use of renewable electricity in transport, such as: renewable electricity in road transport, renewable electricity in rail transport, renewable electricity in all other transport modes, Compliant biofuels Non-compliant biofuels, Other renewable energies. The change in the level of individual components in 2020 from 2004 was as follows:

- Renewable electricity in road transport - change from 6,72 to 112,83 (increase by 1517,11%) with the total volume of renewable electricity in road transport 421,83.
- Renewable electricity in rail transport - change from 835,81 to 1392,51 (increase by 66,61%) with the total amount of renewable electricity in rail transport 18821,68.
- Renewable electricity in all other transport modes: change from 191,96 to 282,13 (46,97% increase) with a total Renewable electricity in all other transport modes of 3990,51.
- Compliant biofuels - change from 1506,58 to 16251,87 (increase by 978,73%) with the total amount of Compliant biofuels at 171980,47.
- Non-compliant biofuels - change from 0 to 71,09 with the total amount of Non-compliant biofuels 12354,15.
- Other renewable energies – a change from 0,1 to 0,04 (decrease by 61,9%) with the total value of Other renewable energies at 4,15.

Table 5.

Amount of use of renewable electricity in Transport

Year	Renewable electricity in road transport	Renewable electricity in rail transport	Renewable electricity in all other transport modes	Compliant biofuels	Non-compliant biofuels	Other renewable energies
2004	6,72	835,81	191,96	1506,58	0,00	0,10
2005	6,65	818,51	199,06	2573,17	0,00	0,68
2006	6,76	794,45	198,61	4503,33	0,00	0,60

Cont. table 5.

2007	6,54	825,22	183,81	5796,73	0,00	1,39
2008	6,48	832,76	187,96	8951,36	0,00	0,15
2009	7,09	865,37	183,98	10466,68	0,00	0,08
2010	8,22	924,81	178,59	11924,29	0,00	0,01
2011	10,76	1033,27	218,70	7496,91	5189,53	0,03
2012	10,99	1045,59	214,33	10594,47	2903,42	0,03
2013	14,55	1138,43	227,12	10711,19	1324,68	0,32
2014	17,56	1191,41	242,18	11727,95	1282,24	0,32
2015	23,47	1280,07	278,69	11882,59	1131,81	0,05
2016	27,28	1396,97	291,80	12558,29	183,79	0,15
2017	34,48	1459,46	299,67	13806,96	112,24	0,13
2018	44,97	1492,11	302,78	15292,93	82,27	0,04
2019	76,50	1494,93	309,15	15935,19	73,08	0,03
2020	112,83	1392,51	282,13	16251,87	71,09	0,04
Suma	421,83	18821,68	3990,51	171980,48	12354,15	4,15

Source: <https://ec.europa.eu/eurostat/web/energy/data/shares>.

The table below (Table 6) presents the results of the TOTAL RES-T numerator with multipliers, TOTAL RES-T denominator with multipliers and the percentage share of RES-T [%] in subsequent years: this value changed from 1,432% in 2004 to 10,218 % in 2020, i.e. increased by 613,56%. Based on the presented results, an increase in RES-T [%] can be stated except for 2011.

Table 6.

TOTAL RES-T numerator with multipliers, TOTAL RES-T denominator with multipliers, and percentage share of RES-T [%] in 2004-2020

Year	Total (RES-T numerator with multipliers)	Total (RES-T denominator with multipliers)	RES-T [%]
2004	3821,75	266879,51	1,432%
2005	4852,42	266782,61	1,819%
2006	6722,46	271917,20	2,472%
2007	7950,29	275407,27	2,887%
2008	11280,43	272964,79	4,133%
2009	13015,23	266121,12	4,891%
2010	14612,91	265712,72	5,500%
2011	10879,10	264345,61	4,115%
2012	14737,95	255574,21	5,767%
2013	15301,77	252070,20	6,070%
2014	16732,50	255377,27	6,552%
2015	17555,02	259945,33	6,753%
2016	19022,67	265487,03	7,165%
2017	20244,38	270958,85	7,471%
2018	22470,30	271882,92	8,265%
2019	24110,22	274111,41	8,796%
2020	24757,52	242287,93	10,218%

Source: <https://ec.europa.eu/eurostat/web/energy/data/shares>.

The chart below presents the shares of the renewable electricity components in Transport in the years 2004-2020 in Total RES-T.

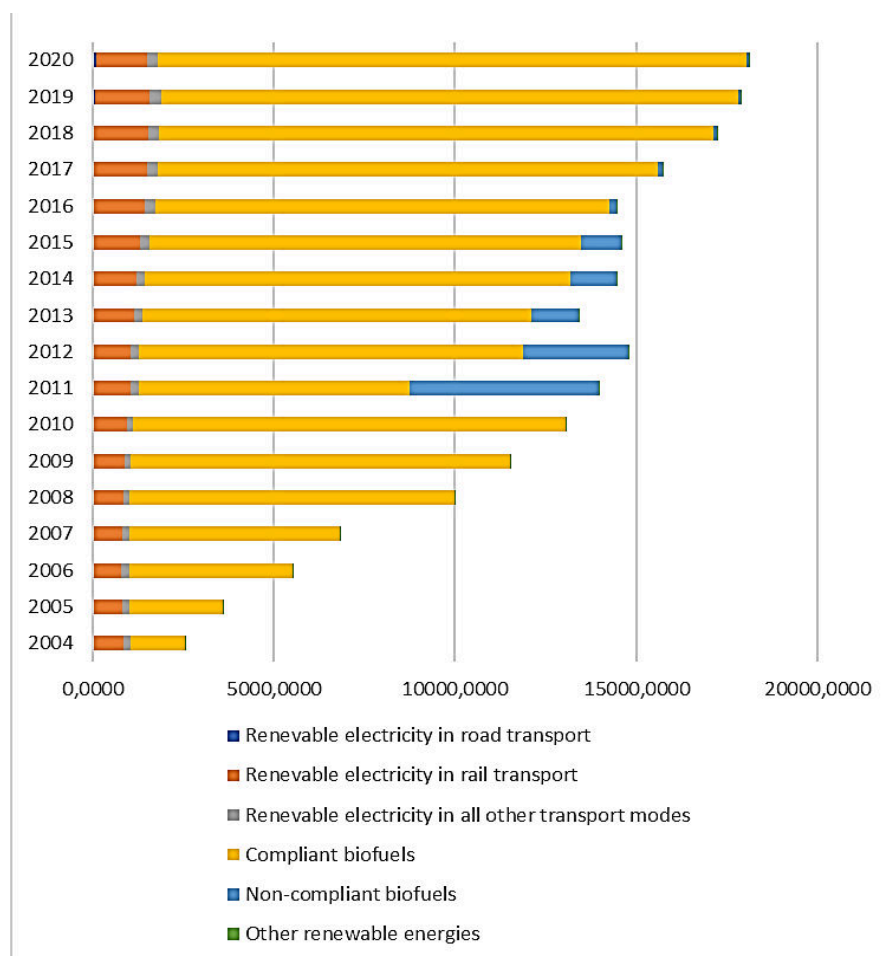


Figure 3. Share of renewable electricity in Transport.

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

The presented chart shows a stable increase in Renewable electricity in road transport - an increase of 1579,11%, and Renewable electricity in rail transport - a rise of 66,61%. Increases were also recorded in the case of Renewable electricity in all other transport modes, although there were decreases here, for example, in 2006, 2009, 2010, 2012, and 2020. Energy obtained from Compliant biofuels generated the highest values throughout 2004-2020 from this source - the exception is 2009, where a significant decrease from 11924,29 to 7496,91 was recorded. The chart presents the appearance of non-compliant biofuels in the shares in 2011, which was not recorded in previous years.

For a more precise depiction of the share of individual components of renewable electricity in Transport, a table of percentage shares of the mentioned energy sources in the Total RES-T numerator with multipliers is presented below.

Table 7.

Percentage share of individual components renewable electricity in Transport in Total RES-T numerator with multipliers

Year	Renewable electricity in road transport	Renewable electricity in rail transport	Renewable electricity in all other transport modes	Compliant biofuels	Non-compliant biofuels	Other renewable energies
2004	0,18%	21,87%	5,02%	39,42%	0,00%	0,00250%
2005	0,14%	16,87%	4,10%	53,03%	0,00%	0,01394%
2006	0,10%	11,82%	2,95%	66,99%	0,00%	0,00899%
2007	0,08%	10,38%	2,31%	72,91%	0,00%	0,01752%
2008	0,06%	7,38%	1,67%	79,35%	0,00%	0,00134%
2009	0,05%	6,65%	1,41%	80,42%	0,00%	0,00061%
2010	0,06%	6,33%	1,22%	81,60%	0,00%	0,00005%
2011	0,10%	9,50%	2,01%	68,91%	47,70%	0,00029%
2012	0,07%	7,09%	1,45%	71,89%	19,70%	0,00021%
2013	0,10%	7,44%	1,48%	70,00%	8,66%	0,00207%
2014	0,10%	7,12%	1,45%	70,09%	7,66%	0,00190%
2015	0,13%	7,29%	1,59%	67,69%	6,45%	0,00031%
2016	0,14%	7,34%	1,53%	66,02%	0,97%	0,00079%
2017	0,17%	7,21%	1,48%	68,20%	0,55%	0,00063%
2018	0,20%	6,64%	1,35%	68,06%	0,37%	0,00019%
2019	0,32%	6,20%	1,28%	66,09%	0,30%	0,00015%
2020	0,46%	5,62%	1,14%	65,64%	0,29%	0,00015%

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

Based on the presented table, it can be concluded that the percentage share of Renewable electricity in road transport has increased since 2004 from 0,18% to 0,46% (an increase of 159,2% compared to 2004). A significant decrease in the share was recorded in the case of Renewable electricity in rail transport: a change from 21,87% in 2004 to 5,62% - a decrease of 74,28%. A decrease can also be observed for Renewable electricity in all other transport models: a share of 5,02% in 2004, share of 1,14% in 2020. – this is a decrease in the share of 77,31%. The largest share can be observed in the case of Compliant biofuels - the change from 39,42% to 65,64% is an increase of 65,52%. Obtaining energy from a Non-compliant biofuel source was not recorded until 2010, but in 2011 the share of this source reached the level of 47,7%, followed by a decrease in subsequent years until 2020, reaching the level of 0,29%. The share in the Total RES-T numerator with multipliers was very low for other renewables energies, whose rank in 2004, 0,0025%, decreased to 0,00015% by 2020 (a decrease of 94,12%). The presented analysis is presented in the chart below (Figure 4).

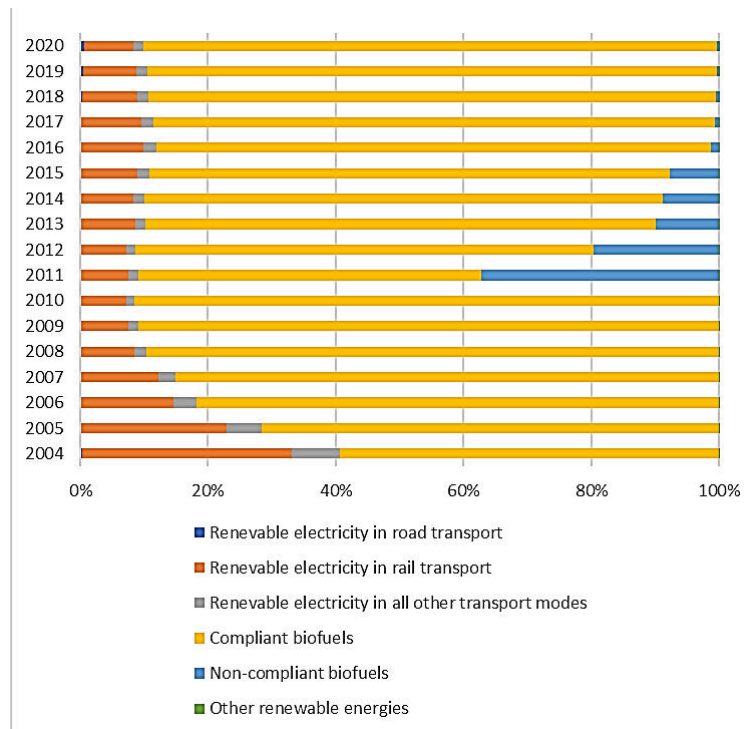


Figure 4. Percentage share of renewable electricity components in Transport.

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

For an in-depth analysis of changes in the acquisition of renewable energy sources in Transport, a table of changes in the amount of energy obtained in subsequent years was presented. The results are shown in the table (Table 8).

Table 8.

Percentage change in the share of renewable electricity components in Transport from year to year

Year	Renewable electricity in road transport	Renewable electricity in rail transport	Renewable electricity in all other transport modes	Compliant biofuels	Non-compliant biofuels	Other renewable energies
2004	-	-	-	-	-	-
2005	-1,09%	-2,07%	3,70%	70,80%	-	607,78%
2006	1,64%	-2,94%	-0,22%	75,01%	-	-10,60%
2007	-3,18%	3,87%	-7,45%	28,72%	-	130,38%
2008	-0,95%	0,91%	2,26%	54,42%	-	-89,18%
2009	9,38%	3,92%	-2,11%	16,93%	-	-47,54%
2010	16,02%	6,87%	-2,93%	13,93%	-	-90,61%
2011	30,85%	11,73%	22,46%	-37,13%	-	321,54%
2012	2,12%	1,19%	-2,00%	41,32%	-44,05%	0,08%
2013	32,41%	8,88%	5,97%	1,10%	-54,38%	913,19%
2014	20,71%	4,65%	6,63%	9,49%	-3,20%	0,00%
2015	33,68%	7,44%	15,08%	1,32%	-11,73%	-82,75%
2016	16,22%	9,13%	4,71%	5,69%	-83,76%	174,44%
2017	26,37%	4,47%	2,69%	9,94%	-38,93%	-14,79%
2018	30,44%	2,24%	1,04%	10,76%	-26,70%	-67,21%
2019	70,12%	0,19%	2,11%	4,20%	-11,18%	-16,67%
2020	47,48%	-6,85%	-8,74%	1,99%	-2,72%	4,03%

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

4. Renewable electricity in heating and cooling

The table below (Table 9) presents the consumption of electricity obtained from renewable sources Heating and Cooling: Final energy consumption, Derived heat and Heat pumps and their total volume in the years 2004-2020.

Table 9.

Quantity Final energy consumption, Derived heat, and Heat pumps

Year	Final energy consumption	Derived heat	Heat pumps	Total (RES-H&C numerator)	Total (RES-H&C denominator)	RES-H&C [%]
2004	54125,42	6152,36	1752,46	62030,23	528607,85	11,73%
2005	56906,38	6704,30	2290,91	65901,59	529897,38	12,44%
2006	59208,97	7054,18	2854,21	69117,35	523214,31	13,21%
2007	63115,06	7324,87	3520,16	73960,09	499079,95	14,82%
2008	65929,34	8012,72	4221,51	78163,57	510041,19	15,32%
2009	66544,48	8474,48	4970,74	79989,71	476528,63	16,79%
2010	71366,87	10099,70	5507,69	86974,27	511776,45	16,99%
2011	66457,09	9966,71	6270,23	82694,03	474833,78	17,42%
2012	71560,23	11377,64	6844,54	89782,41	483181,30	18,58%
2013	73132,01	12198,46	7370,67	92701,14	486727,41	19,05%
2014	67886,79	12509,96	8737,36	89134,11	447206,89	19,93%
2015	70667,56	13175,58	9286,16	93129,30	458532,26	20,31%
2016	71361,27	14139,04	10034,44	95534,75	468241,11	20,40%
2017	72496,01	14773,00	10672,42	97941,43	470384,35	20,82%
2018	75303,58	14940,62	11467,23	101711,42	470797,88	21,60%
2019	76045,88	15704,10	12393,14	104143,11	464251,40	22,43%
2020	75520,82	15752,88	13316,03	104589,73	452972,90	23,09%
Suma	1157627,77	188360,61	121509,86	1467498,24		

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

The values in the table above show how the quantities of Final energy consumption, Derived heat, and heat pumps changed over 2004-2020. In the case of Final Energy consumption, the values finally increased from 54125,42 to 75520,82 (an increase of 39,53%), although in 2011, 2014, and 2020, a minor increase was recorded compared to the previous year. The value of Derived heat increased from 6152,36 to 15752,88 (an increase of 156,05%), with a decrease in increases in 2011. Only the number of Heat pumps recorded only increases compared to previous years: change in value from 1752,46 to 13316,03 (an increase of 659,85%). The share of individual factors is presented in the chart below.

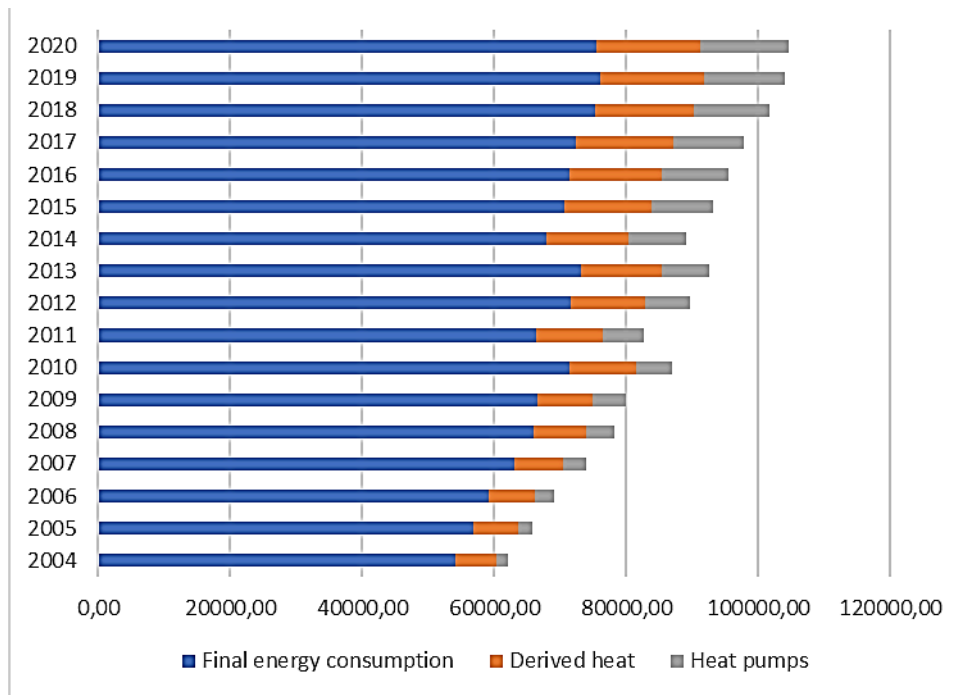


Figure 5. Heating and cooling component share.

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

This chart clearly shows Final Energy consumption as the factor with the largest share compared to the other two elements. As the analysis in the table below shows, the percentage of Final Energy consumption decreased from 87,26% in 2004 to 72,21% in 2020, still being the factor with the largest share (a decrease of 17,25%). The percentage share of Derived heat from 9,92% in 2004 increased to 15,06% in 2020 (an increase of 51,86%), remaining in second place in terms of share in Heat&Cool. The third factor - Heat pumps, increased its stake in the following years, from 2,83% to 12,73% (an increase of 350,65%).

Table 10.

Percentage of Final energy consumption, Derived heat, and Heat pumps

Year	Final energy consumption	Derived heat	Heat pumps
2004	87,26%	9,92%	2,83%
2005	86,35%	10,17%	3,48%
2006	85,66%	10,21%	4,13%
2007	85,34%	9,90%	4,76%
2008	84,35%	10,25%	5,40%
2009	83,19%	10,59%	6,21%
2010	82,06%	11,61%	6,33%
2011	80,37%	12,05%	7,58%
2012	79,70%	12,67%	7,62%
2013	78,89%	13,16%	7,95%
2014	76,16%	14,03%	9,80%
2015	75,88%	14,15%	9,97%
2016	74,70%	14,80%	10,50%
2017	74,02%	15,08%	10,90%
2018	74,04%	14,69%	11,27%
2019	73,02%	15,08%	11,90%
2020	72,21%	15,06%	12,73%

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

The presented analysis is confirmed by the chart below (Figure 6), emphasizing the vast share of Final energy consumption in Heat&Cool with the observed decrease in its percentage share in favor of Derived heat and Heat pumps in subsequent years.

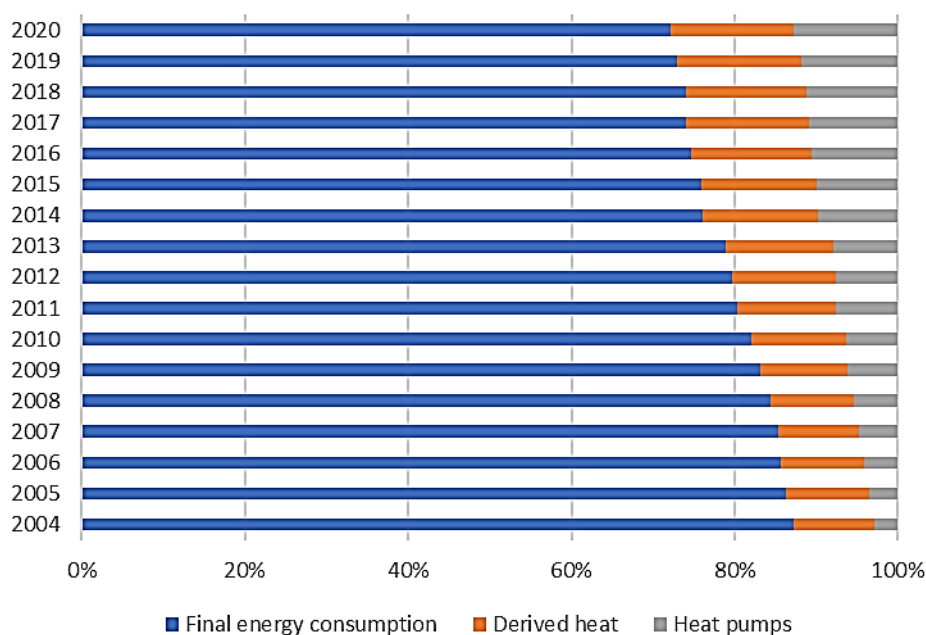


Figure 6. Percentage of components Heating and cooling.

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

In order to conduct a deeper analysis of changes in Final energy consumption, Derived heat and Heat pumps, percentage changes from year to year were determined for the analyzed period 2004-2020. The results are presented in the table below (Table 10).

Table 10.

Change in Final energy consumption, Derived heat and Heat pumps from year to year

Year	Final energy consumption	Derived heat	Heat pumps
2004			
2005	5,14%	8,97%	30,73%
2006	4,05%	5,22%	24,59%
2007	6,60%	3,84%	23,33%
2008	4,46%	9,39%	19,92%
2009	0,93%	5,76%	17,75%
2010	7,25%	19,18%	10,80%
2011	-6,88%	-1,32%	13,85%
2012	7,68%	14,16%	9,16%
2013	2,20%	7,21%	7,69%
2014	-7,17%	2,55%	18,54%
2015	4,10%	5,32%	6,28%
2016	0,98%	7,31%	8,06%
2017	1,59%	4,48%	6,36%
2018	3,87%	1,13%	7,45%
2019	0,99%	5,11%	8,07%
2020	-0,69%	0,31%	7,45%

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

Based on the results presented in the table (Table 10), three decreases in Final energy consumption can be observed in 2011, 2014, and 2020, by 6,88%, 7,17%, and 0,69%, respectively. The most significant increase was followed in 2012: 7,68%. Derived heat values recorded mainly increases, with the largest in 2010 at 19,18% and one decrease in 2011 at 1,32%. The Heat pump factor recorded only increases, with the largest in 2005 at 30,73%.

5. Gross final consumption of energy from renewable sources

The table presented below (Table 11) shows the Gross final consumption of energy from renewable sources, separating: electricity, heating and cooling, and Transport over the years 2004-2020.

Table 11.
Gross final consumption of energy from renewable sources

Year	Electricity	Heating and cooling	Transport	Sum
2004	38071,05	62030,23	2541,16	102642,44
2005	39897,52	65901,59	3598,07	109397,17
2006	41710,75	69117,35	5503,76	116331,86
2007	44032,15	73960,09	6813,69	124805,93
2008	46490,77	78163,57	9978,70	134633,04
2009	49319,24	79989,71	11523,20	140832,14
2010	53074,21	86974,27	13035,92	153084,39
2011	57189,32	82694,03	8759,63	148642,98
2012	61802,10	89782,41	11865,37	163449,89
2013	65150,88	92701,14	12091,29	169943,32
2014	68091,04	89134,11	13179,10	170404,24
2015	71666,11	93129,30	13464,81	178260,22
2016	73568,20	95534,75	14274,34	183377,29
2017	76504,29	97941,43	15600,56	190046,29
2018	78967,18	101711,42	17132,79	197811,39
2019	82614,94	104143,11	17815,78	204573,84
2020	87294,49	104589,73	18039,33	209923,55
Suma	1035444,23	1467498,24	195217,50	

Source: <https://ec.europa.eu/eurostat/web/energy/data/shares>.

Over 2004-2020, the total amount of Electricity in Gross final consumption is 1035444.23, heating and cooling – 1467498.24, and Transport – 195217.50 (electricity used in vehicles is included in Transport and thus not included in electricity). The share of individual factors making up Gross final consumption is presented in the chart below.

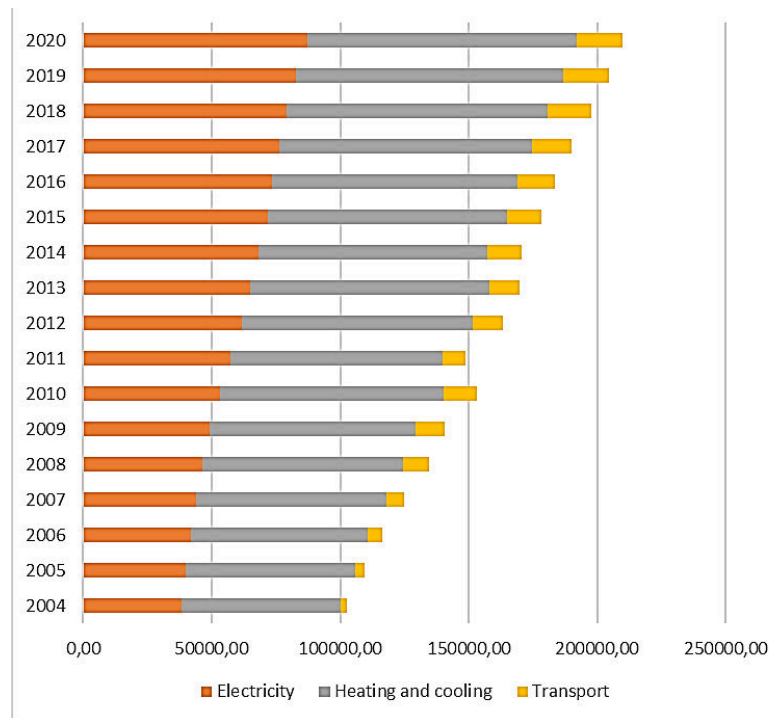


Figure 7. Share of components Gross final consumption of energy from renewable sources.

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

The share of electricity increased from 38071,05 in 2004 to 87294,49 in 2020. It's the second-largest Gross final consumption factor. The largest share was recorded by heating and cooling, which reached the value of 62030,23 in 2004 and increased to 104589,73 in 2020. The smallest share is represented by Transport, whose claim changed from 2541,16 in 2004 to 18039,33 in 2020. For a deeper analysis of the allocation of individual factors, their percentage share was determined - the results are presented in the table below (Table 12).

Table 12.

Percentage share of Electricity, Heating, Cooling, and Transport

Year	Electricity	Heating and cooling	Transport
2004	37,09%	60,43%	2,48%
2005	36,47%	60,24%	3,29%
2006	35,85%	59,41%	4,73%
2007	35,28%	59,26%	5,46%
2008	34,53%	58,06%	7,41%
2009	35,02%	56,80%	8,18%
2010	34,67%	56,81%	8,52%
2011	38,47%	55,63%	5,89%
2012	37,81%	54,93%	7,26%
2013	38,34%	54,55%	7,11%
2014	39,96%	52,31%	7,73%
2015	40,20%	52,24%	7,55%
2016	40,12%	52,10%	7,78%
2017	40,26%	51,54%	8,21%
2018	39,92%	51,42%	8,66%
2019	40,38%	50,91%	8,71%
2020	41,58%	49,82%	8,59%

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

The results of the table (Table 12) show that over the years 2004-2020, the share of:

- Electricity changed from 37,09% to 41,58% (an increase of 12,11%),
- Heating and cooling changed from 60,43% to 49,82% (decrease of share by 17,56%)
- Transport - changed from 2,48% to 8,59% (an increase of 247,1%)

The change in the size of Electricity, Heating, and cooling and Transport from year to year (Table 13) shows that in the case of electricity, only increases of different values were recorded - the most significant increase was in 2012: 8,07% and the smallest in 2016: 2,65%. In the case of heating and cooling, increases can usually be observed - the most significant growth in 2010 at the level of 8,73%. In the following year, one decrease was recorded - 4,92%. Concerning Transport, increases are mostly observed – the largest was in 2006 at 52,96% and one decrease in 2011 at 32,8%. The results of the analysis are presented in the table below.

Table 13.

Volume change: Electricity, Heating and cooling and Transport from year to year

Year	Electricity	Heating and cooling	Transport
2004	-	-	-
2005	4,80%	6,24%	41,59%
2006	4,54%	4,88%	52,96%
2007	5,57%	7,01%	23,80%
2008	5,58%	5,68%	46,45%
2009	6,08%	2,34%	15,48%
2010	7,61%	8,73%	13,13%
2011	7,75%	-4,92%	-32,80%
2012	8,07%	8,57%	35,46%
2013	5,42%	3,25%	1,90%
2014	4,51%	-3,85%	9,00%
2015	5,25%	4,48%	2,17%
2016	2,65%	2,58%	6,01%
2017	3,99%	2,52%	9,29%
2018	3,22%	3,85%	9,82%
2019	4,62%	2,39%	3,99%
2020	5,66%	0,43%	1,25%

Source: own study based on <https://ec.europa.eu/eurostat/web/energy/data/shares>.

6. Summary

Based on the presented data, the countries of the European Union are increasingly using renewable sources from year to year. A constant level of obtained energy is in the case of hydropower. Its share is significantly increased by getting energy from wind power, which reduces the percentage share of hydropower. Other sources (solid biofuels, solar, and all other renewables) also record an increase in their claim, but it is not as significant as wind and water power. In terms of the use of electricity obtained from renewable sources in the case of Transport, compliant biofuels have the largest share, which dominates other sources. Another,

but with a much smaller percentage, is renewable electricity in rail transport. Other factors do not have a significant share in Transport. In the case of heating and cooling, final Energy consumption has the largest share, which recorded a slight increase in subsequent years. Derived heat and heat pumps have a much smaller percentage. Summing up the presented analyses, it can be assumed that individual EU Member States with more minor or significant problems have a chance to achieve the supposed goals regarding acquiring and using electricity from renewable sources. Indeed, this process will be supported by various initiatives and directives, which are developed in case of problems with implementing the plans.

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THE SIGNIFICANCE OF THE ERP CLASS IT SYSTEM IN STRATEGIC DECISION-MAKING

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Purpose: The aim of the paper was to identify the scope of using the ERP class system in strategic decision-making processes.

Design/methodology/approach: The basic sources of the analyzed information are: the results of the survey questionnaire, direct interview with experts and literature review.

Findings: Based on research carried out among 14 leading companies in the printing industry, it can be concluded that there is a need for ERP class systems that include their functional capabilities to support the strategic management process. IT tools are necessary to make information available in real time so that strategic decisions can be made at reduced risk. In an interview with ERP class system experts, their full readiness to adapt their IT tools to the above-mentioned need has been emphasized.

Research limitations/implications: In the future, it is suggested to carry out similar studies on a broader scale. Research should be conducted among representatives of organizations in which such solutions have already operated, i.e. among users. There are also plans to conduct research in the analyzed scope in organizations of other industries than the printing industry. In the fourth quarter of 2022, it is planned to conduct research in the environment of enterprises that belong to the SME sector.

Practical implications: Owners of Polish enterprises should keep searching for ways to use ERP class systems in strategic management. Looking at the process of strategic management as well as long-term decision-making through the prism of the ERP class IT system will have an influence on the elimination or reduction of barriers related to such activity.

Originality/value: The analysis carried out in the article is a response to breaking down the barriers that make the implementation of strategic thinking in Polish enterprises, especially in the SME sector impossible. The value of this article is also the adaptation of an integrated IT tool to the implementation of processes related to making strategic decisions, providing, among others, information about resources. Moreover, an additional effect is the possibility of measuring the fulfillment of the assumed objectives resulting from the strategic decisions that had been taken.

Keywords: strategic management, Enterprise Resource Planning (ERP), strategic decisions.

Category of the paper: Research paper.

1. Introduction

Nowadays, it is important for companies, regardless of their size, to make the right decisions, which should be subject to the lowest level of risk. With such a changing environment, enterprises pay more and more attention to the quality of data necessary in making strategic decisions. This should be real-time data. Data on available resources in the organization and their use play a big role. For this purpose, it is recommended for managers to use ERP class systems. These systems are also the basis for decision making and the determination of strategies in order to increase productivity and reduce costs of running a company. Due to the fact that these systems enable comprehensive support of the company's current operations as well as forecasting and planning of these activities in the future, they indirectly contribute to the success of the company. ERP class systems are also a response to breaking down barriers that do not allow for the implementation of strategic thinking in Polish enterprises.

2. Method

In order to identify the scope of the use of ERP class systems in making strategic decisions, a survey has been used with deliberately selected 14 companies, which are the leaders of the printing industry on the Polish market, and simultaneously they belong to the small and medium-sized enterprises (SMEs) sector. The study was conducted during the RemaDays Warsaw 2020 international trade fair. A measuring instrument in the form of a direct survey questionnaire was used for this purpose. Moreover, an expert evaluation method has been implemented. The experts were the owners of three organizations that are manufacturers and distributors of ERP class systems in Poland. The expert evaluation method has confirmed the need and possibility of creating ERP class systems that will provide the necessary data for strategic decisions with a reduced level of risk. Experts have also pointed out the strategic advantages of ERP class IT systems. An in-depth literature review, on the other hand, was carried out to evaluate the scope of use of the ERP class IT system in a modern enterprise.

3. The scope of application of the ERP class IT system in the process of managing a modern enterprise

An integrated IT system is a management support tool that comprehensively serves all areas of the organization (Lenart, 2010, p. 345). The ERP system effectively collects various tasks performed in the company, mainly planning and controlling internal as well as external resources necessary for process and strategic management (Schuh, 2017). ERP organizes and integrates operational processes and flow of information in order to optimally dispose of resources such as people, materials, cash and production machines (Issar, Navon, 2016).

Continuous development of integrated ERP class IT systems, starting from simple inventory control systems to subsequent versions, which enrich them with new functionalities and modules, have an influence on the scope of their use. The development of these systems can be presented in the following stages:

- MRP (Material Requirements Planning) - is a system that supports production planning and scheduling. It also includes forecasting, determining inventory levels, tracking as well as quantitative settlement of production (Sutrisno, Airlangga, 2020).
- MRP II (Manufacturing Resource Planning) - is a system supplemented with mechanisms for planning other resources apart from materials, i.e. factors of production, e.g. energy, work. In MRP II, the so-called closed management loop is used, whose task is to combine data received at three levels of management, i.e. at the strategic, tactical and operational level (Gozukaraa, Tekinerdogana, Catalb, 2022).
- MRP III (Money Resource Planning) - this system was taken into consideration in evolution as a supplement to the functionality of MRP II with financial procedures. It kept improving the settlement of production and areas directly related to it, not only in terms of quantity, but also in terms of value (Kozioł, Karaś, Bełzowski, 2019).
- ERP (Enterprise Resource Planning) - constitutes a wide range of functionalities, i.e.: human resources management, quality management, support for contact with customers, distribution support, service management, etc. ERP class IT systems provide the opportunity to model processes, which modern enterprises should face. The main objective of the ERP system is to integrate all levels of enterprise management. It improves the flow of information critical to its functioning and allows for rapid response to development of demand. In the case of systems operating in the "online" version, this information is updated in real time and available at the time of decision making (Fauzi, 2021).
- ERP II (Enterprise Resource Planning II) - is a system based on cooperation with the company's business partners, who participate in resource management at subsequent stages, i.e. design, production and distribution of a given product. The ERP II system goes beyond the framework of the enterprise and enables cooperation of companies through the exchange of data and information (Chofreh, Goni, Klemeš, 2018).

- ERP III (Enterprise Resource Planning III) - is an extension of the concept of the ERP II system related to improvement of customer relations by incorporating them into the enterprise's IT system. The purpose of such action is to ensure their direct and active participation in the implementation of business processes. Thanks to the applications installed on IT devices, employees can have an access to the selected ERP functionality and perform their tasks at work with the system anywhere they are. This will be done mainly through making mobile support tools as well as social media available and support in the form of other tools for online communication both inside and outside the company. With this concept of creating IT systems, in which the main activity is to define services, it is possible to implement, even the most sophisticated user requirements. The presented assumptions of the functioning of the ERP III system are complemented by the provision of a constructive dialogue with the customer and, on this basis, the exchange of information in order to introduce innovations when it comes to production and services, and then sales or distribution of better products in improved versions. Such action closes the so-called "value proposition loop", which allows us, as the matter that goes beyond the boundaries of a company, to introduce knowledge about the needs of preferences as well as expectations of customers (Chofreh, Goni, Klemeš, Malik, Khan, 2020).
- ERP IV system (Enterprise Resource Planning IV) - is the planning of enterprise resources with a wider functional scope, using Internet technologies, with particular emphasis on mobile devices, cloud computing, fog computing, cognitive agent programmes, big data, big management. It also enables the implementation of mechanisms of globalization of economic activities as well as integration of connections between market partners and cooperating organizations (banks, Social Insurance Institution (ZUS), broadly understood administration) as well as with social networks. At this stage of development of the ERP class system, it fits into the requirements of the Real Time Enterprise (RTE) concept, which in previous versions of these systems was only a dream. An enterprise operating in compliance with the RTE principle becomes competitive by eliminating delays of management decisions as a result of the automatic implementation of various detailed and key processes. The ERP IV system is also a feedback to the challenge of the network economy related to the commonly implemented new way of organizing connections between cooperating parties. Moreover, in the fourth generation of the system, the Complex Event Processing (CEP) function is used. It operates on the basis of source data, which may be financial, geospatial control data or they can be streamed from the device. CEP detects events, combines them and indicates consistent cause-and-effect patterns (Bytniewski, Matouk, Hernes, 2018).

The presented class of ERP IV systems is a new direction in the development of management IT systems, with extended informative capabilities, turning information into knowledge and making it available in real time for quick decisions. The consequence of such action is the optimization of strategic and ongoing business processes. In this case, it is also possible to take into consideration data transferred in real-time. It should be highlighted that in ERP IV systems, all functionalities and technologies used in ERP III have been extended with solutions in the field of the use of artificial intelligence, the Internet of Things (IoT), big data, big management, industry 4.0 and fog computing (Elbahri, Al-Sanjary, Ali, Naif, Ibrahim, Mohammed, 2019).

Nowadays, Industry 4.0 plays an important role, where the main analytical goal is to draw attention to the main trends in the economy, that are being shaped by the fourth industrial revolution. During this activity, it is also significant to identify the necessary directions of changes in the management of the enterprise and the functioning of their environment that defines the rules affecting the possibilities of development, creating opportunities, but also barriers and even threats. Therefore, the opening of Polish enterprises to the potential of the fourth industrial revolution becomes a necessary condition for maintaining the ability to compete on the market and to meet the new, still invariably efficiently targeted market requirements. The concept of Industry 4.0 forces the management board to change business functioning models, which temporarily, as practice shows, leads to various asymmetries and socio-economic, management and regulatory maladjustments. Therefore, in such a situation, it is an obligation for companies to resort to technologies that integrate the digital and real world. First of all, we include ERP class IT systems and a cooperating module called Business Intelligence to this group. As a result, enterprises which are consciously subject to the fourth industrial revolution will see ways to mitigate these asymmetries and goal achievement of sustainable development, learning to reconcile social, economic, technological and environmental goals in the management process, while simultaneously reducing the waste of material and human resources. The justification for taking the presented actions is indicated, among others, by the increasing risk of threats resulting from the increasingly clear, especially in the European economy, syndrome of deepening access to raw materials, which may result in time delays, e.g. in the implementation of production orders which have been taken over (Frank, Dalenogare, Ayala, 2019).

One should remember that the ERP system does not have a defined standard, which means that the structure of such a system in particular applications may differ. Therefore, it can be perceived by users in the context of solutions that they use in their activities under different names. It can be named differently (Grzeszczyk, Nguyen, 2006):

- eERP (electronic Enterprise Resource Planning) – these are ERP class systems supporting, among others, the implementation of electronic transactions,
- @ERP (active Enterprise Resource Planning) – these are ERP systems focused on the reconstruction of organizational structures, management practices as well as business processes,
- IERP (Intelligent Enterprise Resource Planning) – these are intelligent ERP systems in which the balance point has been transferred to the strategic level and support of ERP systems with BI, SWO, SE, GSWD, artificial intelligence techniques, OLAP, data mining,
- EERP (ang. Extended Enterprise Resource Planning) – it is an extension of the functionality of ERP systems, e.g. through its integration with CRM, SRM, SCM systems.

The Business Intelligence subsystems of the ERP system also use the concept of the Strategic Scorecard. It is used to measure the effectiveness and control of the organization, which connects the organization's strategy with operational activities. It uses indicating instruments that support ongoing monitoring of achievements for the strategy adopted by a particular company (Bakkas, Manouar, 2018).

4. An evaluation of the level of influence of ERP class systems on effective strategic decision-making

In these difficult economic times, enterprises should refer to the concept of an open strategy, which aims to implement processes with increased openness to external forces and influences. This approach is all about the involvement of a relatively large group of stakeholders in the strategy formulation process as well as the transparent communication of strategic choices using various technologies (Morton, Amrollahi, 2018). Research and, above all, good practices regarding strategic openness are focused on transparency, participation, co-creation of values, active initiation of strategic changes, democratic strategic decision-making, inclusion as well as increased integration with external entities (Alexy, West, Klapper, Reitzig, 2018).

Information and Communication Technologies (ICT) support the involvement of stakeholders in the creation of strategic content and knowledge in the enterprise. Most experts focus on the dimensions of strategic openness, providing an analysis of the scope of formulating and implementing an open strategy in an enterprise. As a consequence, ICT is often included in project plans, but they are not considered in research regarding strategic openness. The team of scientists and experts indicates that future research and activities should be targeted to a comprehensive explanation of what types of IT systems exist and how they are used in an open strategy (Kesidou, Narasimhan, Ozusaglam, Wong, 2022). Based on the research

carried out among companies in the printing industry, entrepreneurs drew attention to the importance of placing functionalities from the field of strategic management in ERP class systems (Figure 1).

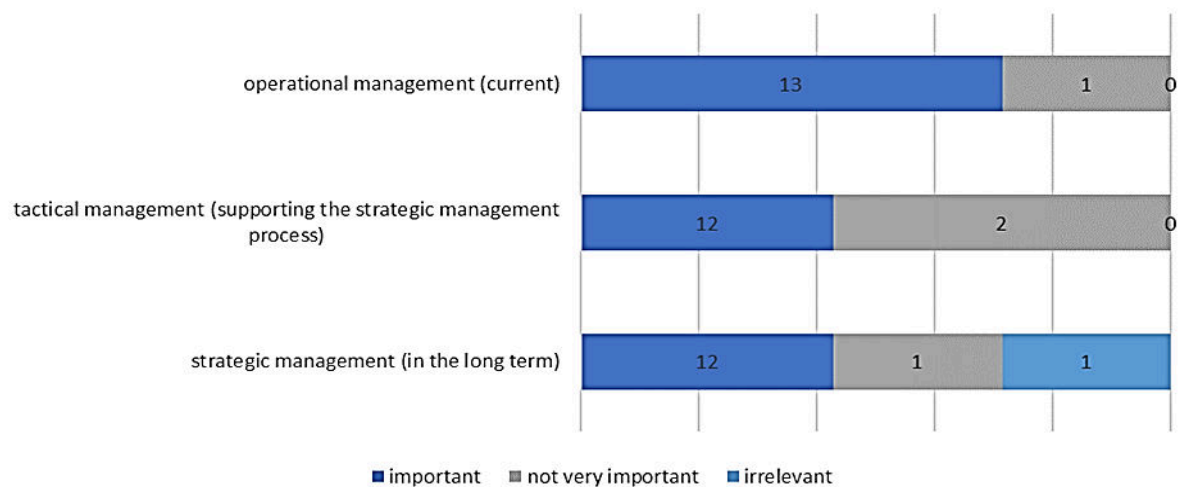


Figure 1. Demand for functional areas of ERP class systems.

Source: Personal analysis of the data gathered in the study.

The concept of an open strategy is based on an active exchange of knowledge and information. It occurs during the cooperation and implementation of the company's relations with the environment using ICT, which is described as a factor that constitutes a significant factor for the strategic openness of enterprises (Schlagwein, Conboy, Feller, Leimeister, Morgan, 2017). The companies from the printing industry clearly stated that they expect ERP class systems to "exchange data within the organization as well as with its environment" (Figure 2). Strategic openness is a concept offering various possibilities, especially in combination with IT. Key aspects of "openness", such as an access to resources and stakeholder participation in processes, can be implemented in completely new ways through systems and IT tools (Schlagwein, Conboy, Feller, Leimeister, Morgan, 2017). Individual experts indicate a clear link between strategic openness and the use of IT systems. This involves creating strategic openness by integrating IT systems with the dimensions of transparency and inclusion (Kindermann, Beutel, Lomana, Strese, Bendig, Brettel, 2021). The most mature IT systems that can be used to implement the open strategy concept are ERP class systems with modules corresponding to BI, CRM, DMS, BPM, SCM tools. To put it simply, ERP class IT systems also provide the opportunity to connect with all tools included in building the enterprise's strategic openness. Summing up, the concept of an open strategy together with the ERP class IT system allows for making strategic decisions with a reduced level of risk (Malik, Khan, 2021).

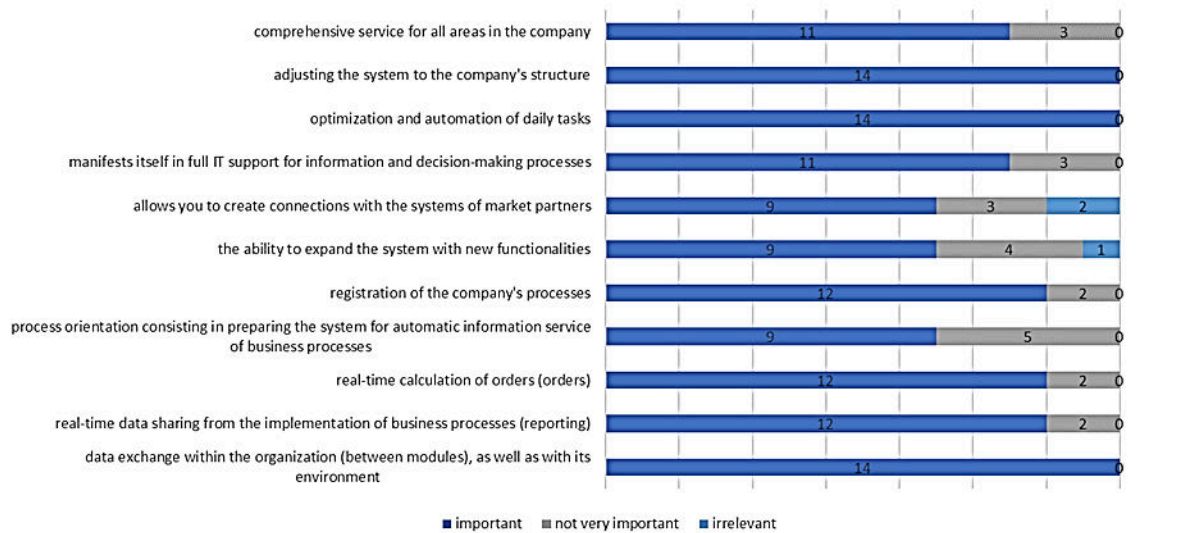


Figure 2. Expected features of ERP class IT systems.

Source: Personal analysis of the data gathered in the study.

ERP systems play a key role in today's organizations in decision-making processes on how to implement their vision and strategy. However, potential users should be aware of the costs and risks of implementation. Therefore, it is necessary to develop a proper approach to selecting the appropriate ERP system for a particular industry and organization. At the beginning, the vision, strategies and key performance indicators of the organization may be checked using the Balanced Scorecard (BSC) method (Grochowski, 2016). The proposed methodology can be used to decide on the implementation of the proper ERP system. Based on the analysis conducted with the help of BSC, we can prepare a request for quotation. From the implementation of Balanced Scorecard we know what is necessary to implement the action in order to achieve the planned long-term goals. The ERP class system, on the other hand, will allow for efficient implementation of these activities. The proposed methodology suggests numerous suggestions for successful implementation of the ERP system. Moreover, a lot of ERP class systems have a built-in BSC tool in their solutions, which is used to monitor the level of achievement of specific strategic goals resulting from previously made decisions (Rotchanakitumnuai, Speece, Swierczek, 2019).

Experts in the field of creating and implementing ERP class IT systems claim that they provide enterprises with dynamics, thanks to support in making tactical as well as strategic decisions. This is due to the current access to information thanks to management decision support systems, such as an ERP system. There are strategic advantages of ERP systems. These advantages are (Alomari, Amir, Aziz, Auzair, 2018):

- increase in the flexibility index,
- increase in the productivity index,
- correct communication, e.g. in informing about decisions that have been made,
- fast decision making,
- rapid response to dynamic changes in the enterprise's environment,

- reduced costs regarding running a business,
- increase in the level of revenues,
- shortened cycle times of particular processes,
- effective cooperation inside and outside the organization,
- transformation of the enterprise's strategy into the objectives of the main processes.

Organizations are obliged to manage changes, i.e. to introduce innovations regarding products, services or capital markets. By accepting ERP systems, we agree to the existence of various modules that help making decisions consistent with speed and efficiency in compliance with market requirements and enterprise expectations. Change management is very often perceived as information management. For reasons of strategic management, operational and financial information as well as changes in the light of this information, it is foreseen that strategies and practices are continuously compared with competition and the best organizational practices. Concepts of ERP systems solutions focus on ensuring competitiveness and increase in value of the organization in all business cycles. ERP users are offered very wide reporting opportunities. Due to the flexibility of the structures, it allows to create a report for the user on any topic. Moreover, it can provide user support when it comes to problem solving due to high analytical capabilities. Therefore, when processing data in the enterprise information bank, indicators of managers' decisions are generated. Apart from ensuring automation, the ERP system function provides accurate and timely information to improve the decision-making processes of managers and employees (Hadi, Alnoor, Abdullah, 2018).

The ERP system, operating together with other operating systems of the organization, creates opportunities for effective corporate supervision, providing information on the effectiveness of the implementation of planned activities resulting from previously made decisions. It is able to link business activity as well as market forecasts with development, production, as well as the warehouse system. Thanks to this, the company is able to develop a system that significantly reduces costs thanks to more accurate and up-to-date planning. Information from corporate governance can be provided to management board using the previously mentioned Business Intelligence (BI) subsystem (Danilczuk, Gola, 2020). This is evidenced by the needs reported by representatives of Polish companies in the printing industry (Figure 3).

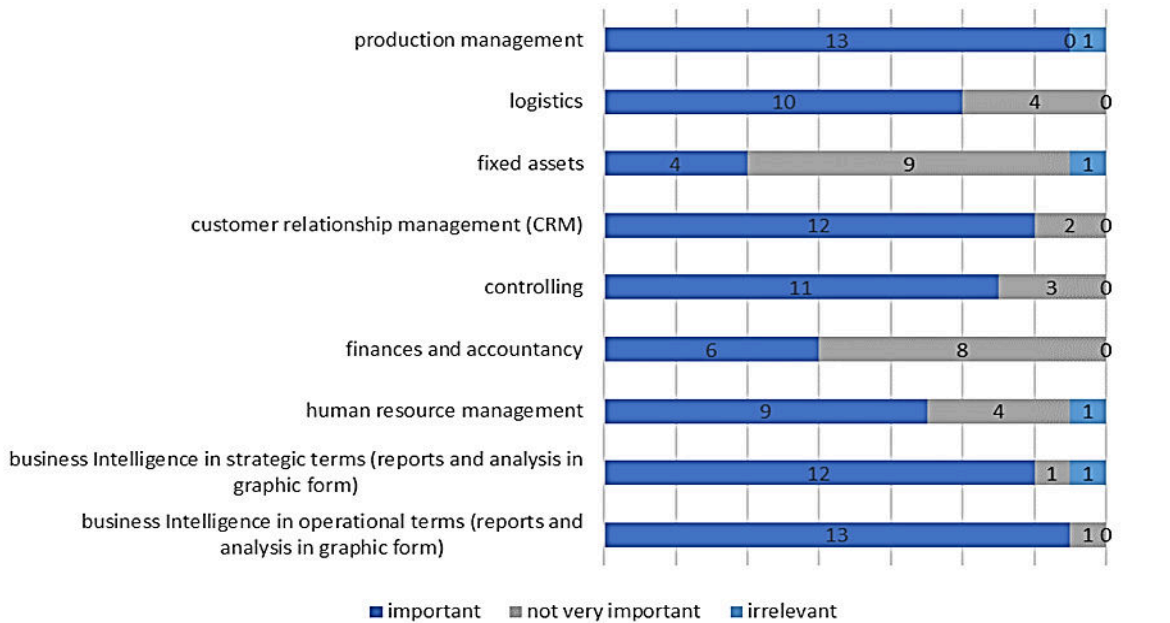


Figure 3. Demand for subsystems of the ERP class system.

Source: Personal analysis of the data gathered in the study.

Moreover, the linking of the ERP system with the CRM system also allows the company to see a broader business and operational context globally with the current and required time base. Therefore, both short-term and long-term strategies can be developed. By configuring this system, it is also possible to monitor KPI (Key Performance Indicators) and NPS (Net Promoter Score) in each country with the same parameters. It is also practicable to compare them and implement positive trends from one country to another. Thanks to this, the Organization has an influence on successful trends, processes and activities as well as competing with local players on the market (Pohludka, Stverkova, Ślusarczyk, 2018).

It is also worth noting that companies creating ERP class systems include tools supporting strategic management processes in their solutions. One such tool is SAP Strategic Enterprise Management, which supports strategic planning, risk management, performance monitoring as well as value communication. SAP SEM is closely integrated with existing business implementation systems, as well as with extended SAP finances. It enables two-way information flow: corporate strategists can monitor performance continuously, using feedback from business implementation systems, and changes in strategy can be brought to operational level with new goals and KPI (Mathrani, 2021).

5. Conclusion

ERP class systems are an effective form of data integration supporting decision-making processes in the enterprise. The concept of building a company strategy oriented on the use of

integrated systems supporting the most important decisions in various positions should mainly take place at the strategic level. However, taking into account this approach, other levels should also be considered, including the operational as well as tactical level.

The high complexity of business processes as well as the need for fast and reliable access to information force enterprises to implement technologies that will allow to achieve a competitive advantage in a dynamic market. ERP belongs undoubtedly to one of such technologies. The use of integrated ERP class standard software can only be profitable and simultaneously consistent with the concept of competitive advantages, when, in addition to the rationalization potential, the potential of decision support will also be implemented. Then the enterprise will have a specific resource of competitive and developmental advantages.

Among Polish enterprises, there is a need to exchange data within the organization, and above all with its surroundings, which should be supported by ERP class systems as the basis for safe strategic decisions. Moreover, companies should remember to refer in their activities to the concept of an open strategy, which aims to implement processes with increased openness to external forces and influences. Therefore, it is necessary to place functionalities referring to strategic management in ERP class systems in order to implement the concept of an open strategy. The ERP system creates opportunities for effective supervision of the organization, providing information on the effectiveness of the planned activities resulting from previously made decisions. The organization's strategists can monitor performance on a continuous basis, using feedback from business implementation systems, i.e. ERP class systems. One should also pay attention to ERP class systems, which inform about available resources in the organization as well as the method of their use, which has an influence on the effectiveness of strategic decisions.

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THE ANALYSIS OF THE FACTORS HAVING INFLUENCE ON ORGANIZATION'S IMAGE

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Purpose: The aim is to determine which factor has the biggest influence on organizational image.

Design/methodology/approach: The main research method used in this paper was management literature study.

Findings: Different theories about creating organizational image and business communication.

Social implications: The purpose of presenting the research on a group of about 100 people is to present the current needs and test the society.

Originality/value: New view on the importance of internal communication in companies and its influence on organization's image.

Keywords: Image organization, communication, social media, digital image organization, management, organizational challenges.

Category of the paper: Research paper.

1. Introduction

A lot of factors including communication, corporate social responsibility, personnel policy, organizational culture, etc. have a big impact on the way the environment perceives the company. Every aspect is more important nowadays due to common internet access and a big competition offering a lot of substitutes on the market. People during making decisions whether to buy something or use the services of a company can take into consideration every aspect they want because the concerned market (OECD, 2010) is not a common situation. The below paper indicates different ways in which a company is communicating with the environment and shows which of them have an influence on the organization's image. The article presents internal and external factors influencing the company's image, as well as the results of the conducted

research. The research was aimed at gathering opinions on factors influencing opinions about a given company, about making decisions about using an organization, recruitment for a given company, and other.

2. Organizations image

The organizational image (Bajdak, 2013) can be defined as the way people perceive the company with or without using their services or buying their products. It is a subjective impression of the organization because for everyone something else counts. The organizational image consists of a lot of different elements, which allow to identify the organization. There are different kinds of business image:

- actual - this is the way people see the organization,
- mirror image - the company seen through employee's eyes,
- desirable - the way the company wants to be seen by the environment,
- optimal image - all of the above combined.

One of the most important things in creating an organizational image is a company's graphic identification and logo. Graphic identification consists of e-mail footer and signature, company paper, colours associated with the company, social media page and a web page. For a modern company its website (Filipczyk, Gołuchowski, 2020) is like its business card, therefore it must be well designed, up to date with all information and free from every kind of errors and malfunctions. The next thing a new customer or a contractor will check is the social media page (Dąbrowski, 2013). Every kind of content placed on facebook or twitter must be deliberative and moderated in order to avoid posting something inappropriate. Something just as important as a web page or social media page is the mobile app. More and more companies regardless of their line of business decide to design and develop a mobile app to establish an easier access to their services and products. It is important to recruit a well educated IT specialist, who will create the app in accordance with the company's vision and then ensure the functionality of it. It is very important to create a good design because that is the first thing people will notice, the functionality is just as important but to take a chance in presenting functionality, the app has to gain people's attention. The most important factor determining the organization's image among the society is the quality of the services and products provided by the company. While price is still important for modern clients, the quality is the thing that determines if they will buy something. The way potential clients get information about the quality of services and products are opinions given by people who already bought something from the company or used its services. That is why avoiding misunderstandings and if they occur, explaining them immediately in line with good customer service is crucial when building an opinion about the organization. Due to globalisation and common internet access, everyone can use the products

and services of a company and then freely express his opinion on the internet. Branding is a marketing technique (Goi, 2019; Wiktor, Niestrój, 2010; Wiktor, 2013) which relies on create and consolidating consumer awareness about the positive organization's image. The aim of branding is to evoke positive associations with a product and creating the ability to differentiate one product from the others. Thanks to branding companies can raise prices however they want because people are associating the brand with quality and will choose one product over the other regardless of the price.

3. External and internal communication

An organization cannot exist and function without communicating with other market environment entities. Without the external communication, no one would ever hear about the company or about products and services it provides. However the external communication on its own will not really do anything, it also has to be designed the right way, constantly developed and managed properly. External communication is the way the organization communicates with clients, investors, competition and everyone who is not directly related to the company in order to accomplish the management functions which are planning, organising, motivating and control (Fayol, 1916; Griffin, 2017). There is no universal way to communicate with the environment and no ready to go advertisement strategy. Therefore a crucial element of constructing the external communication is the definition of target. The target is understood as the group of people, we want to address our business message. It is an information with a persuasive message addressed to everyone but designed to reach the target group. The message is sent through various means of communications including advertisements in television, radio, newspapers, billboards, acquisition and flyers. Defining the target group allows you to choose the correct form of advertisements for example if the target are young people you should not put your ads only in newspapers. The main reason internet advertising differentiates from other kinds of advertising are cookies. Web cookies are small blocks of data created by a web server while a user is browsing a website and placed on the user's computer or other devices by the user's web browser. They enable web servers to store stateful information such as items added in the shopping cart in an online store and track user's browsing activity. Companies which use cookies can design offers to match user's preferences. A specific version of this kind of advertising is social media advertising. It is also using cookies but these include for example recently liked fan pages on Facebook and are analysed to extract information about users preferences. One of the most successful ways to reach the target is the cooperation with famous influencers (Kotas, 2014), athletes and stars. It is important to select a suitable endorser to represent the brand. It's quite obvious that someone obese won't convince bodybuilders to buy supplements he's advertising. When the company has a partnership with a big event like the X-

games or the olympics it can develop a line of event- themed products, in that way people who normally would not buy their products will do it because of the event they are fans of.

Internal communication (Bielawski, 2001; Więch, Rola, 2013; Wójcik, 2013) is a part of public relations (Budzyński, 2001). The main difference is that it is about organizing communication inside of the company and is addressed to employees. Inside PR is more important the more the company has employees. This kind of communication (Rogala, 2013; Quirke, 2011) is working in both directions. To ensure complete information flow and the communication itself effective, employees from every field and level of the organization's structure have to take active part in it (Rogala, 2013). In this kind of communication the informal channels and methods are way more effective. While planned and organised meetings are less effective in terms of achieving established results, regular, informal, ad hoc organised meetings with coffee during informal conversation allow one to see the problem and look for its solution (Quirke, 2011). If the internal communication works well, employees find it easier to identify with the company mission and values and by that feel way more motivated. Internal communication is associated with another term which is organizational culture. According to E. Schein organizational culture is a pattern of basic guidelines, which a group has discovered, invented or developed in confrontation with internal problems of the group (Schein, 2018). An important part of the organizational culture are norms and values which include management style and interpersonal relations. Every company has its own unique culture defined by written and unwritten rules, common history, mission and vision. Well designed and consulted with everyone whom it may concern organizational culture can be the key to effective motivation among the employees. Employer branding is a term which describes actions taken by the company to create their image as a employee friendly place which creates the conditions to self development and promotion. It is important because the employees are expressing the opinion about the company from their point of view and their words can be assigned by listeners to the whole company (Mosley, Schmidt, 2017). People are quite empathic creatures and if they hear about the company treating other people in a way they would not be treated they won't support it by buying its product and using their services. Companies in which the employer branding is well managed are the ones in which employees identify with the company's values and mission. However in this case employees are mostly motivated by external factors like a financial bonus or additional vacation. The managers must know that this will work only as long as the employees will get what they want.

An important thing not every company seems to understand is leadership (Schein, 2018). A lot of companies mistake leadership and employer branding. The importance here lies on the leadership site. If the employees have a leader who they want to follow and who inspires them they will not only work more efficiently due to intrinsic motivation increase in a leader- led team. Whereas employer branding is persuading the employees to their boss. When the company decides to rely on leadership there is no need to bother with such things as employer branding. Winning employees' hearts and minds with the use of efficient leadership is the key

for them to perceive the company's mission and vision as theirs. In this case employees are motivated by the internal belief that everything good for the team is good for themselves as well.

4. Organizational image determinants

What is important in terms of organizational image, is the organization's overall CSR. The society is more aware nowadays and people select products provided by companies which are taking actions for example in ecology, social help and humanitarian aid. Studies show that a modern consumer, who has a choice between various products will choose products from a company that is making less harm to the environment, a company that is helping people in any way, and that is not testing its products on animals. CSR can be a key to stay ahead of the competition. Most organizational image incidents apply to a situation in which the company was not telling the truth about their product, action or about itself. The examples of situations in which a company was lying about something and lost a lot of money when the truth came out: for example Volkswagen lying about new generation diesel engines emission, the Dieselgate (2015) McDonald's lying about their fries being vegan (Budzyński, 2001). The lying is not the only thing that can cause an image crisis but it surely is one of the most difficult to overcome. Other causes of image crisis can be employees telling inconvenient facts about the company, wrong or inappropriate advertising including ads which offend anyone. The advertisement is a message sent to everyone but meant to reach only a group of people but still everyone sees the ad and if it is offensive in any way it can cause serious troubles and even lawsuits. The best way to deal with the image crisis is admitting that the company's actions were wrong, apologizing to everyone who was harmed and promising to make everything right and not to make the same mistake again. It will not always work, because sometimes the crisis is too big or was revealed too late to deal with it, in such cases it often is the end of a company.

5. Conducted research on the needs and expectations regarding building and maintaining a good image

Two surveys were conducted, one regarding the image of McDonald's company, both among employees and people using and not using the company's services. The expensive questionnaire was about the general views and expectations of today's organizations. Research proves that in the context of image, people will when the organization publicly admits guilt (over 70% of interviewers). Participants take into account that the advertisements do not reflect reality and their plan is not well thought out (over 70% of interviewers). The 90% of

respondents answered that the best way to communicate and disseminate information is through social media and websites. Over 80% of the survey participants believe that the employee's opinion influences the use of a given product and the entire service. Additionally, the employee's opinion influences the recruitment decisions of a given company. One of the motivators are group leaders and all kinds of additional benefits that the company offers (about 50% of the survey participants).

6. Conclusion

Customers' opinions are very important. No matter how hard a company tries to attract new customers, if they didn't take appropriate care of their former clients, they can't expect them to express favourable opinions. Negative opinions which unsatisfied clients will surely give to their friends, family and on the internet will stick to the company for a long time, if not forever. Of course a few negative opinions will not completely destroy the company's image but everyone should take into consideration that one customer will share his opinion to approximately 5 people who will give this information to five other people. If there will be more negative opinions than the positive ones no one will buy the company's product. But it is not only about customers, it also has to do with employees. If an employee is not well treated, he will share his negative opinion with family and friends, and they will forward it to other people. In society's mind will be created a negative image of company and people will ask the question: „If the company doesn't care about its employees why would it care about their customers?”. This brings to the conclusion that not only external communication is important in the process of creating an organizational image but also organizational culture and employee policy. Based on the research, where 90% of people are aged 19 to 26, it turns out that the challenge for the organization today is to maintain a good image of the organization. One of the challenges is using the social media of the organization, because 90% of respondents answered that the best way to communicate and disseminate information is through social media and websites. Another challenge is to maintain good relations with both employees and potential clients, because nowadays many people are suggested by the opinion of others, e.g. employees, friends, influences. Maintaining a good image is time-consuming and labor-intensive because it requires the organization to adapt to the current needs and require the society and monitor trends that give the organization an advantage over competitors. The next stage of work on researching the company's image and the factors that affect it will be regular research on the development and progress of digitization of the company, and taking care of good contact between the boss and the employee.

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CYBERSLOAKING AND CYBERLOAFING – IMPACT OF SOCIAL MEDIA USE IN THE WORKPLACE

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Purpose: The main purpose of the article is to review the literature and research results on very important problems like cyberloafing and cyberslacking in the workplace.

Design/methodology/approach: The method used to meet the objective was a critical review of source literature, documents and reports analysis.

Findings: At the beginning of the article, the phenomenon of cyberloafing was discussed, analysing its positive and negative effects on organisations, and then attempting to explain the determinants of cyberloafing in organisations and also the controlling measures it.

Research limitations/implications: The article uses a literature review and secondary research. Research on this problem is planned using quantitative and qualitative methods.

Practical implications: The results showed how employers can take action to mitigate cyberslacking and maintain employee productivity.

Originality/value: The paper provides practitioners with insights into cyberslacking activities at the workplace. Particularly explain how they can decrease cyberslacking activities.

Keywords: social media, cyberloafing, cyberslacking, workplace deviance.

Category of the paper: research paper.

1. Introduction

In recent years, social media has become an integral part of people's daily lives. More importantly, social media has strengthened its role in the professional world. More and more employees are using social media in their workplaces to communicate with colleagues, keep formal and informal relationships with customers and business partners, check information about enterprises, and gain knowledge about the situation in the industry.

Research conducted by Fair (2018) even before the Covid pandemic showed that employees (58%) don't need social media to do their jobs, but they still can't make it through the day without it (Fair, 2018). Though over 40% do have "occasional" work-related activity on social media, three-quarters (76%) have never received training from their employer on using it as

part of their work experience. Among millennials and Gen Z, the ones spending upward of two hours per workday looking at their phones, an astounding 78% say personal activities are more distracting than work-related intrusions. This would seem to undermine the productivity-boosting effects employers hope to see from collaboration and communication tools like Trello, Slack, or Jira, which must compete with the irresistible pull of the smartphone. Across the general populace, 59% agree that personal use of technology is more distracting than work tools, and Facebook is far and away the top attention thief. A whopping 86% described Facebook as a workplace distraction—twice as much as Instagram.

The literature provides evidence of both the positive and negative impacts of social media (SM) in the workplace. In addition to the many benefits of using SM in areas such as work organisation (Labban, Bizzi, 2020), communication and relationship building (Bednarska-Olejniczak, 2018; Huang et al., 2017), motivation and engagement (Boahene et al., 2019; Ewing et al., 2019) there are also risks associated with a decrease in employee productivity (Wushe, Shenje, Jacob, 2019), or the potential risk of employees posting content contrary to organisational policy (Adjei et al., 2020; Lankton et al., 2017; Szwajca, Prandzioch, 2018).

Of course, the dangers of inappropriate social media use can affect not only the employee but also the employer (browsing social media profiles, forcing constant contact with the employer). It, therefore, becomes important to examine what causes inappropriate behaviour among employees. Knowing these determinants will allow for defining some rules/policies for the use of social media in the organisation. A policy defines what online behaviour of an organisation's members is correct and also provides guidelines on data and information security with sanctions.

Research has shown that a majority of employees tend to spend about 2 to 3 h on non-work-related online activities during work hours. Indeed, recent statistics show that cyberloafing can cost companies approximately \$85 billion a year (Andel et al., 2019)

The purpose of the research is to systematize knowledge regarding non-work-related activities of employees and to examine determinants that cause inappropriate behaviour among employees. Literature, as well as documents and reports analysis, will allow answering the research questions: What are the advantages and disadvantages of using social media in the workplace? What factors and circumstances cause employees to waste time browsing social networks instead of working? How organizations can minimize the loss of productivity and decrease cyberslacking activities?

2. Social media in the workplace

Social media (SM) are applications that utilise web technologies and allow users to create and participate in communities through functions such as communicating, interacting, sharing, collaborating, and publishing (Mauroner, 2016). Different social media technologies, like social networking, online forums, wikis, and blogs are becoming reliable platforms for sharing information to target audiences in a contemporary manner (Osatuyi, 2013). In social media networks (e.g., Facebook, LinkedIn, MySpace, Google+) or collaborative communities people share experiences and information, which pertain not only to personal interests but also to professional matters.

Especially, enterprise social media platforms (ESM), which combine numerous features, such as microblogging and document sharing in one integrated place, can contribute to improving information access and dissemination. Social media usage provides opportunities for employees to collaborate and coordinate work.

Recently social media has been categorised into four main groups (Mao, 2014):

- social networking tools and instant messengers such as Facebook, Skype, Tumbland,
- tools for social publishing, social sharing, bookmarking, and collaborating, including tools like blogs, wikis, Twitter, Delicious, Flickr, Youtube, Picasa, GoogleDocs, Spreadsheets, Slideshare, Dropbox and so on,
- social tools for content management as well as calendars, surveys, and polls such as Moodle or Edmodo,
- virtual worlds and gaming environments such as SecondLife, WeeWorld.

According to Data reportal (2022) there were 5 billion internet users (in Poland 32.86 million). In January 2022, in Poland, there were 27,2 million active social media users (globally 4,65 billion), which constitutes 72% of the population (58,7 globally) (Data reportal, 2022). Year on year their numbers increased by 1,3 million (5%), the last three years by 9,2 million (51%) (Digital Poland, 2022). 22,5 % of respondents use SM for work activities (14,5% in Poland). Interestingly, Kenya is the country where the percentage of social media use in the workplace is the highest at 43,8% and Japan is the lowest at 5,8% (Data reportal, 2022). Currently, in Poland, we can observe the increasingly using of SM by society in the workplace. Another survey showed that as many as 2/3 of respondents (64.5%) use social media during working hours (Pracuj, 2021). Interestingly, only 15% of the respondents use them for business purposes only, and almost half of them use them both for business and private purposes. 47% of Poles have permission from their boss to use social media at work, of which 19% are exclusively for business purposes and 28% also for private purposes. More than one in three respondents (36%) is completely prohibited to use this medium during working hours. Thus, the data may indicate that a significant portion of employees uses social media channels in ways that are not entirely consistent with company policy. Moreover, nearly one in five

respondents (18%) could not answer what attitude their supervisor has toward the use of social media during work hours. The most popular platforms used at work in Poland are Facebook (88%), Youtube (65%), Instagram (39%), LinkedIn (18%), Twitter (18%), Tiktok (12%), Reddit (6%), other (3%) (Figure1).

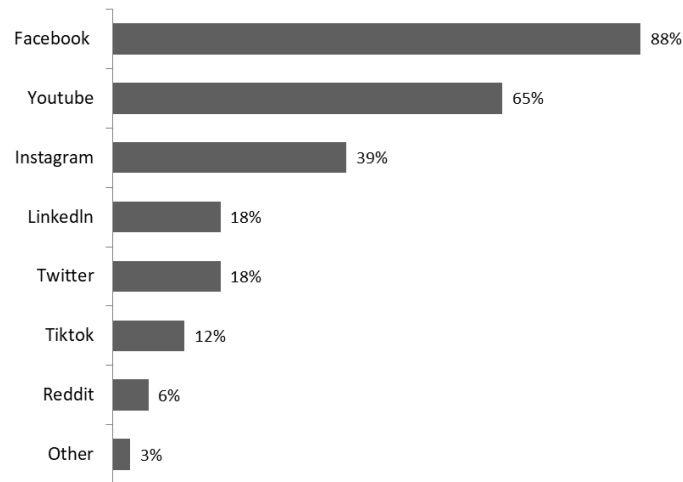


Figure 1. Social media platforms are used professionally at work in Poland.

Source: Own study based on (Pracuj, 2021).

Similar results for the US are presented by Kolmar (2021), in his analyses the most common social media platforms used at work are Facebook (19%), LinkedIn (14%), employer providers (9%) and Twitter (3%) (Kolmar, 2021).

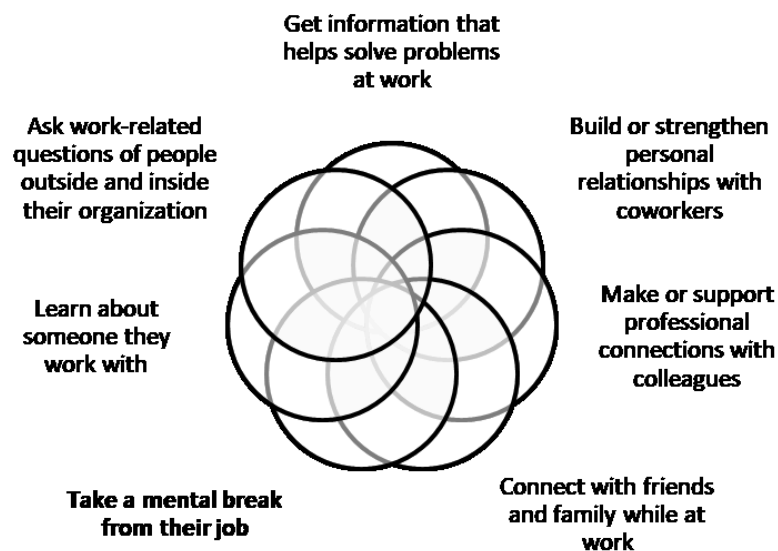


Figure 2. The most common reasons for using social media in the workplace.

Source: Own study based on (Kolmar, 2021; Olmstead et al., 2016).

Employees admit to using social media at work for various purposes (figure 2). The most common reasons that employees use social media at work are to take a mental break from work (34%), to connect with friends and family while at work (27%), to support professional connections (24%), to get information that helps them solve problems in their job (20%),

strengthening their relationship with co-workers (17%), learn more details about a person that they work with (17%) and to ask work-related questions to outside people or inside the corporation (12%) (Kolmar, 2021; Olmstead et al., 2016).

2.1. Pros and cons of using social media in the workplace

Although social media is becoming ubiquitous in the workplace, the use of these technologies has both positive and negative consequences. Studies in the literature report a variety of often contradictory results regarding the impact of social media in the workplace. Research by Mäntymäki and Riemer, (2016) (Mäntymäki, Riemer, 2016) suggested that professional use of social media can support formal and informal communication in the work environment. This is confirmed by the latest Digital (2022) report which indicates that 63,2% of employees daily use social media as communication channels (respondents who use the channel at least once per day during their professional activities). Nowadays, more and more communication takes place online with SM tools which provide constant communication between managers, employee participants of group projects and others. Especially, for younger generations, SM is a common channel of communication (Csobanka, 2016). Therefore, social media provides an opportunity for supporting efficient and effective team communication in organizations and project teams. Improved communication is an increased sense of community and social support which increases employee commitment to work as noted by (Van Zoonen et al., 2017). They confirmed in their study the positive relationship between social media communication and work engagement. An engaged employee is more productive than one who lacks engagement (Ewing et al., 2019; Oksa et al., 2021). Social media allows employees to connect and collaborate more efficiently and also can help employees feel more engaged with their work, leading to higher job satisfaction and morale. Thus, employers who allow using networking sites in the workplace can benefit from increased productivity, employee engagement, and improved overall performance. Moreover, easy and quick communication through social media promotes knowledge sharing within the organization as indicated by studies by Babu et al. (2020) Choi et al. (2014) and Nielsen and Razmerita (2014) (Babu et al., 2020; Choi et al., 2014; Nielsen, Razmerita, 2014). Social media platforms can facilitate more effective knowledge sharing and collaboration within an organization, thereby increasing organizational productivity and competitiveness. Nielsen & Razmerita (2014) indicated that social media platforms are providing benefits, in particular, improving internal communication (41%), increasing knowledge sharing (37%) decrease the number of emails (35%). Other identified benefits are easier to reach colleagues in other departments (34%), employees get a faster response to work-related problems (34%) and it is easier to collaborate on projects (30%) (Nielsen. Razmerita, 2014).

However, there are some limitations to deriving the benefits from communications through social media in an organisation. Madsen (2017) identified four obstacles to motivating employees to use internal social media to communicate (Madsen, 2017):

- employees may not see the professional benefits of using ESM,
- colleagues may not understand the informal nature of communication,
- internal social media was not considered a "natural" part of the daily routine in the organization,
- top managers support internal social media with mostly words, not actions.

Social media at the workplace can also be an excellent way for employees to take a break from their work and relax. This can lead to increased productivity and a more positive attitude towards work. According to survey research "Social Media and the Workplace", 34% ever use social media while at work to take a mental break from their job (Olmstead et al., 2016). Social media can help reduce stress by providing an outlet and a healthy distraction from work, which is helpful when tasks are feeling overwhelming. Logging into social media accounts can also help employees feel more connected to their colleagues and friends, leading to a more positive work environment.

The opposite position regarding the impact of social media in the workplace is presented by Yu et al. (2018), who argue that exhaustion is related to excessive use of social media (information and communication overload) and significantly reduces work productivity (Yu et al., 2018). Employees must learn how to navigate and use the massive amount of information afforded by the addition of social media to internal communication (Ewing et al., 2019). Additionally, security and privacy risks for organizations are critical concerns from using social media. Buettner (2015) argued that concerns about privacy, as well as perceived usefulness and ease of use, can negatively impact employees' intentions to use internal social media. Bizzi (2018) in his survey discovered a downside of employees using social media at work (Bizzi, 2018). He found that 76% of employees using social media for work took an interest in other organizations, compared to 60% of employees using social media only for leisure. Thus, employees using social media at work are more engaged and more productive, but they are also more likely to leave the company. Managers can solve this problem in two ways. In the first place, managers should implement solutions that neutralize the retention risk caused by social media. They can use social media training to keep employees focused on positive social media behaviors, such as collaboration, which can increase satisfaction and attachment by counteracting the risk of rotation. Second, managers can create social media groups in which employees will be more cooperative and less willing to share their withdrawal intentions or discuss external employment opportunities (Bizzi, 2018).

Moreover, other studies suggest that the use of social media in the workplace leads the employee to misuse organizational resources and may stimulate undesirable behaviour among employees and employers (Oksa et al., 2021) such as cyberloafing, (Lim, P.K. et al., 2021; Lim, V.K.G., 2002; Van Zoonen et al., 2017), cyberslacking (Alharthi et al., 2021), cybervetting

(Anatoliy et al., 2020; Berkelaar, Harrison, 2016), cyberbullying (Ozler, Polat, 2012). Which also results in a delay in normal organizational processes and a reduction in employee performance.

2.2. Cyberloafing and cyberslacking

Many often the term cyberslacking or cyberloafing has been used interchangeably. There are used to describe voluntary acts of employees using their companies' Internet access for non-work-related purposes during working hours (Lim, V.K.G., 2002). Generally, any time that employees waste on the Internet can be termed as cyberslacking or cyberloafing, problematic internet use, online loafing internet abuse, workplace internet deviance, and internet addiction disorder (Venkatesh et al., 2023). Cyberslacking can be defined as spending unproductive time on the Internet. Online shopping, surfing, engaging in social media, job searching, sending and receiving personal emails, and downloading non-work-related material are some examples of cyberloafing behaviors.

In this article, cyberloafing or cyberslacking is understood to be employees' use of ICT technologies, including devices (e.g. laptops, desktop computers and smartphones) and the Internet (provided by the organization) to access social media and other websites during work hours for personal or non-work reasons (Venkatesh et al., 2023). There is a nuanced difference between cyberloafing and cyberslacking but the common thread between these terms is that they all describe unproductive use of the Internet in the workplace.

Cyberloafing is associated with not only lost productivity but also other undesirable negative consequences (Koay et al., 2022). Vulnerability to security weaknesses, violation of privacy, employee Internet abuse, and Internet addiction are a few of the challenges facing businesses of all sizes as they venture into cyberspace. As access to the Internet has become more common for employees, so has their propensity to use the Internet for entertainment and other non-work purposes on the job. Organisations may suffer legal liabilities when employees engage in any illegal online activities (e.g., online gambling, illegal downloading, and hacking) using companies' Internet resources. Moreover, employees may accidentally download some unsecured files (e.g., viruses, spyware, or malware), increasing the risks of security breaches. Cyberloafing is usually presented as negative behavior leading to loss of productivity and income. However, engaging in short periods in non-work-related tasks can also have positive effects, including relief from boredom or fatigue, reducing job stress, stimulating creative thinking, enhancing job satisfaction, increasing well-being, recreation and recovery. Furthermore, several studies showed that cyberloafing is a good way to replenish personal resources (e.g., mental energy, self-esteem, and self-control) (Lim, P.K., et al., 2021; Ozler, Polat, 2012) and temporarily detach from work duties, which can potentially lead to better mental health (Koay et al., 2022).

In a social media age not only do employees abuse digital communication but also employers are now turning to use publicly accessible social media data to screen job applicants. This phenomenon is called cybervetting. Cybervetting can be described as the acquisition and use of online information to assess the suitability of a person or organization for a specific role. Information targets can be individuals, groups or organizations. Cybervetting uses information that is becoming more and more accessible and easily accessible by regular and popular uses of internet technologies, especially social media. While often considered in terms of new hires or staff selection, cybervetting can also include online sourcing and the use of information to evaluate a potential or current customer, employee, employer, romantic partner, roommate, tenant, customer, or other relationship partners (Berkelaar, Harrison, 2016).

It is not enough for employers to know what the good and bad sides of using social media are, also it is necessary to know what causes employees to engage in digital deviant behaviours.

3. Determinants of cyberloafing in organisations

Organizations that want to reduce cyberslacking should explore the causes of digital distraction among employees. It is important to understand what factors and circumstances cause them to waste time browsing social networks instead of working. According to the firm's UdeMy online survey chatty coworkers (80%) and office noise (70%) were cited as the top distractors. (Fair, 2018). Millennials and Gen Z are the most likely age group to describe themselves as distracted at work. 74% of them report being distracted, and of those, 46% say it makes them feel unmotivated, and 41% say it stresses them out. The young generations have a smartphone problem because more than a third of millennials and Gen Z (36%) say they spend two hours or more checking their smartphones during the workday. That adds up to at least 10 hours every week when they're doing something outside their job responsibilities. This behavior isn't limited only to junior workers either; overall, just under two-thirds of survey respondents (62%) spend about an hour per day looking at their phones. Meanwhile, a third of Baby Boomers claim they never engage with their devices at work (Fair, 2018).

Based on the literature review and according to the different theoretical perspectives author identified dominant factors that contribute to cyberloafing behaviors in organizations. The factors are divided into three main categories (figure 3): organizational, situational and individual factors (Ozler, Polat, 2012).

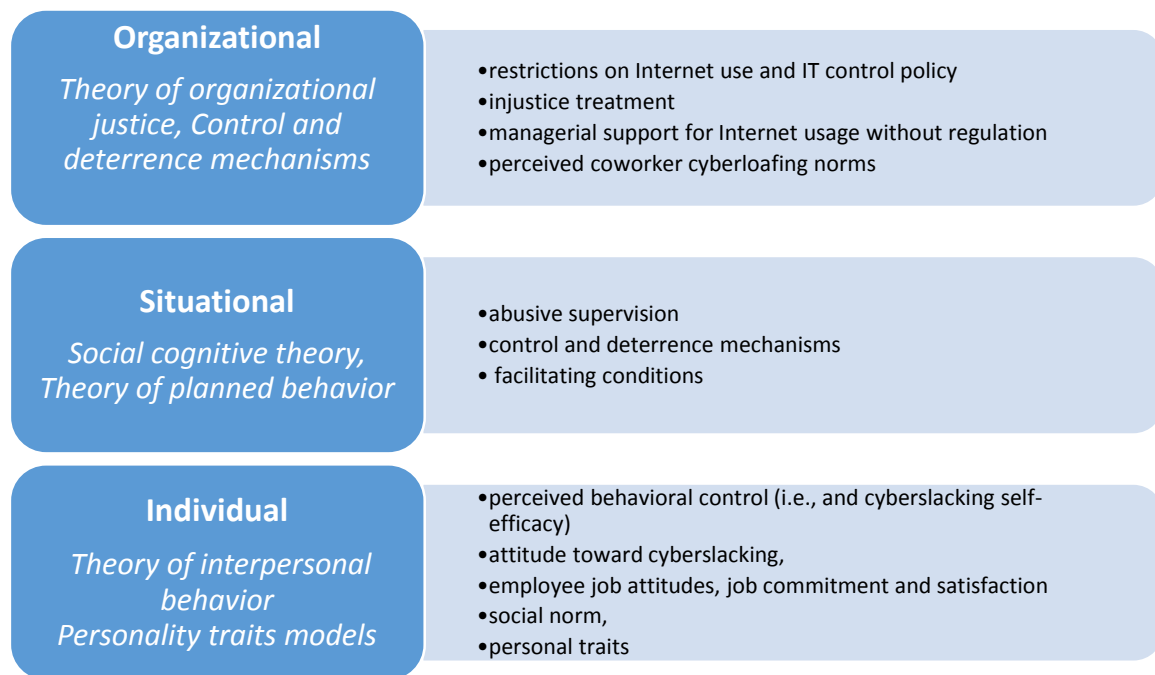


Figure 3. Dominant factors that contribute to cyberloafing behaviors in organizations.

Source: Own study based on (Koay et al., 2022; Lim, V.K.G., 2002; Ozler, Polat, 2012).

From an organisational perspective, employees may engage in cyberstalking when they feel they have been treated unfairly by the organization (Venkatesh et al., 2023). Lower organizational justice has a significant impact on cyberloafing. Lim (2002) tested the role of three justice-based variables in predicting cyberloafing and found that all three forms of justice (distributive, procedural and interactional) were negatively associated with cyberloafing (Lim, V.K.G., 2002). By limiting employees' use of work computers, whether through policy, technological deterrents, or both, employers reduce the benefits of using the Internet for non-work purposes while promoting employee self-regulation. Conversely, employees who would face stronger penalties for engaging in deviant behaviors were less likely to cyberloaf (Ozler, Polat, 2012). Managerial support for Internet usage at work without specifying how to use the internet is likely to increase forms of Internet use among employees for both business and personal reasons. This support may be misinterpreted by employees as an endorsement of all types of Internet use, including cyberloafing. Research showed that employees look to other coworkers as potential role models in the organization and that cyberloafing is learned through copying the behaviors that they see by individuals in their organizational environment (Ozler, Polat, 2012). Individuals, who observed cyberloafing behaviours in their colleagues, were more likely to engage in those behaviours themselves.

The second group of factors focuses on situational aspects. Facilitating conditions are important because people performing a certain activity may not be able to do so because their environment prevents them from performing the activity. Control and deterrence mechanisms such as monitoring, IT control policy, punishment, organizational policies and sanctions, can effectively mitigate cyberslacking (Alharthi et al., 2021; Andel et al., 2019). Moreover, Koay

et al (2022) examined the relationship between abusive supervision and cyberloafing from the lens provided by the conservation of resource theory (Koay et al., 2022). Their study supports the positive relationship between abusive supervision and cyberloafing, indicating that abused employees are more inclined to retaliate against their supervisors by engaging in cyberloafing behaviour. As engaging in overt, direct retaliatory behaviours may put their job at risk, employees resort to more covert means of retaliation by engaging in cyberloafing in response to their abusive supervisors (Koay et al., 2022).

The last group of determinants, which can affect the vulnerability in cyberslacking, is associated with the individual, human factors. Perception and attitudes towards cyberloafing, personal traits, habits and Internet addiction, demographic factors, intention to engage in cyberloafing social norms and personal ethical codes about internet use and cyberloafing are mentioned among the antecedents of cyberloafing behaviour (Ozler, Polat, 2012). People who perceived their Internet use as beneficial to their overall job performance were more likely to engage in cyberloafing than others (Vitak et al., 2011). In addition, individuals' personal normative beliefs (i.e., that cyberloafing is morally wrong) reduced intentions to engage in cyberloafing (Vitak et al., 2011). Job commitment and job satisfaction are also individual factors that might play a powerful role in shaping personal internet use at work. Acts of workplace deviance like cyberloafing could be an emotional response to frustrating job experiences. Employees who are emotionally attached to their work organization will find personal internet use to be less compatible with work routines than those who are not (Kelly, James, 2008). Individuals more committed to their work should be less likely to engage in personal Internet activities during work. There are a number of studies that explore how personality traits, can influence the way people use social media (Özgülven, Mucan, 2013). Personal traits like shyness, loneliness, isolation, self-control, self-esteem, and locus of control may affect the patterns of internet usage. Individuals that are low in self-control seem to have a greater history of cyber-loafing. Employees with a high external locus of control (i.e., they believe their fate is in other people's hands) and those with low self-esteem reported diminished self-control Internet use which in turn affected their level of Internet abuse at work (Vitak et al., 2011).

Some studies indicate that occupational status, perceived autonomy in the workplace; income level, education and gender were significant predictors of cyberloafing (Kelly, James, 2008). Well-educated individuals often engage in online information searches, while those who received less education often participate in online gaming. Personal Internet use at work is an activity that is more often performed by men who are well educated and work in high-status fields such as management, finance or business. Gender can affect the frequency and duration of cyberloafing, as well as the types and perceptions of cyberloafing. Some studies have suggested that men have cyberloafing more often and for longer than women (Lim, P.K. et al., 2021) Being younger and male significantly predicted both the amount and frequency of cyberloafing (Vitak et al., 2011). Research shows that because younger people are more

accepting of technology and more likely to use the Internet, they tend to build a habit that leads from the Internet (Venkatesh et al., 2023). However, some studies contradict these findings. Ugrin et al. (2008) found that demographic differences do not result in a greater likelihood of cyberloafing. Men and women abuse the internet equally.

4. Conclusion

Cyberloafing and cyberslacking are growing phenomenon in today's organisations. Reports on the cost of cyberloafing show organisations the importance of controlling internet misuse behaviour in the workplace. The negative effects of cyberloafing on organisations cannot be ignored. Therefore, the necessary measures should be taken to control and manage cyberloafing in organisations. The organisational and psychological research literature presents two main strategies to control employee abuse, such as cyberloafing-oriented self-regulatory strategies; and externally-oriented coercive strategies; where employees' behaviour is enforced by external circumstances in their environment (Ozler, Polat, 2012). To reduce the negative effects of cyberloafing as well as maintain the positive ones, organisations should:

- educate and inform employees,
- define policies for the use of social media,
- create monitoring systems,
- enforce through penalties.

Frequently, to be successful in controlling efforts, these methods should be used in combination. Especially, a formal social media policy is a necessity. Employers do have the right to prohibit any personal use of company computers and block employee access to social media sites, but such a prohibition is not likely to yield optimal results if employees won't be educated and informed. No methods can be effective unless they are adequately managed and translated into the improvement of awareness or perception of their values (Ozler, Polat, 2012). Awareness of the negative consequences of the behavior diminishes habit strength (Vitak et al., 2011). Electronic monitoring systems may be used to combat cyberloafing behaviors of employees in the workplace. It is found that monitoring mechanisms that either track or deny access to sites along with monitoring emails reduced cyberloafing. These are even more effective on individuals who have a higher propensity for cyberloafing (Ugrin et al., 2013). Sometimes control systems are ineffective in deterring cyberloafing unless being followed up by punitive consequences (Ozler, Polat, 2012) noted that for efficient cyberloafing management to take place, "monitoring activities need to be followed up with disciplinary actions". It is found that individuals that were aware of others receiving punishment for cyberloafing had a lower propensity to cyberloafing (Ugrin et al., 2013).

Although all of these mechanisms impact cyberloafing, they do not come without costs. For example, monitoring systems have both monetary costs and costs of reduced employee morale and job satisfaction (Ugrin et al., 2013). Strategies that place more power in the control of the employees while providing them with feedback about their Internet use may be more readily adopted and may help employees develop healthier (and more productive) habits related to their use of the Internet while at work (Vitak et al., 2011). Since deterrence mechanisms come with other consequences. It seems important to not only examine the importance of deterrence mechanisms alone but also how different deterrence mechanisms work relative to one another as well as to understand the relative impact of deterrence mechanisms (Ugrin et al., 2013).

Moreover, while some organizations entail strict control and monitoring strategies to curb cyberloafing, some employers believe that the brief detachment from work resulting from loafing can allow employees to relax momentarily, which would yield better results in the long term (Stokel-Walker, 2020).

The literature review highlights the frequency of the use of social media by employees and also presents the risks and challenges of using social media in the workplace. The study shows a clear need to understand the risks as well as the benefits of employee social media usage in the workplace. The literature revealed several possible approaches to the implementation of social media in the workplace. Furthermore, the research showed that when social media is used as a “communication tool” as opposed to simply being viewed as a workplace distraction, it can even be beneficial.

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A STUDY ON THE EXTENT OF DIFFERENCES IN ICT USAGE BY ENTERPRISES IN EUROPEAN COUNTRIES DURING THE COVID-19 PANDEMIC

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Purpose: The aim of the study is to employ the proposed taxonomic methods to arrange - in the periods under study - Poland's provinces and European countries according to their similarity in ICT usage (including the use of computers and mobile devices, the internet, various internet services and IT systems) by enterprises.

Design/methodology/approach: The study applies the method devised by S. Chomański and A. Sokołowski, along with its later modifications proposed by A. Młodak. In the study, a taxonomic method was employed to analyse the level of variation of objects described by selected statistical characteristics and identify clusters of objects sharing a similar level of development of the phenomenon under consideration. The study covered the years 2021-2019 and 2012, including the time of the Covid-19 pandemic. First, Poland was analysed and the groups of voivodeships featuring a homogeneous level of development were identified. In the next step, the analysis was performed for the European countries to see how Poland compares to them.

Findings: The study analyzes internet and ICT usage by enterprises in the selected country in the years 2021, 2020, 2019 and 2012, with special focus on the COVID-19 pandemic period. To sum up, comparative analysis performed by means of taxonomic methods can be an effective tool to study the elements of a complex process, can provide a broad picture of this process.

Research limitations/implications: The main limitation is that it is not possible to collect a comparable data set over a long period of years.. The results of the proposed taxonomic method depend on the choice of value α .

Originality/value: The concept of comparative analysis of the phenomenon under consideration presented and implemented in this study can be applied to compare other countries, using relevant measures, or to perform comparative analysis of other aspects of the issue, and the findings of these studies will contribute to further research in this area. The results of the proposed research methodology applied to explore the selected research problem and the set of data the study was based on can be used in the analyses of economic and socio-economic policies.

Keywords: taxonomic methods, internet and ICT usage, COVID-19.

Category of the paper: Research paper.

1. Introduction

For several years now, we have witnessed significant and accelerated development of digitization processes and increased use of information and communication technologies by society, enterprises, public institutions, non-governmental organizations, etc. We have become reliant on the internet and ICTs (Bliźniuk, Nowak, 2005). The changes, taking place both in our daily lives and at work, have turned us into an information society. They have also had a considerable impact on our patterns of production and consumption, market organization, etc.

In order to survive, today's organizations need to respond to the changing environment promptly and implement relevant effective solutions. Thus, the processes related to the advancement in ICTs have brought about changes in the economy, which has led to the emergence of the digital economy. The literature offers multiple definitions of the digital economy; one of them describes it as "a worldwide network of economic activities which is enabled by the existence of information and communication technologies (ICTs). It can also be defined in simple words as the economy based on digital technologies". The transformation taking place in the economy translates into changes in the market, goods, services, the financial sector, enterprises, consumption, manufacturing, work, governments, etc. (Śledziwska, Włoch, 2020). On the one hand it allows development, but on the other, it gives rise to a number of threats. Advanced technologies destroy a lot of jobs and accelerate the creation of digital representations of the real world. Digitization is embraced not only by selected sectors of institutions, companies or administration, but permeates entire organizations, which necessitates the introduction of new solutions for manufacturing, employment, consumption, etc.

Western European countries have undergone a more profound digital transformation than Poland. In the 1980s, first companies providing internet services came into being, which enabled, among others, the use of electronic mail. It was also the time when enterprises and institutions started to provide their employees with access to local computer networks and thus embarked on digitalization. In the beginning, the technologies that digitalization is based on included the use of the computer, laptop and smartphone and later extended to cloud-based technologies, robotization and artificial intelligence (Goban-Klas, Sienkiewicz, 1999). The changes related to digitization have led to digitalization and datification, which have exerted a major impact on society as a whole. Man has access to an ever increasing amount of data and information and through online activities leaves behind digital footprints that are used by enterprises, organizations and public institutions, which changes the way the economy and business function (Śledziwska, Włoch, 2020; Gajewski et al., 2016).

Recent years have brought a lot of uncertainty and anxiety due to the COVID-19 pandemic. In addition, in the last few months, our attention has been focused on the war taking place in Ukraine. These events have had an impact on all of us and forced us to take measures to adjust

to the existing and rapidly changing circumstances. The seriousness of their consequences depends on a business sector and a geographic location. During the pandemic, people and companies unable to work remotely suffered the greatest losses. The tourism industry was one of those most severely affected. People who worked online had to learn to combine work and family commitments in the same environment and arrange a virtual workplace at home. One of the serious problems was a decline in the number of customers resulting from the stay-at-home and social-distancing restrictions. Companies had to increase or introduce online services and thus contributed to the development of e-commerce. They had to deal with higher costs of conducting business activity, which have gone up further because of the war in Ukraine.

To sum up, the COVID-19 pandemic threatened the global economy, including the economy of the European Union. The measures taken by the EU countries in response to the pandemic such as restrictions on social contact, quarantine, travel restrictions or bans for certain countries, shutdown of commercial and cultural facilities, restrictions imposed on tourism, transport, etc., had a significant impact on the functioning of public administration, as well as large, small and medium-sized enterprises in the European Union.

The study analyzes internet and ICT usage by enterprises in the selected country in the years 2021 – 2019 and 2012 with special focus on the COVID-19 pandemic period.

The aim of the study is to employ the proposed taxonomic methods to arrange - in the periods under study - Poland's provinces and European countries according to their similarity in ICT usage (including the use of computers and mobile devices, the internet, various internet services and IT systems) by enterprises.

2. The set of diagnostic characteristics of the problems under study

The study attempts to employ the selected taxonomic methods to order Poland's voivodeships (provinces), and next - European countries, according to the level of their development and to analyse their impact on the overall development in the periods under study as well as to use a taxonomic method to identify homogeneous periods of dynamics variations in the analysed phenomenon in selected countries. The study examines the use of the internet and information and communication technologies by enterprises of the selected country, with special emphasis placed on the Covid-19 pandemic period. In addition, the map add-on Excel was integrated for the selected dataset to compare the years 2012, 2019, 2020 and 2021 and to identify possible similarities or differences. The diagrams are shown below.

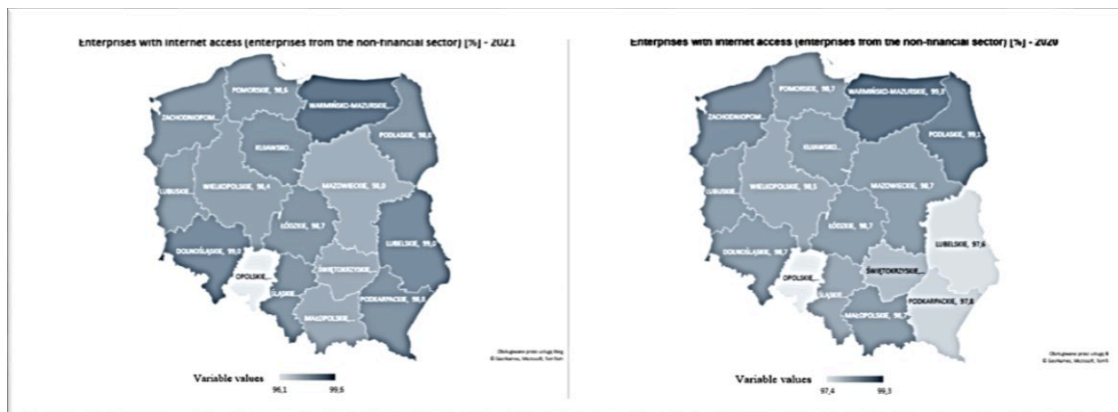


Figure 1. Enterprises with Internet access (enterprises from the non-financial sector) [%] – 2021 and 2020 (the Excel Map).

Source: based on own research.

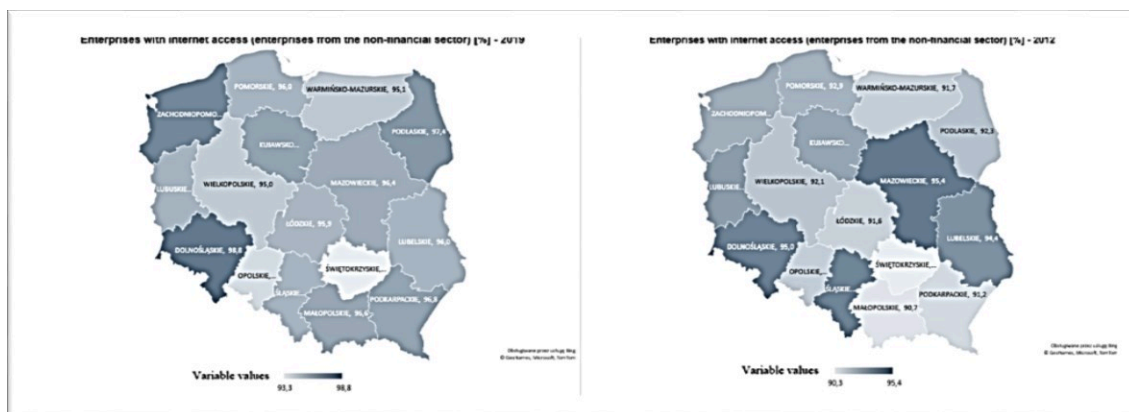


Figure 2. Enterprises with Internet access (enterprises from the non-financial sector) [%] – 2019 and 2012 (the Excel Map).

Source: based on own research.

The second variable was then taken into account - Enterprises with their own website (enterprises from the non-financial sector) [%].

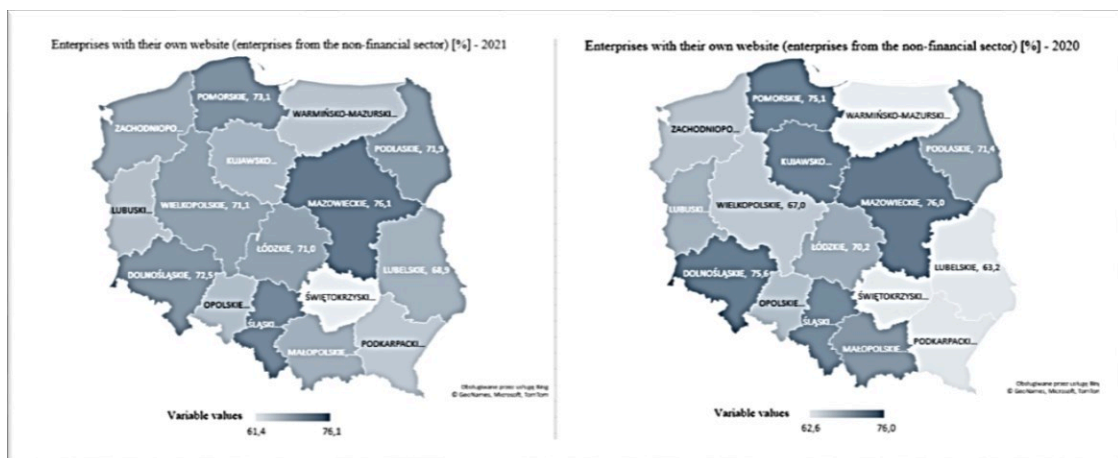


Figure 3. Enterprises with their own website (enterprises from the non-financial sector) [%] – 2021 and 2020 (the Excel Map).

Source: based on own research.

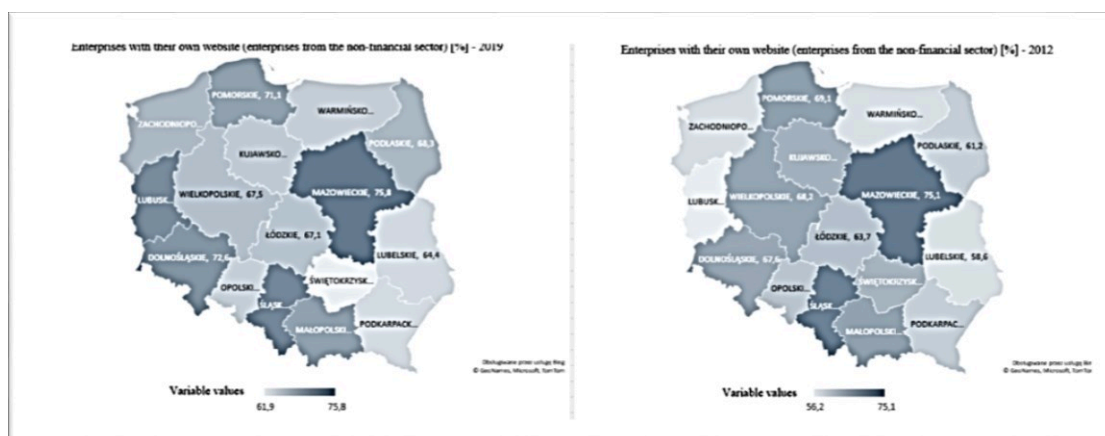


Figure 4. Enterprises with their own website (enterprises from the non-financial sector) [%] – 2019 and 2012 (the Excel Map).

Source: based on own research.

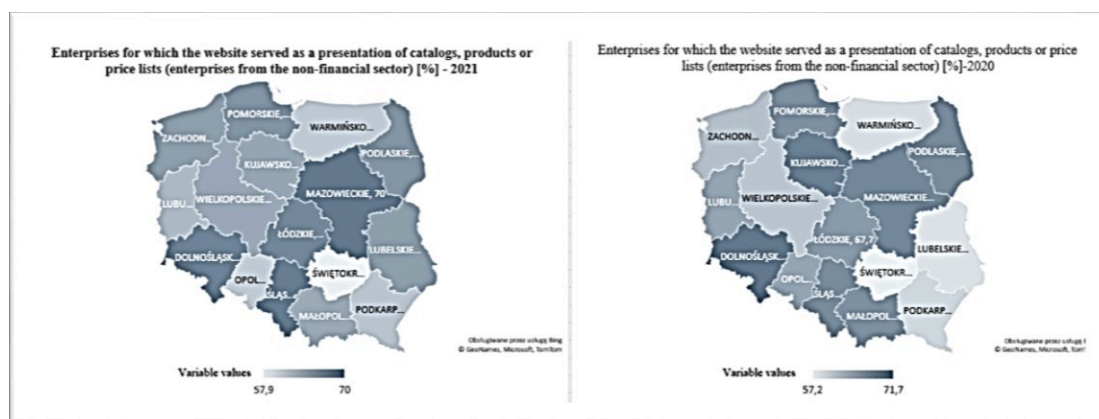


Figure 5. Enterprises for which the website served as a presentation of catalogs, products or price lists (enterprises from the non-financial sector) [%] – 2021 and 2020 (the Excel Map).

Source: based on own research.

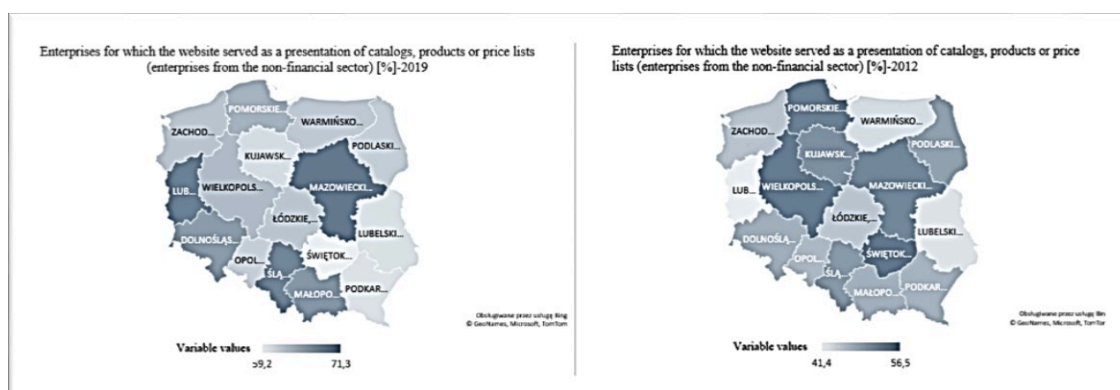


Figure 6. Enterprises for which the website served as a presentation of catalogs, products or price lists (enterprises from the non-financial sector) [%] – 2019 and 2012 (the Excel Map).

Source: based on own research.

Last of the selected statistical variables - Enterprises providing their employees with mobile devices (e.g. laptops, smartphones) allowing for mobile access to the Internet (enterprises from the non-financial sector) [%].

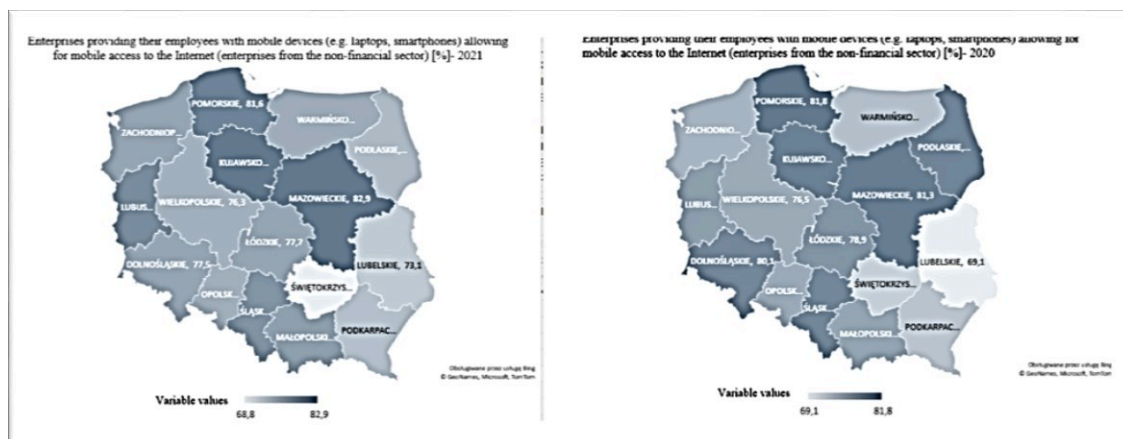


Figure 7. Enterprises providing their employees with mobile devices (e.g. laptops, smartphones) allowing for mobile access to the Internet (enterprises from the non-financial sector) [%] – 2021 and 2020 (the Excel Map).

Source: based on own research.

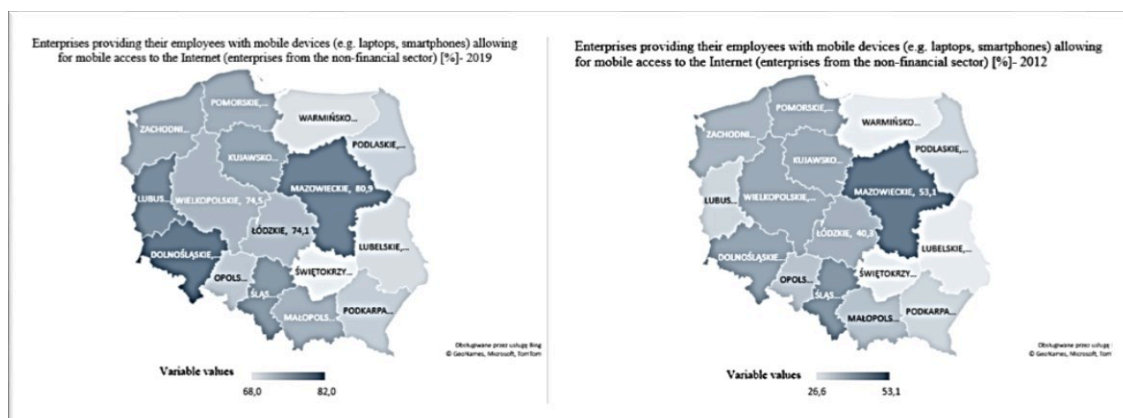


Figure 8. Enterprises providing their employees with mobile devices (e.g. laptops, smartphones) allowing for mobile access to the Internet (enterprises from the non-financial sector) [%] – 2019 and 2012 (the Excel Map).

Source: based on own research.

The graphical representation made it possible to compare a particular phenomenon over time. The richest voivodeship in Poland is the Mazowieckie voivodship due to the capital of Poland. Second place in the ranking of the richest voivodeships is the Dolnośląskie voivodship with the developing city of Wrocław. The third place belongs to the Wielkopolskie voivodeship. The poorest Polish voivodeships are: Lubelskie (agricultural region), Podkarpackie and Warmińsko-mazurskie.

Data were drawn from Eurostat and Statistics Poland, taking into account the thematic scope of the study and data availability. The diagnostic variables selected for the study had to be measurable and best describe the level of development of the examined phenomenon. Based on

the calculated values of the coefficients of variation and the results of verifying correlation analysis conducted by means of an inverted correlation matrix, the final set of diagnostic characteristics which describes the phenomenon for a given country was adopted.

The first stage of the analysis was to examine the voivodeships of Poland in the years 2021, 2020, 2019 in terms of three thematic scopes:

- a. Enterprises and those working with internet access and using mobile devices (for entities from outside the financial sector) - The set of diagnostic features used:
 - x_1 - Number of enterprises operating (S),
 - x_2 - Number of enterprises equipping their employees in mobile devices allowing mobile access to the Internet (S),
 - x_3 - Number of employees equipped with mobile devices enabling mobile access to the Internet (e.g. notebooks, netbooks, tablets, smartphones) (S),
 - x_4 - Number of employees with Internet access (S).
- b. Enterprises with Internet access and e-commerce (for entities outside the financial sector) - The set of diagnostic features used:
 - y_1 - Number of enterprises with Internet access (S),
 - y_2 - Number of enterprises with a website presenting products, goods or services and a price list (S),
 - y_3 - Number of enterprises with a website with the option - online ordering or booking (S),
 - y_4 - Number of enterprises with a website with the option - ordering products according to your own specification (S),
 - y_5 - Number of enterprises with a website with the option - information about job vacancies or the ability to send application documents online (S),
 - y_6 - Number of enterprises with a website with the option - personalization of the website content for frequent/regular users (S).
- c. Outlays on information and telecommunications technologies incurred by enterprises (for entities from outside the financial sector) - The set of diagnostic features used:
 - z_1 - Number of enterprises (S),
 - z_2 - Number of enterprises that incurred expenditure on IT equipment (S),
 - z_3 - Number of enterprises that incurred expenditure on telecommunications equipment (S),
 - z_4 - Number of enterprises that incurred expenditure on financial leasing of ICT devices (S),
 - z_5 - Gross value of expenditure on IT equipment (S),
 - z_6 - Gross value of outlays on telecommunications equipment (S).

In describing the variables, the determination S – stimulant was introduced (Mika, 1995).

3. The set of diagnostic characteristics of the problems under study

The study uses the taxonomic method of direct clustering, which allows obtaining the final classification without prior transfer of objects between subgroups at consecutive stages of the procedure (Ward, 1963; Wishart, 1969). The method was first presented in the works of S. Chomałowski and A. Sokołowski. (Chomałowski, Sokołowski, 1978). In this analysis, some modifications of the method, the proposals of which can be found in the work of A. Młodak, were introduced (Młodak, 2006). The method consists in comparing pairs of objects with the aim of identifying objects of similar structure (Pociecha et al., 1988). A pair of objects is considered similar if their structure distance measure is smaller than the calculated threshold value α . The analysis consisted of two stages. The first stage involved using measure (Młodak, 2006; Panek, 2009):

$$CS_{ik} = 1 - \sum_{j=1}^m \min(x_{ij}, x_{kj}) \quad (1)$$

used in the direct clustering method and calculating the threshold value α in accordance with formula (Młodak, 2006):

$$\alpha = \mu\alpha_{min} + (1 - \mu)\alpha_{max} \quad (2)$$

where:

$$\alpha_{min} = \min_{\substack{i,k=1,2,\dots,n \\ i \neq k}} p_{ik}$$

$$\alpha_{max} = \max_{i,k=1,2,\dots,n} p_{ik} \quad (3)$$

In the second one, measure (1) was replaced with measure (the median “Canberra” measure) (Młodak, 2006):

$$MC_{ik} = \text{med}_{j=1,\dots,m} \left(\frac{|x_{ij} - x_{kj}|}{x_{ij} + x_{kj}} \right) \quad (4)$$

while α was determined according to formula:

$$\alpha = \min_{i=1,\dots,n} \max_{k=1,\dots,n} p_{ik} \quad (5).$$

In the next step, we carry out the following procedure: distance matrix D is converted into similarity matrix P', and afterwards into a dissimilarity matrix P, $P = [p_{ik}], i, k = 1, 2, \dots, n$. A detailed discussion of the method can be found in the works of A. Młodak, S. Chomałowski and A. Sokołowski. In the last step of the analysis, the groups obtained through the applied modifications have to be compared by means of cluster accuracy measures, which requires determining the degree of homogeneity and heterogeneity (Strahl, 1998).

4. The use of taxonomic analysis in a study on the phenomenon under consideration

First, based on the selected set of the diagnostic characteristics, homogeneous groups of Polish voivodeships for the year 2021 were identified. It was done by following the procedure presented in the previous chapter: a distance matrix and next, a matrix of distance structure indicators were built, which provided a basis for the construction of a similarity and dissimilarity matrix ($\alpha = 0.1591$ - for the first stage), (Due to the large number of matrices, their presentation has been omitted). As a result, the following development homogeneous groups of voivodeships formed.

- a. The groups of homogeneous development of the phenomenon - voivodeships of Poland - 2021 (Enterprises and those working with Internet access and using mobile devices (without financial sector)):

Method I:

Group 1 = {Dolnośląskie, Łódzkie, Pomorskie}

Group 2 = {Lubuskie, Świętokrzyskie, Warmińsko-mazurskie, Podlaskie, Opolskie}

Group 3 = {Małopolskie, Wielkopolskie, Śląskie}

Group 4 = {Kujawsko-pomorskie, Lubelskie, Podkarpackie, Zachodniopomorskie}

Group 5 = {Mazowieckie}

Method II:

Group 1 = {Dolnośląskie, Łódzkie, Pomorskie, Małopolskie, Śląskie, Wielkopolskie}

Group 2 = {Opolskie, Świętokrzyskie, Warmińsko-mazurskie, Podlaskie}

Group 3 = {Kujawsko-pomorskie, Lubelskie, Podkarpackie, Zachodniopomorskie, Lubuskie}

Group 4 = {Mazowieckie}

- b. Enterprises with Internet access and e-commerce (without financial sector):

Method I:

Group 1 = {Dolnośląskie, Łódzkie, Pomorskie}

Group 2 = {Lubuskie, Świętokrzyskie, Warmińsko-mazurskie, Podlaskie, Opolskie}

Group 3 = {Małopolskie, Wielkopolskie, Śląskie, Mazowieckie}

Group 4 = {Kujawsko-pomorskie, Lubelskie, Podkarpackie, Zachodniopomorskie}

Method II:

Group 1 = {Dolnośląskie, Łódzkie, Pomorskie}

Group 2 = {Lubuskie, Świętokrzyskie, Warmińsko-mazurskie, Podlaskie, Opolskie}

Group 3 = {Wielkopolskie, Śląskie}

Group 4 = {Kujawsko-pomorskie, Lubelskie, Podkarpackie, Zachodniopomorskie}

Group 5 = {Małopolskie}

Group 6 = {Mazowieckie}

- c. Outlays on information and telecommunications technologies incurred by enterprises (without financial sector):

Method I:

Group 1 = {Dolnośląskie, Łódzkie, Pomorskie}

Group 2 = {Kujawsko-pomorskie, Podkarpackie}

Group 3 = {Lubelskie, Zachodniopomorskie}

Group 4 = {Lubuskie, Świętokrzyskie, Warmińsko-mazurskie, Podlaskie, Opolskie}

Group 5 = {Małopolskie, Mazowieckie, Wielkopolskie, Śląskie}

Method II:

Group 1 = {Dolnośląskie, Łódzkie, Pomorskie, Małopolskie}

Group 2 = {Lubuskie, Świętokrzyskie, Warmińsko-mazurskie, Podlaskie, Opolskie,
Kujawsko-pomorskie, Lubelskie, Podkarpackie, Zachodniopomorskie}

Group 3 = {Mazowieckie, Śląskie, Wielkopolskie }

- d. The groups of homogeneous development of the phenomenon - voivodeships of Poland - 2020 (Enterprises and those working with Internet access and using mobile devices (without financial sector)):

Method I:

Group 1 = {Dolnośląskie, Łódzkie, Pomorskie}

Group 2 = {Lubuskie, Świętokrzyskie, Warmińsko-mazurskie, Podlaskie, Opolskie}

Group 3 = {Wielkopolskie, Śląskie}

Group 4 = {Kujawsko-pomorskie, Lubelskie, Podkarpackie, Zachodniopomorskie}

Group 5 = {Mazowieckie}

Group 6 = {Małopolskie}

Method II:

Group 1 = {Dolnośląskie, Łódzkie, Pomorskie, Małopolskie, Śląskie, Wielkopolskie}

Group 2 = {Świętokrzyskie, Warmińsko-mazurskie Opolskie }

Group 3 = {Kujawsko-pomorskie, Lubelskie Podkarpackie, Zachodniopomorskie,
Lubuskie, Podlaskie}

Group 4 = {Mazowieckie}

- e. Enterprises with Internet access and e-commerce (without financial sector):

Method I:

Group 1 = {Dolnośląskie, Łódzkie, Pomorskie}

Group 2 = {Lubuskie, Świętokrzyskie, Warmińsko-mazurskie, Podlaskie, Opolskie}

Group 3 = {Małopolskie, Wielkopolskie, Śląskie, Mazowieckie}

Group 4 = {Kujawsko-pomorskie, Lubelskie, Podkarpackie, Zachodniopomorskie}

Method II:

Group 1 = {Dolnośląskie, Łódzkie, Pomorskie}

Group 2 = {Lubuskie, Świętokrzyskie, Warmińsko-mazurskie, Podlaskie, Opolskie}

Group 3 = {Wielkopolskie, Śląskie}

Group 4 = {Kujawsko-pomorskie, Lubelskie, Podkarpackie, Zachodniopomorskie}

Group 5 = {Małopolskie}

Group 6 = {Mazowieckie}

- f. Outlays on information and telecommunications technologies incurred by enterprises (without financial sector):

Method I:

Group 1 = {Dolnoślaskie, Łódzkie, Pomorskie}

Group 2 = {Małopolskie Wielkopolskie Śląskie}

Group 3 = {Lubelskie, Zachodniopomorskie, Podkarpackie, Kujawsko-pomorskie}

Group 4 = {Warmińsko-mazurskie, Lubuskie, Świętokrzyskie, Podlaskie, Opolskie}

Group 5 = {Mazowieckie}

Method II:

Group 1 = {Łódzkie, Pomorskie, Małopolskie, Wielkopolskie, Śląskie}

Group 2 = {Lubuskie, Świętokrzyskie, Warmińsko-mazurskie, Podlaskie, Opolskie, Kujawsko-pomorskie, Lubelskie, Podkarpackie, Zachodniopomorskie}

Group 3 = {Mazowieckie}

- g. The groups of homogeneous development of the phenomenon - voivodeships of Poland - 2019 (Enterprises and those working with Internet access and using mobile devices (without financial sector)):

Method I:

Group 1 = {Dolnoślaskie, Małopolskie}

Group 2 = {Łódzkie, Pomorskie}

Group 3 = {Mazowieckie, Śląskie, Wielkopolskie}

Group 4 = {Kujawsko-pomorskie, Lubelskie, Podkarpackie, Zachodniopomorskie}

Group 5 = {Lubuskie, Warmińsko-mazurskie}

Group 6 = {Świętokrzyskie, Podlaskie, Opolskie}

Method II:

Group 1 = {Dolnoślaskie, Małopolskie, Śląskie, Mazowieckie Wielkopolskie}

Group 2 = {Świętokrzyskie, Opolskie Podlaskie Warmińsko-mazurskie}

Group 3 = {Kujawsko-pomorskie, Lubelskie Podkarpackie, Zachodniopomorskie, Lubuskie, Łódzkie, Pomorskie},

- h. Enterprises with Internet access and e-commerce (without financial sector):

Method I:

Group 1 = {Dolnoślaskie, Łódzkie, Pomorskie}

Group 2 = {Lubuskie, Świętokrzyskie, Warmińsko-mazurskie, Podlaskie, Opolskie}

Group 3 = {Wielkopolskie, Śląskie}

Group 4 = {Kujawsko-pomorskie, Lubelskie, Podkarpackie, Zachodniopomorskie}

Group 5 = {Małopolskie}

Group 6 = {Mazowieckie}

Method II:

Group 1 = {Dolnośląskie, Łódzkie, Pomorskie Małopolskie}

Group 2 = {Lubuskie, Świętokrzyskie, Warmińsko-mazurskie, Podlaskie, Opolskie,
Kujawsko-pomorskie, Lubelskie, Podkarpackie, Zachodniopomorskie}

Group 3 = {Mazowieckie Wielkopolskie, Śląskie}

- i. Outlays on information and telecommunications technologies incurred by enterprises (without financial sector):

Method I:

Group 1 = {Dolnośląskie, Łódzkie, Pomorskie}

Group 2 = {Wielkopolskie, Śląskie }

Group 3 = {Lubelskie, Zachodniopomorskie, Podkarpackie, Kujawsko-pomorskie}

Group 4 = {Warmińsko-mazurskie, Lubuskie, Świętokrzyskie, Podlaskie, Opolskie}

Group 5 = {Mazowieckie}

Group 6 = {Małopolskie}

Method II:

Group 1 = {Łódzkie, Dolnośląskie, Małopolskie}

Group 2 = {Pomorskie, Śląskie, Wielkopolskie}

Group 3 = {Lubuskie, Świętokrzyskie, Warmińsko-mazurskie, Podlaskie, Opolskie,
Kujawsko-pomorskie, Lubelskie, Podkarpackie, Zachodniopomorskie}

Group 4 = {Mazowieckie}

The analysis was repeated for European countries. For selected countries, the following data was taken into account:

w1 - Type of connections to the internet, Enterprises use DSL or other fixed broadband connection, All enterprises, without financial sector (10 or more employees and self-employed persons). Percentage of enterprises (S).

w2 - Use of computers and the Internet by employees (S),

w3 - Value of e-commerce sales (Percentage of turnover) (S),

w4 - Number of enterprises with e-commerce sales (S).

The following homogeneous groups were identified – 2021.

Method I:

Group 1 = {Bulgaria, Romania, Greece, Portugal}

Group 2 = {Latvia, Poland, Slovakia, Hungary}

Group 3 = {Czechia, Malta, Serbia, Spain, Croatia, Slovenia}

Group 4 = {Ireland Lithuania Germany France Estonia Italy Cyprus}

Group 5 = {Denmark, Sweden, Netherlands}

Group 6 = {Finland, Norway}

Method II:

Group 1 = {Bulgaria, Romania}

Group 2 = {Czechia, Greece, Portugal, Italy, Cyprus}

Group 3 = {Latvia, Poland, Slovakia, Hungary}

Group 4 = {Germany, France, Estonia, Spain, Croatia, Slovenia, Malta, Serbia, Lithuania}

Group 5 = {Denmark, Sweden, Netherlands, Ireland}

Group 6 = {Finland, Norway}

Groups of homogeneous development of the phenomenon for countries in 2020:

Method I:

Group 1 = {Bulgaria, Romania}

Group 2 = {Estonia, Italy, Cyprus, Portugal}

Group 3 = {Greece, Latvia, Hungary, Slovakia, Poland}

Group 4 = {Czechia, Malta, Lithuania Serbia, Spain, Croatia, Slovenia, Ireland}

Group 5 = {Denmark, Sweden}

Group 6 = {Germany, France}

Group 7 = {Netherlands, Finland}

Group 8 = {Norway}

Method II:

Group 1 = {Bulgaria, Romania}

Group 2 = {Greece, Cyprus, Portugal, Latvia, Hungary, Poland, Slovakia, Czechia}

Group 3 = {Croatia, Serbia, Spain, Lithuania, Slovenia, Malta}

Group 4 = {Germany, France, Estonia, Italy, Ireland}

Group 5 = {Denmark, Sweden}

Group 6 = {Finland, Norway, Netherlands}

Groups of homogeneous development of the phenomenon for countries in 2019:

Method I:

Group 1 = {Bulgaria, Romania}

Group 2 = {Greece, Latvia, Hungary}

Group 3 = {Italy, Poland, Slovakia, Cyprus, Portugal}

Group 4 = {Czechia, Lithuania, Serbia}

Group 5 = {Estonia, Croatia, Spain, Malta, Slovenia, Ireland}

Group 6 = {Denmark, Finland, Netherlands, Norway, Sweden}

Group 7 = {Germany, France}

Method II:

Group 1 = {Bulgaria, Romania}

Group 2 = {Greece, Latvia, Hungary}

Group 3 = {Italy, Poland, Slovakia, Czechia, Portugal, Serbia, Lithuania}

Group 4 = {Estonia, Croatia, Malta, Spain, Slovenia}

Group 5 = {Ireland, Germany, France}

Group 6 = {Finland, Norway, Netherlands}

Group 7 = {Denmark, Sweden}

In the last step of the analysis, the groups obtained thanks to the applied modifications were compared by means of cluster accuracy measures.

5. Conclusion

In the present study, the taxonomic method discussed in the works of S. Chomałowski and A. Sokołowski (Chomałowski, Sokołowski, 1978; Młodak, 2006), which estimates the level of variation of objects described by selected statistical characteristics and groups the objects according to the similarity of development of the examined phenomenon, to conduct an analysis of the internet and ICT use in the years: 2021, 2020, 2019, 2012 with special focus on the time of the Covid-19 pandemic. In this analysis, some modifications of the method, the proposals of which can be found in the work of A. Młodak, were introduced (Młodak, 2006). In the first stage of the analysis, Polish voivodeships were examined with regard to the phenomenon in question.

The groups of homogeneous development were identified for the years 2021, 2020 and 2019.

Both methods determined groups of voivodeships with a similar level of the phenomenon, differed in the number of designated groups.

In 2021 (theme a), five homogeneous groups were identified for method I and four homogeneous groups for method II. Both methods designated one-element groups with the same voivodeships, i.e. Mazowieckie. The third group (method I) included voivodeships: Małopolskie, Wielkopolskie, Śląskie. The first group (method II) included voivodeships: Dolnośląskie, Łódzkie, Pomorskie, Małopolskie, Śląskie, Wielkopolskie. The group 3 (method I) and group 1 (method II) represent voivodeships with the similar level of the phenomenon. In 2021 (theme b, method II) one-element groups with the same voivodeships, i.e. Mazowieckie and Małopolskie were determined. In 2021 (theme c), five homogeneous groups for method I and three homogeneous groups for method II were identified.

In 2020 (theme a) one-element groups with the same voivodeships, i.e. Mazowieckie and Małopolskie were determined. In 2020 (theme a) method I, two one-element groups of voivodeships were identified: Mazowieckie and Małopolskie. And for method II only a one-element group was obtained (Mazowieckie voivodeship). Method I - Śląskie and Wielkopolskie voivodeships were classified into one group, and for Method II - with the following voivodeships: Dolnośląskie, Łódzkie, Pomorskie, Małopolskie, Wielkopolskie. For method II (theme b), the Małopolskie and Mazowieckie voivodeships were classified as one-element groups. And for method I and method II (theme c) only a one-element group was obtained (Mazowieckie voivodeship).

In 2019 (theme a), six homogeneous groups were identified for method I and three homogeneous groups for method II (no one-element groups). In 2019 (theme b) - for method I, two one-element groups were obtained (the Małopolskie and Mazowieckie voivodeships). In 2019 (theme c) for method I, the Mazowieckie and Małopolskie voivodeships formed a one-element groups. For method II, a one-element group (Mazowieckie Voivodeship) was obtained.

In the next step, the method was used again to compare Poland and the European countries, which involved determining groups of homogeneous development among the latter. In 2021 six homogeneous groups were identified for method I and six homogeneous groups for method II. The second group included Latvia, Poland, Slovakia, Hungary in both methods (low level of development of the phenomenon). The eighth group (method I) was a single-element group in 2020, including only Norway, and was enlarged with Denmark, Finland, Netherlands and Sweden in 2019. In 2020, the third group (method I) included Greece, Latvia, Hungary, Slovakia, Poland and was enlarged with Cyprus, Portugal and Czechia for method II (group 2). In 2019, the third group included Italy, Poland, Slovakia, Cyprus, Portugal, but for method II the group comprised also Czechia, Serbia and Lithuania (without Cyprus).

In the years covered by the study, the Nordic countries always formed a separate group. They display a high level of the internet and ICT use. The groups include the time of the pandemic, which triggered an increase in the internet and ICT use. This is the time when remote work and online education entered our lives on a massive scale and a lot of people had to buy PCs or computer hardware, etc.

To sum up, the results of the analysis show that the homogeneous groups of Polish voivodeships with the highest level of the internet and ICT use form around the capital and big cities, which offer ample employment and educational opportunities. The lowest level can be observed in the groups comprising mainly rural areas. The analysis of the countries reveals that another factor affecting the level of internet and ICT use is economic development. Rich countries and states can afford to invest in new technologies, ensuring their citizens access to such solutions while companies and investors provide them with job opportunities.

This leads to a society's improved standard of living, extended life span and successful fight against poverty and hunger.

In sum, it can be said that the enterprises, public administrations, society and the national economy are implementing the digital transformation.

In recent years, automation and robotization have covered more and more new areas of life.

Digitalization has a significant impact on consumer behaviour, changes the rules of competition in the market and creates new economic models. We should know that digitization is not just a technological innovation, but an important response to changes in the environment.

We should solve problems that are related to the rapid development of digital technologies (transformation of economic activity, organizational changes of the enterprise, changes in public administration, etc.).

Automation is a threat to many professions. In the literature we find the term “technological unemployment”. Technological unemployment will increasingly affect people in the tourism, construction, food and transport sectors.

To sum up, in order to survive, today’s organizations, enterprises, society and economy need to respond to the changing environment promptly and implement relevant effective solutions. In the future, the effects of digitization will be a major problem, but we cannot foresee them all.

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CITY MANAGEMENT DURING THE PROCESS OF ACQUIRING INVESTORS TO MUNICIPALITIES ON THE EXAMPLE OF ŚWIDNICA IN YEARS 2002-2014. ECONOMIC ASPECTS

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Purpose: The process of acquiring investors to municipalities is related with a wide range of criteria. Among them, public authorities play an important role, both at local as well as national level. Appropriate involvement at regional level is the basic determinant of entrepreneurship development. The purpose of this article is to analyse the process of acquiring investors to municipalities on the example of Świdnica.

Design/methodology/approach: Analysis of source material is the main method used in this article. The thematic scope includes activities of the city of Świdnica for the development of entrepreneurship in years 2002-2014. Important aspects are also general investment-friendly criteria in a particular region.

Findings: In this article reports on the city of Świdnica in the field of entrepreneurship were analysed as well as general data related to the Polish economy in years 2002-2014.

Another important factor analysed in this article are the criteria stimulating development of enterprises. Particular initiatives of Wojciech Murdzek, the Mayor of Świdnica, related to the process of acquiring investors were analysed.

Originality/value: The article shows examples of activities of the city of Świdnica related to the development of entrepreneurship in years 2002-2014. The article may be valuable for both managers, investors as well as for people responsible for managing the city at various levels of public administration, in particular for local government officials.

Keywords: Economics, business, local government, investment.

Category of the paper: Research paper.

1. Introduction

Acquiring investors to municipalities is one of the most important aspects of city management. Thanks to this, the municipality can provide basic services related to functioning of the city such as public transport, lighting and order in the city. Also residents have stable employment situation. There are many issues that are crucial for the future of business such as qualified staff, well-developed road infrastructure, right location and also method of managing by local authorities who are responsible for municipalities where large factories and corporations are located.

Over the last twenty years, the influx of investors to Poland as well as to Europe has started. It can be proved by multiple indicators. An example of this might be the report made by Central Statistical Office informing that in 2002 gross domestic product in Poland amounted to PLN 772,2 billion and in 2019 it was PLN 2273,6 billion. Approximately, threefold increase confirms the right direction economic expansion in III RP.

The Government and the Parliament determines the creation of legal regulations and programmes for entrepreneurs in Poland. However, it is necessary to remember the importance of local government in the process of acquiring investors to municipalities. Local communal authorities and officials play an important role in this process. They can stimulate its development through appropriate activities. Their actions may also lead to decrease the amount of enterprises depending on the services provided in the public sector (Kanchana et al., 2013).

This article aims to show the specifics of city management in the aspect of acquiring investors to municipalities on the example of Świdnica. In the paper competencies of local governmental authorities are discussed and specific data related to the process of acquiring investors to municipalities on the example of Świdnica are presented. The time frame of the paper covers the years 2002-2014. This is the period when Wojciech Murdzek (2002-2014) was in charge of city management as a president of Świdnica. These data will be used to assess his work within the indicated period and will also help to define key factors in investment decisions.

In the first part of this paper, investment-friendly factors are discussed. In the second part, information on Świdnica and the most important processes and decisions made by the government of Wojciech Murdzek, the Mayor of the city are presented. In the third and final part strengths and challenges for the coming years of the city of Świdnica are described. All the mentioned data will allow to verification of the thesis about whether Świdnica was well-managed within the context of development and whether the way of city development was exceptional compared to other municipalities in the Lower Silesia region.

2. Factors conducive to the development of entrepreneurship in municipalities

The period after the change of political system in Poland since 1989 is one, if not the most, dynamic time in the history of Polish economic growth. Poles, as a nation are seen as hard-working, loyal and ambitious people. Such an image is based on labour migration that occurred after 2004, when Poland became part of European Union. It was also a time of the opening of the Polish borders to international trade and also enabled development of export of Polish products and resources (CEO World Magazine, 2018). Figure 1 is a confirmation of the scale of development of Polish in recent times.

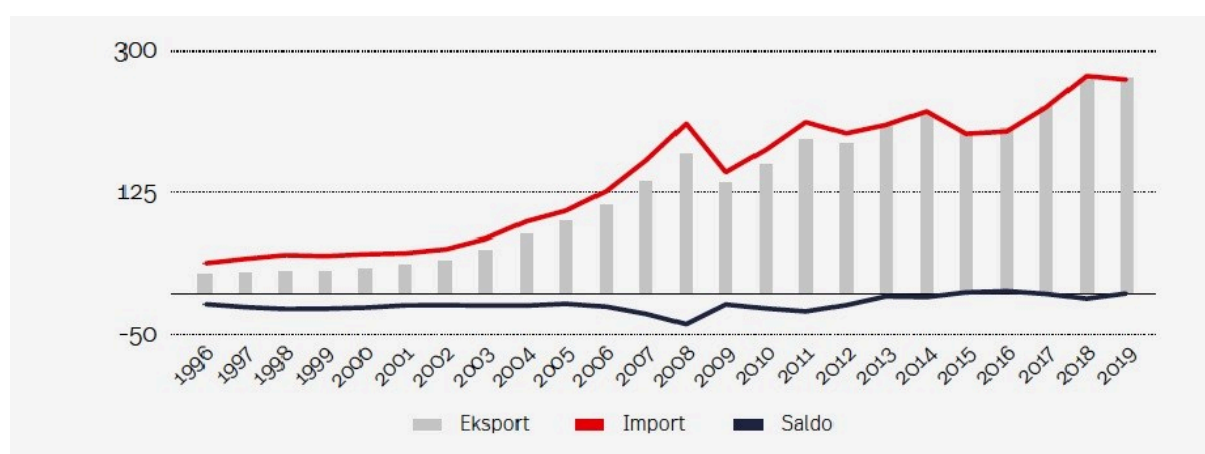


Figure 1. Polish import and export in years 1996-2019 (calculated in billions of dollars). Source: J. Rosa, „Polski eksport w liczbach: 7 wykresów, które pokazują, jak zmienił się handel zagraniczny Polski od lat 90”, <https://300gospodarka.pl/analizy/polski-eksport-pie>, 11.08.2021.

Indicators in Figure 1 show the pace of development of trade and entrepreneurship in Poland. This is an important factor, but not the only one, which may indicate the attractiveness of investing in Poland. Defining investment-friendly factors in particular region is crucial to understand determinants in the process of acquiring investors to municipalities. In the literature there are a number of methods of studying the relevance of individual factors and each of them can be valuable for both researchers of this phenomenon and local government officials involved in attracting investors.

Road and railway infrastructure was among the most frequently mentioned factors for investors, as this is trade-related element crucial for distribution of manufactured goods. Therefore, from municipality's perspective, location, the significance of this region, the proximity of the border or demographic structure are crucial aspects for which local government has no direct impact. Another important factor is appropriate human resources. Without a doubt, this is a very important aspect which is essential for investors when making investment decisions. It is also worth mentioning the economic position of the country and average earnings as another factors taken into account when making business decisions by investors (OECD, 2007). In addition to the mentioned factors that significantly influence the

decision on the investment location in a given municipality there are a number of factors for which the local government is responsible. An example might be the attitude of the broadly understood public sector, officials and public institutions which play an important role in the process of building factories in a given municipality. In fact, much depends on their competencies and commitment. It is therefore necessary for local officials to introduce appropriate standards among employees to competently make contacts and develop cooperation with the private sector. In this respect, it should be noted that the amount of fees and taxes that apply in a given region is also important for investors. The municipal council also has instruments in the form of resolutions of the city council based on which benefits and reliefs for entrepreneurs can be applied (World Bank Group, 2019).

Factors important for investors are presented below. Their author is Wojciech Dziemianowicz (1998) who has been dealing with this issue for years. The key factors that depend on municipal officials were marked in a circle. The experience gained in establishing contacts with entrepreneurs may be helpful in the future due to acquired skills and recommendations from local businesses which are of key importance for potential investors. Technical infrastructure is another major factor which plays an important role in the construction of the factory in a given location. The construction period depends on commitment and willingness to cooperate on the part of municipality, but first of all investor's decision is essential.

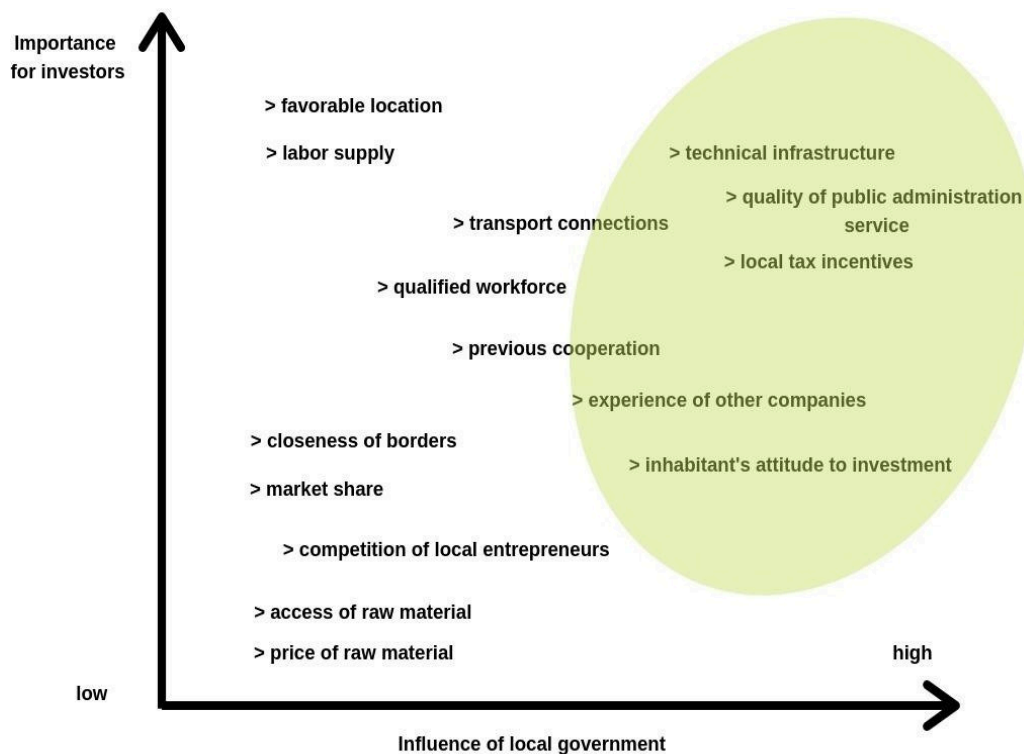


Figure 2. Factors important for investors (Dziemianowicz, 1998; Olesioski, 1998).

Figure 2 indicates two groups of factors that are necessary in the process of acquiring investors to municipalities. The first one is a group of factors that happen in the long-term perspective (more than one mandate), for example, strategic road network or location of municipality in the context markets of potential clients. The second group includes factors that significantly depend on commitment and determination of the Mayor of the city.

3. The city of Świdnica

Świdnica is a city located in Lower Silesia Sudeten Foreland region. In its rich history there are Prussian, German, Czech and Polish influences. In the past, the city was famous for the commerce. The city was built based on German law. Świdnica is connected with larger urban centres such as Wałbrzych - 20 kilometers, Wrocław - 50 kilometers and Legnica - 60 kilometers. The main communication artery of Świdnica is national road number 35 and rail connections. The city is located about 35 kilometers from the border with Czech Republic and about 180 kilometers from the border with Germany. The location of Świdnica is presented in figure 3. The city has close to 58 thousand inhabitants.



Figure 3. Location of Świdnica Source: website of Town Hall in Świdnica.

The city cooperates with partner cities from Czech Republic, Germany, Ukraine, Lithuania, Hungary or the United Kingdom - (Biberach (Germany), Ivano-Frankivsk (Ukraine), Kazinbarcika (Hungary), Police (Czech Republic), Święciański District (Lithuania), Tendring (Great Britain), Trutnov (Czech Republic)).

In 2002, Wojciech Murdzek became the mayor of the city. It was the first election after amendment to the Act on administration, based on which the mayor was elected by residents in direct elections. I was a legal competence of the city council before the change. At the beginning of his presidency unemployment was among the main challenges related to the management, the city's level of unemployment stood at 15-20%. Nearly six thousand people did not have permanent employment. Moreover, getting the private sector to expand was the biggest challenge for the municipality at that time. Other neighboring towns such as Dzierżoniów or Żarów experienced similar difficulties. The Wałbrzych Special Economic Zone was key to the development of entrepreneurship in the region. The company looked after various areas for new factories. One of the priorities for Wojciech Murdzek, the mayor of Świdnica was the formation of economic subzone located in Świdnica and its direct neighbourhood. It is worth to mention, that in other regions were similar economic subzones: in Dzierżoniów since 1999 and in Żarów since 2001 (Szymkiewicz, 2019).

The structure of Świdnica's companies in terms of the number of employees was dominated by companies employing between 10 and 49 workers. In 2002 it was 278 of them. It was only 7 the biggest ones that employed more than 250 people (Regon, 2002).

Table 1.

The number of business entities registered in the REGON system in Świdnica 2002-2005

SPECIFICATION	2002	2003	2004	2005
10-49	278	282	283	308
50-249	69	75	71	64
250 and more	7	7	6	6

Source: Raport o stanie przedsiębiorczości w Świdnicy oraz efektywności systemu poszukiwania i wspierania inwestorów, Świdnica 2009, p. 3.

The actions taken contributed to progressive improvement of the labour market situation. During the years 2002-2005 unemployment decreased by 24% from 6461 to 4889 people. First actions of Wojciech Murdzek as the Mayor of the city aimed to strengthen the position of existing enterprises. The city tried to revive the economy through the development of tourism. Among the areas that were the weakest in reports on state of the town in 2004 and 2005 the lack of investment areas for larger companies was mentioned as one of the main issues. Another concern was the lack of employees with specific expertise, for example, employees working with CNC machines (Urząd Miasta Świdnica, 2005).

The year 2004 was a turning point in the process of acquiring investors to Świdnica. At that time, the Council of Ministers decided to form the economic subzone in Świdnica. It was crucial to prepare properly at local level before the decision was made in Warsaw. For this purpose, the City Council of Świdnica adopted *The resolution of the Świdnica City Council XV/170/03 from 30 December 2003* regarding efforts to establish the economic subzone. Initially, the subzone area in Świdnica was 17,5 hectares. With time, however, it was decided to expand the area to 47,5 hectares in 2005 (Uchwała XV/170/03, 2003).

Table 1 shows the area and number of enterprises which were located in the Świdnica Subzone in years 2002-2006. Throughout the first three years of operating it is important to notice huge interest and funds that have been dedicated to development of enterprises and investments in this region.

Table 2.
Subzone Świdnica 2002-2006

Subzone	Year	2004	2005	2006
ŚWIDNICA	Number of permits/decisions issued in a given year	0	4	7
	Employment (status at the end of each year) [number of people]	0	21	484
	Investment expenditures (status at the end of each year) [PLN]	0 zł	20 266 100 zł	338 321 080 zł
	changedate	2004	2005	2006
	surface[ha]	17,50	47,55	106,04
	Degree of development [%]	-	72%	68%

Source: Official data prepared by WSEZ "Invest Park".

In the presidential election in 2006, Wojciech Murdzek was re-elected as the Mayor of the city. It was a time of further actions aimed at improving city's economic situation and developing entrepreneurship. During this mandate was the global financial crisis of 2007-2008.

Among the activities related to the city development that was supposed to impact on inhabitants and entrepreneurs was the decision to build an interchange center and to start the renovation of the railway station. Both strategic investments were aimed at improving the transport conditions in the city, but also in neighbouring municipalities. For this purpose, Świdnica also sought to renovate national road number 35 (Moczulska, 2011).

Another important task was to expand the area of Świdnica Subzone that was intended to development of enterprises. In years 2007-2010 the area was extended by more than 35 hectares. The number of employees has significantly increased, they all found employment in the Świdnica Subzone. It was over 1000 people during that period. The investment expenditures were successively increasing in particular enterprises. The city consistently was seeking to attract new investors which can be confirmed by a number of decisions. The year 2008 was groundbreaking, then it was decided to build 7 factories or companies. The effectiveness of the actions aimed at attracting investors can be confirmed by the fact that in 2010, 94% of special area for investors was used (Urząd Miasta Świdnica, 2008).

Table 3.
Subzone Świdnica 2007-2010

Subzone	year	2007	2008	2009	2010
Świdnica	Number of permits/decisions issued in a given year	0	7	2	1
	Employment(status at the end of each year) [number of people]	1064	1521	1758	2175
	Investment expenditures(status at the end of each year) [PLN]	561 794 463 zł	720 671 547 zł	867 047 906 zł	850 486 395 zł
	change date	2007	2008	2009	2010
	Surface [ha]	149,94	149,94	162,56	183,00
	Degree of development [%]	48%	56%	60%	94%

Source: Official data prepared by WSEZ "Invest Park.

Table 3 shows a list of registered companies in the city. Bringing two companies employing over 250 people was a huge success. The number of companies employing from 10 to 49 people also was increasing.

Table 4.
The number of business entities registered in the REGON system with number of employees in Świdnica

SPECIFICATION	2005	2006	2007	2008	2009
10-49	308	303	304	313	313
50-249	64	65	65	65	63
250 and more	6	6	6	8	8

Source: Raport o stanie przedsiębiorczości w Świdnicy oraz efektywności systemu poszukiwania i wspierania inwestorów, Świdnica, 2009, p. 8.

In the next term, Wojciech Murdzek was the Mayor of the City until 2014. The economic situation during this period changed radically. Unemployment was successively decreasing. The number of new enterprises and factories was increasing in the city. This was an important factor for the city that provided budgetary resources to current city management. The graph presented below shows the growth of tax revenue PIT and CIT, which were directly related to income of the residents of Świdnica. Since 2012 an upward trend in personal income tax PIT is clearly visible. This is a consequence of the current economic policies in the city. Similarly, income from the CIT tax increased significantly. Although, the growth period falls on 2016, when the next Mayor was in charge, but the measure is a consequence of previously developed strategy for Świdnica (Urząd Miasta Świdnica, 2017).

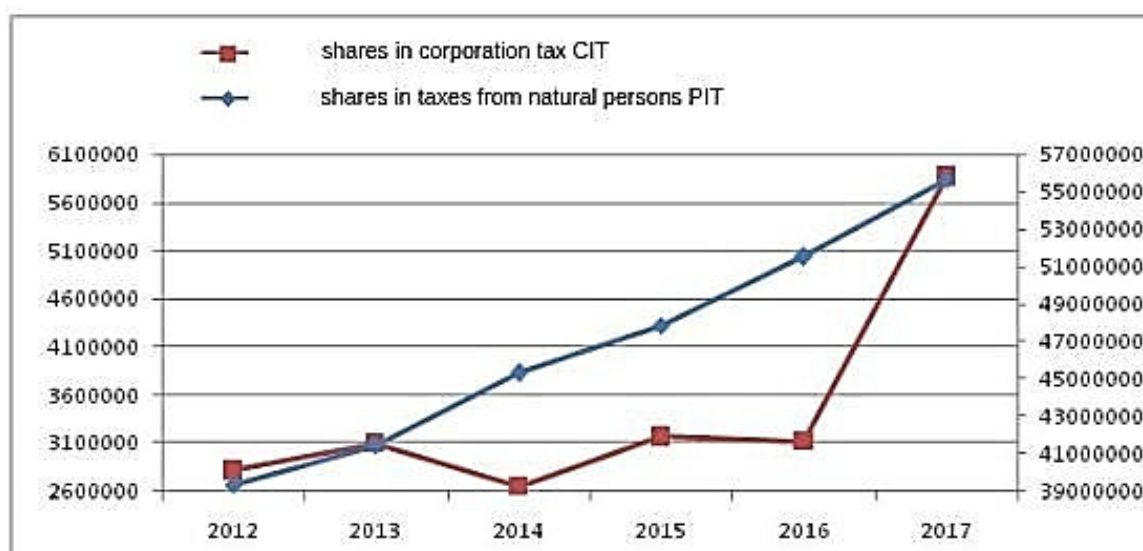


Figure 4. Share in taxes (PIT AND CIT). Source: Report on the condition of entrepreneurship in Świdnica 2017, Świdnica 2018, p. 12.

It is also worth mentioning the examples of further actions related to the improvement of road infrastructure in the city and the surrounding area. For this purpose, local and voivodeship authorities played an important role for this reason the cooperation between these institutions was extremely important. The works associated with planning and building district road number 3396D began in 2011. It was a distance linking the voivodeship road number 383 and the country road number 35. This investment was strategic for convenient connection to the motorway A4. As a result, there should be improvement of communication in the region. The total investment cost amounts to 110 million and Świdnica has provided almost PLN 8 million. This solution enabled transport connections with the express road. At the same time this was meant to redirect transit traffic outside the city of Świdnica.

The investment areas in Świdnica and surroundings were later expanded. It was over 167 hectares in 2014. This resulted in further decisions made by investors. In years 2011-2014 10 decisions were made to build the factory. The number of employees in the economic subzone was constantly increasing, it was almost 2700 people in 2014.

Table 5.

Subzone Świdnica 2011-2014

Subzone	year	2011	2012	2013	2014
Świdnica	Number of permits/decisions issued in a given year	2	2	3	3
	Employment(status at the end of each year) [number of people]	2324	2382	2566	2689
	Investment expenditures (status at the end of each year) [PLN]	891 733 465 zł	962 195 713 zł	1 083 319 534 zł	1 215 913 179 zł
	change date	2011	2012	2013	2014
	surface[ha]	159,88	159,81	159,81	167,74
	Degree of development [%]	73%	73%	73%	69%

Source: Official data prepared by WSEZ "Invest Park".

Adopting spatial development plans in the city was particularly important task. A separate legal act regulated the possibility of building in particular parts of the city, what was well received by residents and entrepreneurs because of transparent use a given area. From business owner's point of view it was also important due to the evaluation of a possibility expansion of investments in the future .

4. Challenges for the future

Świdnica is a city in a good economic situation and position in a region in terms of cooperation with investors. The vast experience of council workers is the basis for further development in this field. Further expanding of investment areas is one of the main challenges. At the same time, the difficulty is having multiple small investment plots which constitute a barrier for larger entrepreneurs. The construction of expressway S5 and S3 is essential for increasing economic potential of Świdnica and its region as it might be attracting factor for investors. Demography issue and the depopulation of smaller cities is a challenge for Świdnica and the whole country. Young residents, often well-educated decide to migrate to larger, for instance, to Wrocław or Warsaw. This is a serious challenge for the city authorities. The following data confirm the importance of this aspect for the city. Birth and death rates in years 2002 – 2013 in Świdnica should be taken into account within the context of demography demographic aspect, because they have huge implications on the entire economic sector.

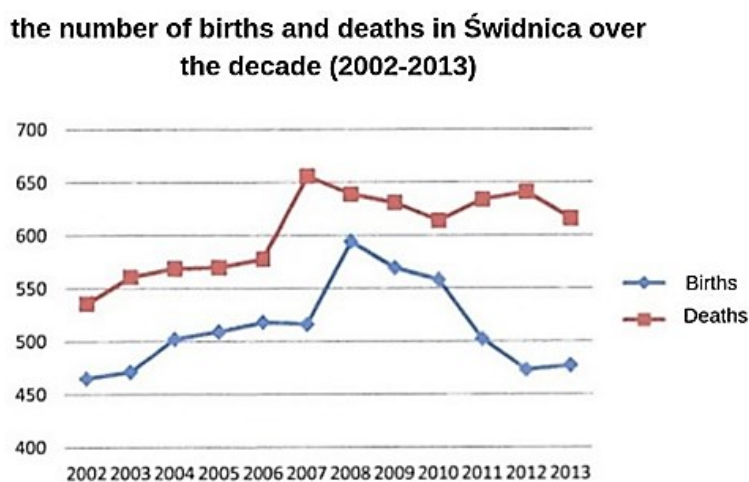


Figure 5. Ranks of births and deaths in Świdnica (2002-2013).

Table 6.*Demographic forecast for the municipalities of Lower Silesia until 2035 year (Świdnica)*

Age	2020	2025	2030	2035
Pre-production	8422	7853	6852	6044
Inorking	32226	29572	27778	25659
Post-production	15360	15834	15466	14833
Altogether	56008	53259	50096	46536

Source: Demographic forecast for the municipalities of Lower Silesia until 2035 year, IRT, Wrocław 2014.

5. Conclusion

Summarizing the efforts of Wojciech Murdzek regarding city management and actions taken to attract investors to municipalities in years 2002-2014 they should be assessed as thoughtful and efficient. It was a key challenge for the city of Świdnica which enabled the further development and raising additional funds. The basis of these actions was a huge unemployment which stood at 24% of all residents of Świdnica. The city has good perspectives for development after this period. It can be proved by the assessment of Świdnica in comparison with other municipalities from Lower Silesia by H. Godlewska-Majkowska in view of investment potential. The city of Świdnica is marked in darker green in the graphic below which means that Świdnica is among the most successful and effective municipalities in terms of acquiring investors to municipalities. The assessment can be a summary of the developed strategy and standards by Wojciech Murdzek, the Mayor of the Świdnica (Godlewska, 2017).

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RANDOMNESS TESTING OF THE RANDOM NUMBER GENERATORS USING DIEHARDER TOOL

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Purpose: The aim of the research is to determine whether the Dieharder battery of statistical tests suite is able to demonstrate the superiority of the true random number generator over pseudorandom number generators.

Design/methodology/approach: Based on a number of random number sequences obtained from different generators, the randomness of these sequences was tested and the results obtained were compared between different classes of random number generators.

Findings: The research indicated that we are not able to determine in a positive sense the quality of a given generator on the basis of statistical testing with a Dieharder battery, but only able to determine whether there are no grounds to reject the generator as non-random. Statistical testing only has the character of a negative criterion.

Originality/value: The research carried out provides an answer to the question of whether statistical randomness testing with a battery of Dieharder tests can provide information about the level of randomness of a given generator in relation to another generator, when both random sequences have passed the tests. The results of the research indicate that additional quality criteria should be taken into account when selecting a random number generator that passes the statistical tests in order to unambiguously answer which generator is better.

Keywords: strategy of randomness testing, random number generator, quantum cryptography, Dieharder.

Category of the paper: Research paper.

1. Introduction

One of the many characteristics of the world around us is randomness. Randomness is understood as the lack of connection between events or the lack of predictability of these events and their causality. What for a human may be a random event, from the mathematics point of view may not. Encryption is a good example of this.

Randomness is fundamental in many algorithms, not only in computer science. However, good quality random numbers are essential for developing secure cryptography methods.

However, testing random number generators, due to its non-deterministic nature, is a complex issue (Kałuski, 2012). Therefore, the Dieharder tool (Brown, 2022) was proposed to determine whether the tested generator has the characteristics of a good quality random number generator. In this paper, an analysis of randomness testing of different random number generators will be conducted. The study uses the Dieharder tool used in randomness testing of pseudorandom and random number generators. Based on the generators built there, as well as statistical tests, testing of the quality of the random numbers generated was carried out. The aim of this paper is to try to determine whether the battery of Dieharder tests will indicate the superiority of truly random generators over pseudo-random generators. This includes a new class of quantum generators that fundamentally deliver unpredictability and randomness according to the Copenhagen interpretation of quantum mechanics.

2. Characteristics of the used sources of randomness

The literature distinguishes two basic classes of random number generators (L'Ecuyer, 2021):

- Pseudo random number generators – PRNG.
- True random number generators - TRNG.

Pseudo random numbers can be obtained from mathematical algorithms. Generators of this type require an initial entropy seed to be supplied to the generator input (Marsaglia, 2003). The next state is generated deterministically by applying a mathematical function. These are the so-called LCG (Linear Congruential Generator) generators. Generators of this type have the serious drawback of a limited number of states. After a certain number of steps of the generator the internal state loops and the generator repeats its work. This type of behaviour makes it possible to predict each subsequent state of the generator, especially if the attacker knows the seed used to run the generator. Despite these drawbacks, due to the high speed of these generators, they also find application in cryptography.

The second group of number generators are true random number generators. They differ significantly from pseudorandom number generators. These numbers can be obtained from various sources of physical phenomena by using magnetic fields, light intensity, sound waves, or quantum phenomena (Jian, et al., 2011). A good example of generating truly random numbers is a generator using the decay of radioactive elements. However, these generators are slow. They are chosen when the quality of the numbers generated is more important than the quantity.

There are many more practical quantum phenomena which can be considered as good candidate processes for the truly non-deterministic randomness generation. An in-detail study can be found in (Jacak, Józwiak et al., 2021) mainly focusing on quantum shot noise as well as on quantum optics. It is possible to consider quantum phenomena in nano-plasmonics as well, yet of a lesser practical significance (Jacak, 2020). Furthermore quantum entanglement independently of its technical implementations can bring important advantages in efficient randomness testing (Jacak, J., Jacak, W. et al., 2020), which is of critical role for implementing Quantum Key Distribution (Jacak, M., Jacak, J. et al., 2016; Jacak, Mielniczuk et al., 2015).

Hardware randomness generators should be equipped with internal testing devices. However, this type of approach is not trivial when using phenomena of the surrounding nature. Therefore, the most common choice is an empirical approach (Knuth, 1997), in particular statistical randomness testing. The most important implementations of the tests are the NIST (Rukhin et al., 2010) and Dieharder (Hotoleanu et al., 2010; Brown, 2022; Suresh et al., 2013; Vascova et al., 2010) batteries. In this paper, a set of Dieharder tests was chosen to study generators. Note that in addition to empirical implementations of the tests, methods for quantum generator properties are detailed.

Three algorithmic pseudo-random number generators were used for the study:

- *rand()* - C/C++ library function used to generate a random number. Does not allow the initial entropy to be given as a seed. Used as a known very weak source of random numbers,
- *ran1* (Class *Ran1*, 2022) - a generator developed by Park and Miller (Park et al., 1988) with the Bays-Durham shuffling algorithm (Bays et al., 1976),
- *random256-glibc2* generator from GNU C library.

Another pseudorandom number generator uses a virtual device on a unix machine. This solution is based on generating random numbers based on interrupts occurring in the system from device drivers and other events in the operating system:

- */dev/urandom* - random number generator using system events to obtain.

A triple pendulum has been used as an example of a generator using a physical phenomenon. Such a implementation becomes a chaotic system when tilted appropriately (Stachowiak et al., 2006; Botha et al., 2013). The generator is an implementation based on the work of (Nouar et al., 2020) and (Awrejcewicz et al., 1999). Three masses are sequentially connected to each other by inextensible rods, and the first one is additionally attached to a fixed point in space.

This is a physical phenomenon whose behavioural description we are able to calculate. In the literature this effect is known as the "Butterfly Effect":

- *Triple pendulum* (Małachowski, 2021).

As a counterbalance to the pseudo-random generators discussed earlier, a sequence of numbers generated by a quantum random number generator called:

- *ANU QRNG* (Małachowski, 2021).

Unlike previous generators, this generator is fully non-deterministic. This generator was developed at the Australian National University (ANU). The generation of random numbers is carried out on the basis of phenomena occurring in a vacuum (Botha et al., 2013). As the authors of this generator point out, the definition of a vacuum in classical terms differs from the quantum definition. In classical physics, a vacuum is considered as a space that is empty of matter or photons. Quantum physics however says that same space resembles a sea of virtual particles appearing and disappearing all the time. These particles produce a magnetic field that causes minute changes in phase and amplitude at all frequencies of the waves passing through the field (ANU QRNG, 2022). The researchers, by using a laser, are able to read these differences, allowing for a high-throughput quantum generator. The authors of the solution provide an API in which quantum random number strings can be obtained on the project website (ANU QRNG 2022). For the research in this paper, the mentioned API was used to obtain test samples.

3. Statistical testing of randomness with Dieharder test suite

Empirical randomness testing uses various types of statistical methods to test for randomness based on hypothesis testing. Generally, in this type of testing, the null hypothesis H_0 is set, which generally reads: *the sequence under test is random*. Directly related to the definition of the null hypothesis is the alternative hypothesis H_1 , which takes the opposite claim to H_0 , namely that: *the sequence under test is not random*. Initially, the position is taken that the null hypothesis is true and, on the basis of a given statistical test, an attempt is made to show that it is not. If the test is confirmatory then the null hypothesis is rejected and the alternative hypothesis is accepted as valid for the given random sequence under test. Otherwise, there is no basis for rejecting the null hypothesis H_0 (Bobrowski, 1986).

Directly connected with hypothesis testing is the determination of the significance level α for a given test. For the adopted significance level α there is a critical area R_α . If the value of the K statistic does not belong to the critical area R_α , we have no grounds to reject the hypothesis of randomness of the sample. Otherwise, we reject the null hypothesis and accept the alternative one that the sample is not random. A significance level of $\alpha = 0.005$ was assumed in the conducted study.

To allow easier analysis of results, each statistical test provides a result in the form of a number called P_{value} . Each P_{value} is the probability that an ideal random number generator would generate a sequence of numbers less random than the sequence being tested. Note that if P_{value} for the test equals 0, then the sequence of numbers appears to be completely non-random. This is because we need to perform many statistical tests in order to accurately test a sequence of numbers against the null hypothesis of randomness. Each statistical test examining different characteristics provides a non-normal value of the statistic. Only the calculation of P_{value} introduces a standardised measure for the entire set of statistical tests.

A positive pass of a given statistical test is taken to mean that the inequality $P_{value} > \alpha$ must be satisfied. In addition, in order to consider that a given sequence does not show basis for rejecting the hypothesis of its randomness, the sequence must obtain positive results for all tests in the battery.

The Dieharder statistical test battery (Brown, 2022) was developed by Robert G. Brown based on the Diehard test battery proposed by George Marsaglia (Marsaglia, 1996). The author has improved and developed the basic battery with additional statistical tests. The current version 3.31.1 has 31 implemented tests listed in table 1. Not all tests are considered reliable, therefore the author of this paper marks 4 tests as not recommended in randomness testing. In this paper the non-recommended tests have been omitted.

4. Description of research method

Test samples with sizes close to 5GB were obtained from each of the six generators. Each test from the Dieharder battery was repeated a hundred times in five iterations, obtaining multiple P_{value} for each test of a given generator. This fulfils the requirement for multiple string testing to minimise the possibility of confusion. Finally, the Kolmogorov-Smirnov statistic is calculated. This test is designed to verify that for a given significance level $\alpha = 0.005$ the obtained distribution of P_{value} values is consistent with the theoretical uniform distribution. Application of this test allows to obtain an unambiguous answer whether a given generator can be considered random. The Python library `scipy.stats` and the `kstest` test were used to calculate the statistic. The library easily allows to calculate the Kolmogorov-Smirnov consistency test providing the result in the form of normalized P_{value} .

In addition, the final value calculated for the tested generators will answer the question of whether the battery of Dieharder tests will be able to show that the quantum random number generator is superior to algorithmic generators. If this is the case, then the Kolmogorov-Smirnov test should show a better distribution of P_{value} derived from individual statistical tests for this generator relative to deterministic generators.

Table 1.*Randomnes test results obtained using the Dieharder test battery*

No.	Test name	Test status	Random number generators test results					
			rand()	ran1	random256 glibc	/dev/ urandom	triple pendulum	ANU QRNG
1.	Diehard Birthdays	Good	passed	passed	passed	passed	passed	passed
2.	Diehard OPERM5	Good	passed	passed	passed	passed	passed	passed
3.	Diehard 32x32 Binary Rank	Good	passed	passed	passed	passed	passed	passed
4.	Diehard 6x8 Binary Rank	Good	failed	passed	passed	passed	passed	passed
5.	Diehard Bitstream	Good	failed	passed	passed	passed	passed	passed
6.	Diehard OPSO	Suspected	skipped					
7.	Diehard OQSO	Suspected	skipped					
8.	Diehard DNA	Suspected	skipped					
9.	Diehard Count the 1s (stream)	Good	failed	passed	passed	passed	passed	passed
10.	Diehard Count the 1s Test (byte)	Good	failed	passed	passed	failed	passed	passed
11.	Diehard Parking Lot	Good	passed	passed	passed	passed	passed	passed
12.	Diehard Minimum Distance (2d Circle)	Good	passed	passed	passed	passed	passed	passed
13.	Diehard 3d Sphere (Minimum Distance)	Good	passed	passed	passed	passed	passed	passed
14.	Diehard Squeeze	Good	passed	passed	passed	passed	passed	passed
15.	Diehard Sums	Bad	skipped					
16.	Diehard Craps	Good	passed	passed	passed	passed	passed	passed
17.	Marsaglia and Tsang GCD	Good	failed	passed	passed	passed	passed	passed
18.	STS Monobit	Good	passed	passed	passed	passed	passed	passed
19.	STS Runs	Good	passed	passed	passed	passed	passed	passed
20.	STS Serial (Generalized)	Good	passed	passed	passed	passed	passed	passed
21.	Diehards Runs	Good	passed	passed	failed	passed	passed	passed
22.	RGB Generalized Minimum Distance	Good	failed	passed	passed	passed	passed	passed
23.	RGB Permutations	Good	passed	passed	passed	passed	passed	passed
24.	RGB Lagged Sum	Good	passed	passed	passed	passed	passed	passed
25.	RGB Kolmogorov- Smirnov	Good	passed	passed	passed	passed	passed	passed
26.	Byte Distribution	Good	failed	passed	passed	passed	passed	passed
27.	DAB DCT	Good	failed	passed	passed	passed	passed	passed
28.	DAB Fill Tree	Good	passed	passed	passed	passed	passed	passed
29.	DAB Fill Tree 2	Good	failed	passed	passed	passed	passed	passed
30.	DAB Monobit 2	Good	failed	passed	passed	passed	passed	passed

5. Results

The test results based on P_{value} for all iterations are presented in table 1. It is impossible to present the exact P_{value} in a concise form, so the final judgment based on the calculated P_{value} is presented. A test was considered to have failed if at least one iteration of the test failed.

The generators *rand()*, *random256-glibc2* and */dev/urandom* were qualified as not random for a given level of significance. No basis was found to reject the hypothesis of randomness for the generators *ran1*, *triple pendulum* and *ANU QRNG*.

Table 2 shows the results of calculating the final Kolmogorov-Smirnov consistency test for the obtained P_{values} .

Table 2.

Kolmogorov-Smirnov consistency test for the obtained P_{values} .

Generator	Kolmogorov-Smirnov uniformity test P_{value}	Result
rand()	$6.18 \cdot 10^{-23}$	failed
ran1	0.40815	passed
random256-glibc2	0.19808	passed
/dev/urandom	0.06175	passed
triple pendulum	0.19757	passed
ANU QRNG	0.03800	passed

6. Summary and discussion

The obtained results confirm that algorithmic pseudorandom number generators are generally of low quality. This was particularly evident for the *rand()* generator from the standard C/C++ library. The *random256-glibc2* and */dev/urandom* generators using system interrupts performed slightly better. This may seem quite unexpected, as it is a generator that does not use a specific mathematical algorithm. However, if you consider the fact that in the operating system many interrupts are executed in a cyclic manner, you can expect a certain repetitiveness that will manifest itself in the generated numbers. The only algorithmic generator that passed all the tests positively is the *ran1* generator. The tests for the *triple pendulum* generator were also positive, which confirms that the chaotic nature of this classical phenomenon is so high that statistical tests are unable to find determinism. The *ANU QRNG* quantum generator, as expected, passed the test positively.

It remained to answer the question whether, based on the obtained results, we are able to indicate which generator is a truly random generator, e.g. a quantum generator. For this purpose, the Kolmogorov-Smirnov test was performed, the results of which are presented in table 2. The value of this test determines the uniformity of the distribution of all P_{value} values. The Kolmogorov-Smirnov test itself, from the Python library *scipy.stats*, provides a result in

the form of a P_{value} specifying the probability that the two distributions are identical. It is expected that this value should be as high as possible. Which would indicate a good distribution of values with respect to the theoretical uniform distribution. As can be seen from the above results in table 2, the *ANU QRNG* quantum generator received a lower score than other deterministic generators. Thus, the result did not confirm the high fit of the two distributions, which does not prejudice the non-randomness of a given generator. It follows that we are not able on the basis of statistical hypothesis testing with the Dieharder battery to determine additionally the quality of a given generator, but only to determine whether there are no basis to reject the generator as non-random. Statistical testing only has the character of a negative criterion. In the absence of basis to reject the hypothesis of randomness, statistical testing does not provide a mechanism to account for how positive the tested sequence of numbers was. Thus, a quantum generator in a positive way is not distinguishable in statistical testing from deterministic generators.

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STRATEGY OF CHOOSING A MOBILE APPLICATION FOR SMALL ARCHITECTURE DESIGN

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Purpose: The aim of the work is to present the concept of the mobile application strategy choice in the process of architectural design.

Design/methodology/approach: The best solution to the problem would be to develop and design application and implement on mobile platform.

Findings: This system is the most popular system for mobile devices in Poland.

Research limitations/implications: The work focuses on presenting the concept of an application that facilitates establishing contacts between representatives of architecture industries.

Practical implications: This is an important issue for future users as it allows for product improvement.

Originality/value: The application can be a preliminary step to developing a conflict management strategy.

Keywords: information technology, architectural design, strategy, mobile application.

Category of the paper: Research paper.

1. Introduction

Poland is famous for an established there culture of buying houses and flats, especially by young people who organize their family life. In order to meet the expectations of citizens, a number of government programs have appeared in recent years. These programs help young people to meet the needs by providing solutions enabling the purchase of their first own flat or house. The “Mieszkanie dla Młodych” (MDM) program, introduced by the Act of 27 September 2013 on Polish state aid in the purchase of the first apartment by young people (Ustawa..., 2013), was very popular. The aim of this program was to provide financial support to young people who would like to buy their first apartment or house as well as just wish to move to a larger apartment (in case of a large family). In spite of new problems that appeared for the

youth - in particular numerous refusals by banks to grant loans for the purchase of their first house/apartment caused by inability to set aside funds for own contribution, required by banks in an increasingly higher amount - another government program appeared, constituting a response related to the new housing market situation. By the Act of October 1, 2021 on a guaranteed housing loan (Ustawa..., 2021), solutions were introduced that allow the purchase of the first flat or house to own property, provided that certain statutory conditions are met, but without the need for young people to have the money necessary to cover their own contribution. The broad interest of the young people in these programs over several years has resulted in further-reaching consequences, such as the preparation by banks of appropriate products in the form of mortgage loans. These programs were also adapted to statutory requirements they had to meet. The other consequences provoked by the interest of youth in aforementioned programs included active actions by developers, who in order to gain a client, tried to comply with the conditions specified by the legislator (in particular with regard to the area of premises). In view of the numerous amenities provided by housing programs and the positive response from the housing market in the form of banks and developers, young people took steps to meet their housing needs.

There is no doubt that all real estate purchases involve renovation. Renovation is preceded by a project in tact with visualization of the project's effect. It is a necessary part of the operation before the renovation begins. It is often forgotten when planning the necessary action steps. Architects propose to buy a ready-made design, which is an expensive solution. What does the proposal to develop a project look like? One looks for interior design solutions inspiration elements on the Internet. Most often, the solutions are found on web platforms, which means that it is a common way of shaping the vision of decorating your apartment.

An analysis of the existing solutions presented in this paper was carried out. The study was conducted through a thorough analysis of the needs of people looking for competitive solutions on the market. The analysis will enable the selection of essential functionalities and the designation of the amenities desired by the client, which in turn will lead to designing the interior of the apartment in an optimal way.

2. Description of mobile solutions for interior design

This chapter presents an analysis of the user's needs of a mobile application for interior design. The technology available on the market was discussed, and the best solutions for the implementation of the application were indicated. The focus was on the description of the application intended for the mobile platform (Android, 2015). The applications were analyzed according to the following criteria (Borek, Sobczak, 2016):

- a) brief introduction to the application,
- b) list of functionalities,
- c) user-friendliness and interface aesthetics,
- d) a list of advantages and disadvantages of the application,
- e) general evaluation of the application issued by its authors.

Five mobile applications were selected to compare the solutions available on the market. The selection criterion is their availability free of charge in the AppStore (AppStore, 2022). This store is installed on all iOS devices (Hegarty, 2015). These applications are:

1. The "HOMEBOOK" application (Homebook, 2016).
2. The "DECOROOM" application (Decoroom, 2022).
3. The " We are decorating the house and apartment" application (Title in Polish: "Urządzamy dom i mieszkanie " application (Urządzamy dom i mieszkanie, 2016, 2022).
4. The "Pinterest" application (Pinterest help, 2021).
5. The "HomeStyle" application (Borek, Sobczak, 2016).

Ad. 1. You can download the Homebook application from the AppStore (AppStore, 2022). The creator of this application is the former company Domodi Sp. z o. o. It is the transfer of functionality from the homebook.pl web platform to the iOS application (Hegarty, 2016). The Homebook application is a tool for finding the selected interior design. It is not a social application. Although the application has a forum, there is no interaction between users when analyzing the number of responses.

The functionalities of the Homebook application are as follows (Borek and Sobczak, 2016):

- a) it is possible to view photos of the interior,
- b) it is possible to redirect the user to the stores where the selected products are available,
- c) the application has a tab with articles that have been designed by homebook.pl (homebook.pl, 2016), as well as by other companies, for example Generit, Castorama, VAKU-DSGN, etc.,
- d) it is possible to conduct discussions on the forum, but this functionality is not used by users.

After turning on the application, a photo appears as well as menu on the bottom bar with buttons: start, Products, Inspirations, Articles, More. There is a search engine in the middle of the top bar. Browsing for inspiration is nice, but saving a photo is not intuitive.

The advantages of the Homebook mobile application are (AppStore, 2022):

- application transparency,
- the ability to save selected interiors,
- having a list of articles,
- the possibility of shopping.

The disadvantages of this application are (AppStore, 2022):

- no possibility to quickly save a photo,
- poor interaction between users.

It is reasonable to note that the Homebook is a well-developed, user-friendly application and the photos that can be seen there are of a good quality.

Ad. 2. The Decoroom application is a solution dedicated to the iOS mobile platform (Decoroom, 2022). It is in English language. The user selects a standard package or a premium package. An interesting fact is that browsing the application is in the form of translating newspaper pages. These cards display the proposed interior fittings. It is interesting that the user has the opportunity to view photos of ready-made interiors, as well as fragments of interior fittings, fragments of the floor and fragments of interior doors. The way of presenting the interior as an electronic newspaper in the form of tiny elements is not a convenient way to view products that interest you. The elements are small and you can't see the details, and screen magnification is a problem as you are not continuously magnifying the image. This is, we can say, a disadvantage of the application. The advantage of this application, however, is the high quality of viewing photos and well-known brands of companies used to view an interior design.

Ad. 3. The "Urządzamy dom i mieszkanie" application is also a solution intended for the iOS mobile platform ("Urządzamy dom i mieszkanie", 2016). It contains the electronic version of the magazine (journal) of the Murator publishing house under the title: "Urządzamy dom i mieszkanie" - Polish Journal on We are decorating the house and apartment (Urządzamy dom i mieszkanie, 2022). The advantage of this application is that one screen takes up one page of the magazine. The elements are enlarged continuously. The user can continuously reduce or enlarge them. This enables user-friendly reading of the text, item descriptions and comments. Clicking on a product contained in the electronic warehouse may take the user to the manufacturer's website. This is a great convenience for the users of the magazine. The paper version of the newspaper was transferred here to the mobile application. This application contains brands of well-known companies.

Ad. 4. The Pinterest mobile application (Why is Pinteriset, 2021) is an American social networking site that allows users to share visual materials, i.e. videos, pictures, photos, GIFs. The name PINTEREST is a combination of two English words: "pin" and "interest". The elements visible on the platform are called PINA, which the user can add to his board or attach a pin that was posted by another user. The Pinterest application is used to save content for inspiration or to motivate to act on interior design. The user can easily and quickly develop a collection, called a table, in which he sorts the given thematic content in order to remember it or use it in the future. In the Pinterest application, you can be inspired by, among others, interior design proposals. However, this has the disadvantage that after selecting a given picture with an exemplary interior design, the website sends more pictures with similar solutions. The advantage of the Pinterest application is the ability to send content by e-mail to different people who are not users of the portal, as well as creating group boards with other users that

allow you to collaborate on a specific board. The Pinterest application also serves as a platform to promote your services and products.

Ad. 5. The mobile HomeStyle application developed by two authors, Adam Borek and Daniel Sobczak at Wrocław University of Technology (Borek, Sobczak, 2016), is the highlight of the application for interior design. It has its own graphic identification, shown by a lamp on a red background. The lamp is, you could say, the basic element of interior design. As the authors of the project noted, the HomeStyle application designed to reduce the time that the user would have to spend on finding out how he could arrange his apartment or house. Therefore, it also saves the user's time.

The authors of the HomeStyle application (Borek and Sobczak, 2016) list a set of tasks that application users will be able to perform using the HomeStyle application:

1. An unregistered or logged-in user can log in to the application using an e-mail address and password.
2. Users who are not logged in can try the application by browsing the list of interior design proposals, the so-called lists of inspiration.
3. Logged in user can search for inspiration by tags.
4. A logged in user can view inspiration.
5. A logged in user has the opportunity to like inspiration.
6. A logged in user has the option of not liking the inspiration.
7. The logged in user can view the list of liked inspirations.
8. A logged in user can add his inspiration to the system.
9. A logged in user can go to the product page to purchase it.
10. A logged in user can view the list of products shown in the photo.
11. A logged in user has the option of reporting offensive or illegal texts.
12. A user may use the application in Polish.

Considering the above list of tasks that the user of the application can perform using the HomeStyle application, it is worth indicating the most important requirements from the user's point of view. These are:

- the option which makes it possible to view the inspiration of the apartments' interior design,
- the option to view the list of inspirations liked by the user.

The set of non-functional requirements provided by the above-mentioned authors of the HomeStyle application to be met by this mobile application is also interesting:

1. The application will be available for download by users in the Apple AppStore.
2. The mobile application will run on devices with iOS version at least 9.0 (Hegarty, 2016; Nahavandipoor, 2011).

These guidelines are standard requirements for the user to ensure the stability and reliability of the application. Since it is a social application, designing your own interior will be very easy.

3. Comparative analysis of the application for interior design

The mobile applications for interior design presented in chapter 2 have their advantages and disadvantages. “The Homebook”, “Decoroom” and “Urządzamy Dom i mieszkanie” applications are examples of those applications that are designed to transfer physical catalogs with furniture to the memory of a mobile phone in the form of a pdf file viewer (Borek, Sobczak, 2016). Such an approach to the issues of designing the interior design for apartment or house is not sufficient and not convenient to use. The first three applications related to interior design, mentioned in chapter 2, do not use the social aspect for mobile platforms.

This criterion is met by the HomeStyle application, which is a solution for the iPhone mobile platform. It helps you to find inspiration about the interior design of your home or apartment. It is a social application content of which populates stores such as Ikea and Black Red White – it’s also going to be populated by users who implement the application itself. It’s essential to emphasize that the software allows you to view inspiration with the save function in order to recreate selected interiors at any time using a mobile device with Internet access. Additionally, users can check the parameters and prices of selected interior fittings. This application is intended for every user who creates an apartment project and who would like to look for inspiration to develop your own interior design for a flat or house. It should be noted that the implemented platform consists of a mobile application and a server side that secures access to the necessary data and multimedia necessary to be displayed on the screen of the mobile phone as well as provides access to documentation that facilitates the operation of the application. To use the application, it is required to have an Internet access due to the constant synchronization with the database managed by the server side (Borek, Sobczak, 2016). The data is stored on a server with the history of users browsing the data.

4. Summary

The paper presents the most important Internet applications that are used to design architectural interior design of an apartment or house. The issues of self-designing interior design are described. The presented applications were analyzed and the most user-friendly solution was identified. Apple presented on its website the criterion of what should be a graphical interface in iOS (Nahavandipoor, 2012; Sadun, 2013). This criterion is that the user's screen of the mobile application is to be legible and user-friendly. These user interfaces were analyzed for their intuitiveness and aesthetics. This screen, as mentioned, should be clear and aesthetic.

The article shows that the social platform of the interior design application is based on two aspects: the mobile application and the server side. They are the most important elements of the implemented solutions in the architectural design of the interior design of apartments or houses. Architectural patterns and the presentation of source code fragments were taken into account. These elements influenced the legibility of the existing solution and its quality.

When designing very complex software, its basic element is comprehensive testing of the most important functionalities of the application. Using this approach will allow you to find gaps in the application for architectural design of the interior design of a house or apartment.

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FACTORS CONTRIBUTING TO THE FORMATION OF A PROJECT TEAM SUBCULTURE – CASE STUDIES

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Purpose: In the literature relatively little attention is paid to the project team subculture. On the other side, according to theory of weak ties, even with a minimal amount of contact among people, it is possible to develop shared norms and values. Also the project management practitioners believe that the execution of projects often requires a different project culture. The purpose of this paper is twofold. Firstly, it aims to describe the factors that foster the formation of a project team subculture with the use of the case study analysis. Secondly, it attempts to assess the importance of these factors for forming this subculture, making use of the respondents' opinions.

Design/methodology/approach: The research method used for this study is the multiple case study, in which cases are replicated so as to show both similarities and differences found in the phenomena studied and in their context. The case studies used various research techniques such as interviews, direct observation and participant observation as well as surveys.

Findings: The formation of the project team subculture was fostered primarily by organisational structure, project properties and the authority or power of the project manager.

Research limitations/implications: The role in the formation of the project team subculture (1) by the acceptance of working in a project team, (2) by the education and qualifications of project team members and (3) by dynamics and complexity of the project environment is not clear and this indicates the need for further research in this area.

Practical implications: Organizational culture has been considered an important success factor for over 40 years. In the case of the project team subculture, a similar relationship can be expected.

Originality/value: The case studies have illustrated the existence of the project team subculture. This means that, if individual projects are unique, searching for norms and values in the project team is more relevant than making general recommendations at the project management subculture level or the organisational culture level. The subculture of the project team becomes a level of analysis that is difficult to ignore and should be a part of the project management research.

Keywords: project management, project team, culture.

Category of the paper: research paper.

1. Introduction

The growing importance of changes and projects in the activities of organisations is now referred to in the literature as *projectification*, which means that projects have become one of the primary forms of implementing activities, not only within organisations but also outside of them (Jałocha, 2019). In the case of enterprises, their management increasingly seeks to build a project organisation, which is a collection of individuals and institutions working (successfully) together to execute projects. However, it quickly becomes apparent that the introduction of project management involves numerous organisational changes, including those present in the sphere of organisational culture. This problem is reflected in scientific studies on, among others, cultural aspects of project management. Thus, first of all, there has emerged an entire research trend oriented towards the search for an organisational culture that positively influences project management and, consequently, project success (e.g. (Kendra, Taplin, 2004; Belassi, Kondra, Tukel, 2007; Morrison, Brown, Smit, 2008; Aronson, Lechler, 2009)). Secondly, scholars have started to describe the subculture associated with project implementation in the organisation, which reflects, on the one hand, the norms and values of the process organisation and, on the other hand, the norms and values typical of project work, i.e., the project organisational culture (e.g. (Firth, Krut, 1991; Thomas, Marossezeky, Karim, Davis, McGeorge, 2002; Wang, 2001; Zuo, Zillante, 2006; Du Plessis, Hoole, 2006; Stare, 2012; Nguyen, Watanabe, 2017; Aguilera, Alba, 2018)). In this context, some authors have started to see another – third – area of exploration. For example, Kerzner (2001) notes that both the project manager and line manager can develop a mutually acceptable project culture and cooperation principles, pointing to an even lower possible level of analysis, which is a specific single project and the project team associated with it. In this way, a subculture is to be formed. Such subculture results from norms and values arising from the needs of carrying out a specific project and the constraints that the organisation with its culture creates. Kerzner's observations are echoed in studies carried out by such authors as Aronson and Lechler (2006), Fellows, Grisham and Tjihuis (2007) and Szeptuch and Dyla (2015). Interestingly, by 2022, the number of queries of the term *project team subculture* in Google Scholar databases was only a few literature items, which indicates that the potential research direction signalled by Kerzner has not received the attention of many researchers. This can be explained by the probable belief that, first of all, the composition of project teams is often not fixed. Individual people involved in the project come in, complete their tasks in the project and leave. Therefore, there will be project team members who are in it from the beginning to the end as well as those who will be in it only for a while. Secondly, the people involved in the project can simultaneously, for instance, on the same day, work in their line position and the project. This means that they divide their working time to perform both repetitive processes and unique tasks in the project. Thirdly, many employees are simultaneously members of several project teams. Fourthly,

the project manager himself may also change. All of this speaks somewhat against the emergence of a project team subculture even in relatively long-running projects. Nevertheless, the existence of the aforementioned project organisational culture in the organisation can accelerate the formation of norms and values in the newly formed team, whose members not only form a kind of project community in the organisation but may also already know one another from previous projects. In addition, for example, according to Granovetter's (1983) theory of weak ties, even with a minimal amount of contact among people, it is possible to develop shared norms and values (Grzesiuk, 2015), which is facilitated today by the available modes of communication and social networks or social roles of project team members. Finally, it is essential to keep in mind that the subcultural distinctiveness of a project team does not have to apply to all aspects of the culture and could mean, for example, just a different approach to risk or a different way of managing employees. Likewise, the project team subculture does not have to challenge the core norms and values of the organisational culture; instead, it can highlight them.

Doubts arising from the nature of projects and, in addition, few theoretical studies justify researching the issue of the project team subculture. Thus, the purpose of this article is twofold. First, it aims to describe the factors that foster the formation of a project team subculture with the use of the case study analysis. Secondly, it attempts to assess the importance of these factors for forming this subculture, making use of the study respondents' opinions.

2. Theoretical framework

As Mingus (2002) notes, traditional project management is seen mainly as planning, scheduling and controlling a project to achieve its objectives. The author points out that this understanding of project management, unfortunately, overlooks important personnel relationships. She rightly points out, therefore, that the success of a project is measured not only by its completion on time, maintenance of the planned budget, fulfilment of goals or customer satisfaction but also by good relations among employees. This perception of project management is consistent with the definition offered by the Project Management Institute, according to which project management stands for the application of knowledge, skills, tools and techniques of project operations to meet or even exceed the needs and expectations of project stakeholders (Mingus, 2002). In the following discussion, what will be regarded as project-related stakeholders will be primarily participants in the project organisation who are, on the one hand, the representatives of the organisational culture of the entire enterprise and, on the other hand, members of the project team. Within the project team, as indicated, for example, by Kerzner (2001), Aronson and Lechler (2006), Fellows, Grisham and Tjihuis (2007) or Szeptuch and Dyla (2015), specific norms and values typical of the project currently

underway, different from those of the enterprise's organisational culture, are developed. Moreover, they lead to the formation of an organisational subculture. This subculture is referred to as the project team subculture. It is characterised, on the one hand, by norms and values typical of the organisational culture (e.g., of a particular enterprise) and, on the other hand, by norms and values developed during project management and in the course of carrying out project tasks by project team members (Kamiński, 2021).

According to Kerzner (2001), a project team subculture is created by project managers. They can develop subcultures for their projects, especially when the timeframe for their implementation will be many years. Such project cultures develop within the constraints created by the organisational culture, which justifies calling them subcultures. As observed by Kerzner, this results from the fact that the project manager should not expect top management will express their consent to completely free activities. Therefore, within the scope of his/her authority, he/she must respect not only the interests of the project but also those of the organisation in which the project is implemented. Kerzner states that this means that a subculture results from norms and values arising from the needs of executing a specific project and, at the same time, from the constraints created by the organisation along with its culture.

Aronson and Lechler also point to the project team subculture (2006). In their view, the content of the subculture is specific to the project and reflects the work carried out within the project and the basic tasks that team members must perform. The authors provide the factors influencing the formation of subcultures. These are the nature of the project that differs from routine tasks carried out by the organisation, the matrix organisational structure in whose area the projects are carried out or the norms brought to the project team by its members. Aronson and Lechler show that constructive project team norms (achievement orientation, self-fulfilment, humanism, affiliation, that is, the norms that lead to taking the initiative and collaboration) influence project success. In fact, a constructive project team subculture is an essential predictor of project success which may include business success, customer satisfaction and increased project knowledge.

However, Szeptuch and Dyla (2015) note that project teams produce their own organisational culture. Therefore, the project manager plays a critical role in building culture in the work of the project team. It is up to the project manager whether what will be promoted in the team is, for example, a culture of blame or influence, which, according to the authors, significantly translates into project success. The following characteristics of the project team subculture emerge from their empirical research: lack of prejudice and inhibition in team cooperation with people of other nationalities and cultures, a common language and system of terms, the influence of norms and principles of behaviours promoted in the organisation on integrating employees within the project team.

Based on the analysis of the studies cited, it can be noted that the authors point to factors that affect the formation of a project team subculture. These include the nature of the project, the (matrix) organisational structure and the figure of the project manager. In addition, it should

be noted that the literature on the issue of organisational subcultures points to several other factors influencing their formation (Maanen, Barley, 1985; Trice, Beyer, 1993; Boisnier, Chatman, 2003; Schreyögg, Geiger, 2016; Schein, 2017). Thus, in the first place, these include the organisation participants' education and qualifications, their properties and their environment. The impact of all the already mentioned factors on forming the project team subculture will be discussed below.

If it is assumed, following Aronson and Lechler (2006), that **the project nature** is related to how the project differs from the routine tasks performed by the organisation, then the description of project characteristics developed by Shenhar and Dvir (2008) can be used to determine this nature of the project. They base their approach on four dimensions of a project – the degree of novelty or innovation of the project, its complexity level, its pace and the level of technology. Thus, in project innovation, Shenhar and Dvir (2008) distinguish its three levels: a derivative project, a platform-based project and a breakthrough project. As far as project complexity is concerned, they identify assembly, system and matrix projects. As regards the project pace, they specify a normal pace, a fast (competitive) pace, a critical pace and an instant pace. Furthermore, in the case of the level of technological uncertainty, they speak about technologically non-advanced projects based on mature, known technologies, technologically medium-advanced projects, high-technology projects with significant technological uncertainty involving new but already known technologies and very high-technology projects with very high technological uncertainty requiring the development of new technologies that do not exist at the time of project initiation. The cited authors recommend a differentiated approach to projects of a different nature in terms of the dimensions discussed. When the intensity of project features is not high, the project can be managed based on an approach similar to the management of enterprise's routine operations. On the other hand, when the innovation, complexity and pace of project implementation are greater and the type of project technology is higher, the more the nature of the project deviates from the routine tasks performed by the organisation and the more it will foster the formation of a project team subculture (Kamiński 2020).

As regards **the organisational structure**, it was studied by, among others, Trocki (2009), who made an extensive review of project-related structural arrangements. Among others, he distinguished between a line-structured project organisation, a line-staff project organisation, a matrix project organisation, or a “pure” project organisation. According to him, the aforementioned forms of project organisation can be characterised by two factors – the position and autonomy of the project in the structure of the parent organisation. The project position depends on the importance of the project to the parent organisation and its specialisation while the project autonomy depends on its complexity and innovation. Thus, if in the case of a project organisation in a line structure, there is the highest degree of integration of the parent structure and the project team and the project tasks are performed by the units of the parent organisation, then, in the case of a “pure” project organisation, there is

complete separation of current activities from the activities for the project (there is no involvement of the people implementing the project in the current activities of the institution). The project manager has the total organisational capacity necessary to manage the project, and the assignment of employees to the project is also complete and unambiguous. This isolation of project team members (in a pure project organisation) should promote the formation of different norms and values and, consequently, the formation of a project team subculture (Kamiński, 2020).

Then, attention should be directed to **the project manager's** possible influence on forming the project team subculture. It is so since it is widely believed that executives strongly influence the formation of norms and values (Schein, 2017; Zbiegień-Maciąg, 2005; Kets de Vries, Miller, 1984). This influence should be analysed with respect to two aspects: (1) the project manager's ability to influence the project team and (2) the norms and values the manager will disseminate to the project team. As Lichtarski (2008, 2018) observes, in the case of power, regardless of the way projects are executed in the organisation and their temporality, the implementation of projects means a move away from the unity of giving commands towards a multiplicity of power centres; it means a distortion of the stable hierarchy, which will be replaced by a more complex and fluid heterarchical coordination. What is more, project managers are increasingly seen as leaders whose role is not only to manage the project but also to create shared norms and values within the project team (Grzesik, Piwowar-Sulej, 2013; Jędrych, Pietras, Szczepańczyk, 2016; Marek-Kołodziej, Łapuńska, Jagoda-Sobalak, 2018). Therefore, whether the project manager's behaviour is in line with the organisational culture or whether it is based on other norms and values (e.g., external to the organisation or his/her own) will, as might be thought, influence forming the project team subculture. This influence, however, depends primarily on the project manager's power. Therefore, the project manager with more power also has more power to shape the subculture of the project team (Kamiński, 2021).

In the case of the influence of **the education and qualifications of organisational participants** on subculture formation, it is essential to point to the studies of Trice and Beyer, which are deemed to be fundamental in this regard (Trice, 1993; Trice, Beyer, 1993). Those scholars, who focus on professional subcultures, point to the importance of the existence of specific hermetic knowledge and know-how, high or unusual emotional demands (the nature of work in many professions requires dealing with various emotions), awareness of people's membership in a given professional group, the omnipresence of professional norms and contacts that go beyond the work-related sphere, the favourable image of a given professional group, the extent to which representatives of a given profession are a point of reference for one another in shaping behaviours (developing a professional subculture will be possible if the members of professional groups imitate one another, treat one another as authorises or compare themselves to one another).

Assuming that the project implemented requires, to some degree, (by definition, so to speak) a unique approach, it will also sometimes require specialised knowledge, education and qualifications different from those typically needed to carry out repetitive processes in the organisation. As might be thought, it is the different education and qualifications of project team members that may lead to the formation of a specific subculture. In other words, the more project team members differ in their education and qualifications from other employees in the organisation, the more this will foster the formation of the project team subculture.

Further, **the properties of organisation participants** related to their (1) reactivity, (2) satisfaction and (3) commitment (Boisnier, Chatman, 2003) are also factors contributing to the formation of subcultures. According to the cited authors, these factors influence people's propensity for joining and/or forming subcultures.

First, the psychological phenomenon of reactance involves an individual's desire to restore his/her freedom of choice, which is threatened by someone trying to impose something on him/her or prohibit him/her something). Reactance is measured by determining whether people tend to polemicise, are unwilling to cooperate, behave in a manner described as deviant, are unwilling to take advice from others and, for instance, to ask others how to do a job. It is believed that the phenomenon of reactance is stronger if a more important opportunity for action is taken away from a person, more opportunities are blocked or taken away or the threat to freedom of action is greater (Trejderowski, 2009). In the case of organisations, those who do not share the values of the prevailing organisational culture will therefore flee to subcultures in which certain generally unacceptable behaviours are acceptable. In this context, Boisnier and Chatman (2003) suggest that the phenomenon of reactance is more likely the stronger the organisational culture is. Ultimately, people characterised by higher reactance are more likely to join subcultures as they will reject the values of the (strong) culture regardless of their content.

Thus, in the case of a project team, some members of the organisation may view working in a project team as a more attractive alternative than their work in carrying out repetitive processes which are executed, for example, in the manner typical of a mechanistic organisation. Restricting the freedom of organisation members by the managers' authoritarianism, subordinating the individual to the social group, displaying conservatism, and achieving a high degree of standardisation and specialisation of activities may induce some organisation participants to escape to the subculture.

The drive to regain freedom and the desire to engage in innovative projects are indicated, for example, by Hammer (1998) and Wozniak (Wozniak, Łokaj, 2009). Hammer (1998) notes that if organisational cultures operate according to the principles of paternalism, employ control and bureaucratic mechanisms and target personal freedom, then all invention is lost in the maze of formal company rules. Hence, creative thinking is more likely to be developed outside working hours. However, during an interview, Wozniak speaks "about a small garage on the side-lines of the corporation". In his view, corporate culture can hinder the development of

ideas and a group of innovators should not be placed too deep in the organisational structure. It means that such a structure should not have too many hierarchical levels. Those innovators should not have too many superiors and decision-making dependencies above them. The management of the organisation must understand that true innovation, which brings things that are so new that they are called “revolutionary”, is almost always created not in the organisation but at home. It is created by young people who often work in their garages. This is why highly innovative organisations provide their employees with 20% of their working time to develop their own ideas and projects independently.

Additionally, people’s propensity for joining and/or forming subcultures depends on employees’ satisfaction with the dominant values in the subcultures in question (Martin, Siehl, 1983; Graham, 1986; Rose, 1988; Cha, Edmondson, 2001; Boisnier, Chatman, 2003). This effect is amplified if, for example, employees are additionally dissatisfied with the organisational culture in which they find themselves or when the organisational subculture helps create norms and values that are more relevant to them (e.g., from the perspective of the work they do). Thus, if the organisation participants see an opportunity to achieve their goals better in the subculture than in the organisational culture, they will willingly join the subculture.

Furthermore, commitment, loyalty and identification with the organisation can also influence the formation of subcultures (Meyer, Allen, 1991; O’Reilly, Chatman, 1996). This strong commitment to the organisation can result from dispositional characteristics (i.e., the individual properties of an employee) and the organisational context. As regards the context, participants in organisations with a strong organisational culture are more committed and loyal and identify themselves more strongly with the enterprise. This phenomenon intensifies when there is the normative commitment to the organisation (organisation participants strongly identify themselves with and internalise its values), reducing the tendency to form subcultures. However, as the cited authors point out, in the case of the organisations where participation rests on the compliance-based commitment to the organisation or is instrumental, e.g., there is a need for extrinsic motivation for people to identify themselves with the organisation, the relationship between commitment and the presence or absence of subcultures is no longer explicit.

Similarly, in the case of commitment, loyalty and identification with the project team, it is possible to identify employees who are less attached to the organisation and identify themselves more strongly with their work in project teams. As Kanter (1998) noted many years ago, today’s highly skilled employees work hard, from task to task, and are concerned with the quality of their benefits, deriving their sense of self-esteem from the nature of the work they do, not from their association with a particular enterprise. Their professional value is reputation because employees need the professional values, skills and reputation they can use in many other jobs. Kanter states that “[t]hey are motivated by the attractiveness of the industry and the challenges that require constant improvement of skills and they dream of starting their own businesses in the future” (Kanter, 1998, p. 166). Such employees will identify themselves less

with the organisation and more with the project, which will foster the formation of the project team subculture.

In conclusion, if members find working in a project team more attractive than working in an organisation, they will believe that participation in a team leads to satisfying their needs and they will be committed to the project team. This, in turn, will promote the formation of the project team subculture.

Finally, Boisnier and Chatman (2003) distinguish yet another vital factor (indirectly) contributing to the formation of subcultures. It is **the dynamics of the environment** that, causing structural changes, trigger the emergence of subcultures. This is because the more dynamic the environment is, the greater the need to hire new employees with changing skills or to delegate power is. According to Bloor and Dawson (1994), it is just the dynamic environment that provides the opportunity for the emergence of occupational subcultures that begin to interpret the surrounding environment differently.

Like the factors considered at the organisational level, the way groups operate depends on the dynamics of the environment. If, for example, the demands of a particular environment segment become unusual, those involved in “serving” it will begin to develop a subculture that depends on it. For example, the need to respond to emerging problems of the environment may make the research team focus on adapting better to market needs the technology it has just developed and which has been positively received by the market, instead of developing another new technology (Benner, Tushman, 2003). In the case of this particular team, it will mean a change in values from those favouring research to those typical of a department dealing with implementation.

Project management depends on the context in which it takes place. This issue has been discussed by, among others, Collyer and Warren (2009), Stead (2010), Świętoniowska (2015) or Kopczyński (2013, 2016). They believe that the increase in the dynamics and, additionally, in the complexity of the environment affects the way projects are managed. They also highlight that traditional project management methodologies based on mechanistic approaches and cause-and-effect thinking cannot meet the challenges of modern projects. For this reason, there is a growing need and ability to adapt the project management approach to the current circumstances defined by the complexity, uncertainty, scope and criticality of the project, the nature of the people involved, their relationships and the project environment.

In the analysis of the impact of the environment dynamics and complexity on project management, it should be noted that the theme of projects executed in highly uncertain environments is one of the key project management issues which is still discussed today (Gray, Larson, 2011; Szpitter, 2012). It is linked to such issues as planning uncertain outcomes, balancing flexibility with reliability and accountability, balancing the quality of decisions against the speed of decision-making, and freezing project scope during rapid changes. According to Stead (2010), the complexity of the project environment affects the diversity of project team members in terms of their skills and experience. A diverse mix of what employees

bring to the team regarding their technical, business and cultural backgrounds increases the likelihood of project success.

In the context of the approaches presented above, it can be concluded that the increasing changeability and complexity of the environment requires the project manager to apply a situationally tailored approach to project team management. If it is assumed that the organisational culture reflects the management of repetitive activities, then its norms and values will refer to a higher degree of standardisation and formalisation of activities, lower risk, more evolutionary changes and relying primarily on historical data. However, in a project, the degree of standardisation and formalisation of activities will be lower, the risks higher, the changes rather radical and the project team rather future-oriented. Thus, it can be thought that the project team, depending on the environment in which it is located, will develop a specific subculture relevant to the current conditions. The extent to which it will be done will be the greater, the more heterogeneous and variable its environment is.

3. Research methodology and data collection

The research method used for this study is the case study method. Since organisational subculture is always understood with reference to the organisational culture, which is broader than the organisational subculture, the case study will allow showing the functioning of the project team in a broader organisational context. In addition, the case study will show how the processes and behaviours of the project team members affect the project team context and, conversely, how this context affects the processes and behaviours of the project team members. Furthermore, the so-called multiple case study was used, in which cases are replicated so as to show both similarities and differences found in the phenomena studied and in their context. The case studies used various research techniques such as interviews, direct observation and participant observation as well as surveys. Thus, the relationship of the factors leading to the formation of the project team subculture with the occurrence of the project team subculture will be discussed based on two case studies. The case studies presented differ both in the formation of the factors that foster the development of the project team subculture and in the strength of the project team subculture. In the first case study, the subculture of the project team is strong while in the second one, it is weak.

As regards the interviews, the sponsors of two projects, the manager of each project and four members of each project team were interviewed. Each interview lasted about one hour. After each interview, the summaries of the interviews were prepared.

As for observation, in one project, it was non-participatory observation (the author of this paper was a consultant of the management board of the enterprise where the project was implemented) while in the other project, it was participant observation (the author of this paper was a member of the project team).

Finally, survey questionnaires were also distributed to those interviewed to identify the strength of the project team subculture. The project team subculture will be stronger when, as viewed from the perspective of project team members, there is a difference in a bigger number of dimensions of culture (up to seven possible dimensions of culture) between the project team and the rest of the organization. The seven equivalent dimensions of culture (i.e., employee autonomy, degree of formalisation, support given to subordinates, identification with the organisation, rewards for performance, acceptance of conflict and acceptance of risk) were based on a study conducted by Hopkins, Hopkins and Mallette (2005). With one difference, the subculture of the project team is weak whereas it is very strong with seven differences. No such differences between the project team and the organisation mean that there is no project team subculture. The respondents were two project managers and six members of each project team (most of whom were non-participants in the interviews). Finally, seven correctly completed survey questionnaires were obtained for each project.

First, an attempt was made to assess the strength of the subculture of each project team. Then, the importance of various factors that foster the formation of the project team subculture was discussed in each of the two projects. Thus, reference was made to the nature of the project, the organisational form of the project, project team members' education and qualifications, project team members' acceptance of work in a given project, the project environment, and the figure of the project manager.

4. Case studies

4.1. Case study 1 – a project in heavy industry

The first project was executed in heavy industry. The core business activity of the enterprise was the execution of repetitive processes carried out on a large scale. The enterprise's position was stable (*e.g.*, in terms of its revenue), its operations were and are highly formalised and its processes are subject to strict procedures. Hence, it is necessary to meet state standards and regulations. Despite the strong repetitive nature of the processes carried out, the organisation had a total of dozens of projects divided into large (strategic), medium and small projects. It can be said that the implementation of projects according to a structured approach has become an element built into the organisation and directed to support the main business processes,

both in the area of improving efficiency, introducing innovation and in the area of solving problems and responding to production and organisational challenges.

The selected project concerned the development of changes in the way the enterprise's production facilities operate in order to achieve process parameters (Key Result Indicator (KRI) and Key Performance Indicators (KPI)). The context for its introduction was to change the long-established practice of production management based on planning and holding production plants accountable for final production outputs measured in such quantifiable quantities as pieces, tons, etc. This long-established practice led to a situation where the performance of production tasks in most periods and production plants was precisely equal to the assumed annual plans. In addition, due to external factors, planned and obtained production volumes steadily declined on a year-to-year basis. What is more, given the multitude of external factors affecting production processes, in the managers' opinion, the described approach did not allow understanding whether a given plan was optimal or whether it was too unambitious or its implementation came at an excessive cost. For this reason, frequent were the questions asked by the members of the supervisory board, for example, about the efficiency of the management of the production process. This prompted the enterprise's management to initiate a project involving the development of a production management strategy based on KPI measures. Due to its strategic importance and the required high level of involvement of top managers, the project was given priority, with a lead time of several months. The responsibility for its various modules was assigned directly to the directors of each production plant. The issues of coordination and "facilitation" of the material preparation process were entrusted to a unit located at the enterprise's management. The project was implemented on the basis of a corporate methodology developed from the PMBOK library of best practices.

As far as the individual dimensions of culture are concerned, the project team differed from the rest of the organisation in terms of:

- the autonomy of project team members: the team included directly and indirectly the top management of all production plants reporting directly to the vice-president of the management board so the project team members had a very high degree of autonomy as to how to perform project tasks;
- the lower degree of formalisation of activities: when the whole organisation was characterised by a very high degree of formalisation, the way of performing project tasks was practically not regulated by any documents, except for very general guidelines for working out the various elements of the project. However, it should be noted that the final result of the project was to be a comprehensive written study describing a functional production strategy;
- the support given to subordinates: the role of the project manager usually focused on the implementation of the project scope, schedule and budget; however, during the work of the team, the project manager provided assistance by clarifying doubts, supported the flow of information and shared his/her knowledge of the functioning of the entire

organisation and the desired parameters of the production processes. While the project team members were very independent, they were eager to involve the project manager in their discussions of the solutions being developed;

- the acceptance of conflicts: within the team, there was a very high degree of the acceptance of conflicts that arose. It can be said that they were a direct result of the nature of the project, which aimed to give a single direction to the various production facilities. Before the project, the activities of many plants were divergent and subordinated to the individual ambitions of their directors. What is more, it is worth noting that some of them were people with very strong personalities. In order for the project work to continue, the inconsistent activities had to be mitigated at the level of the project work (the role of the project manager) and at the level of their immediate supervisor, i.e., the vice-president;
- the acceptance of risk: the risk was to take many members of the project team outside their current comfort zone. They always met annual production targets while the project involved, among other things, identifying new key operating parameters and setting ambitious goals over a multi-year horizon. The solutions formulated in this way thus diverged sharply from operating on the basis of an annual horizon and on the basis of the fact that it was previously almost 100 per cent confident that annual plans would be achieved.

As regards the other two dimensions of culture, it should be noted that the project team members did not differ from the rest of the organisation's employees in terms of identifying themselves with their work. Likewise, there was no additional remuneration for participating in the project (like in other projects, except for the cases in which project managers were hired from outside or were delegated to the project full-time). However, an annual discretionary bonus system was in place throughout the organisation. It offered the possibility of additional remuneration for people who, for example, were involved in additional project work next to their line functions.

As can be seen, the project team differed from the rest of the organisation in terms of the five dimensions of culture out of the possible seven dimensions. Therefore, there was an attempt to explain the occurrence of a relatively strong subculture of the project team by analysing the various factors contributing to its formation.

Thus, the first factor considered to foster the formation of the project team subculture can be presented in the following way. In the case of the following project properties:

- the innovation of the project: It entailed aligning, within a single strategy, the interests of individual production facilities both as to their direction and business parameters, identifying and measuring key performance indicators (KPIs) so that the system forms a coherent and logical whole depicting cause-and-effect relationships and formulating a schedule of tasks to be implemented in order to achieve the identified KPIs. While the approach to solving problems was new, there had been a number of similar

projects in the enterprises before. This prompts us to characterise the project as a derivative project (according to Shenhar and Dvir) involving improving existing solutions,

- the level of complexity of the project: the project concerned the improvement of existing business practices at a number of plants linked together in a production sequence. What was characteristic of the project was the multiplicity of stakeholders and the divergence of their interests, which – in Shenhar and Dvir's typology – would allow classifying the project as moderately complex or systemic;
- the pace of the project: the project was to be implemented over several months so that the results could be presented at a specific meeting of the supervisory board. From this point of view, the project can be categorised as a time-critical project as long as completing the project on time was not crucial for the competitiveness of the enterprise. However, the expectations of the management board concerning the project deadline were clearly defined and absolutely unbreakable;
- the level of technology of the project: the project referred to existing and already used technologies in the enterprise. New technological solutions resulted at most from the project's defined undertakings scheduled for implementation at a later date. Therefore, the uncertainty of project technology was very low.

According to the respondents, what made the implemented project different from the others and contributed to the formation of a unique – in their opinion – subculture of the project team was, in the first place, the high pace of the project (i.e., high speed of project implementation resulting from the critical time of its implementation). Furthermore, the analysed organisation was always characterised by relatively long-term planning and the high degree of formalisation, standardisation of activities and centralisation (i.e., the bureaucratisation of the enterprise) meant that even small projects were implemented over a long period of time. On the other hand, while the complexity of the project (it is a systemic project) should argue for a stronger subculture of the project team, there have been many other projects of this nature in the organisation and the project in question did not stand out from the others in this regard. This is because a large number of projects in the organisation had multiple stakeholders, consisting of many subgroups and subcontractors (often coming from outside the organisation) and were coordinated by a central, formalised project office.

Second, members firmly accepted working in a project team. This is because the project was carried out as an official order from the vice-president directly to his subordinates. Because of the rank, subject matter, somewhat innovative approach to the project and the requirement for the project manager's frequent reporting, the plant directors were heavily involved in the work. The team members' commitment required them to devote time to working out the various components of the project but this did not interfere with other current responsibilities, which – for a short time – receded into the background. The project was assigned the highest priority, which facilitated its implementation. Thus, the team members fully accepted the project's

typical way of working and values (e.g., the flexibility of action, cooperation with others in a diverse environment, the need to share knowledge, learning, self-discipline and creativity). It should also be noted that the results of the project were strongly linked to the personal interests of many project team members (primarily the maintenance of their jobs in the long term). It was the high acceptance of working in a project team, the desire to attend all team meetings and the need “to have their finger on the pulse” that, according to the respondents, contributed significantly to the emergence of the project team subculture.

Third, the respondents pointed to the organisational form of the project. Its head served as a department director reporting directly to one of the vice-presidents of the management board (i.e., the sponsor). The project team consisted of the directors of each production plant also reporting directly to the sponsor. The project work at each manufacturing plant involved their top managers. In addition, the so-called “liaisons” were designated for operational and administrative work at the level of each production site, streamlining the transfer of data, arranging meetings and preparing materials, which greatly facilitated the project. In total, dozens of people participated in the project work. Using the forms of project organisation distinguished earlier, it can therefore be considered that the project was implemented in a line-staff structure. While this form of collaboration was not judged to be unique in the organisation, the project team, firstly, brought together individuals from the highest level of the hierarchy of the enterprise’s organisational structure and, secondly, was highly interdisciplinary as it included individuals representing the entire value chain of the enterprise. According to the respondents, this specific composition of the project, induced by the organisational form of the project, translated into a unique set of norms and values adhered to by the project team, different from the one found in the organisational culture.

As for the education and qualifications of the project team members, it should be noted that the project team members differed significantly from other employees of the enterprise. First of all, the project manager had extensive experience both in implementing projects involving all production plants and in understanding the business processes at each production plant, which allowed him to both efficiently coordinate the work and act as a facilitator and challenger in the development of the document. Secondly, the team consisted of production plant managers who had both technical expertise (also required by law) and management expertise confirmed by years of experience in managerial positions. The same was true of plant-level work teams. They consisted of senior managers and “liaisons” who served as the “right hand-men” of plant directors and were characterised by excellent knowledge of their organisations. Third, the project required educating the team on both the implementation approach (the strategy development process) as well as its individual elements (including, but not limited to, goal setting, strategic analysis, KRI and KPI parameter system, etc.). Fourth, the project was implemented with the support of an external company that both provided the implementation approach as well as provided the necessary training for the team and acted as a facilitator in discussions at the plant level and ensured that the work and results of the project

were consistent across the enterprise. In summary, the members of the project team had education and qualifications different from those which other employees of the organisation had. Thus, the respondents again stated that while people from outside the organisation were not included in the project team and no training was provided for the acquisition of skills related to the implementation of project tasks, the education and qualifications of the team members were justified the formation of a specific subculture.

According to the respondents, the formation of the subculture was not influenced by the figure of the project manager and the project environment. When the project manager started the project, he had already served for several years as a department director responsible, among others, for improving the efficiency of production. He also reported directly to the vice-president of the management board. The appointment as the project manager involved neither vertical nor financial advancement. His authority stemmed from his reporting directly to the vice-president of the management board (the sponsor), as well as his recognition at production sites as a result of previous projects. He also enjoyed the confidence of both production plant directors and top managers. As a result, he acted as both the coordinator of the work, the moderator and the aforementioned challenger during the content-related discussions. The sponsor's decisions were made following the project manager's recommendations. However, in the assessment of the influence of the figure of the project manager on the formation of the project team subculture, it should be noted that according to the respondents, the project manager's ability to influence the project team was relatively low. He had a weaker position in the line organisation compared to the project team members (in the rank of directors higher up the organisational structure hierarchy) and, although the norms and values he represented could be the basis for creating an organisational subculture, he did not strongly influence the norms and values of the project team members.

Finally, as regards the environment, its elements were relatively stable. The project team included the division of one of the vice-presidents of the management board. However, throughout the project and its importance for the production processes, a group of new internal stakeholders became active, mainly from support functions outside the production division. This had a twofold dimension. On the one hand, it became clear that the projected changes in production required changes and the involvement of other support functions and their confirmation of the implementation capabilities. However, on the other hand, there was a need to make the approach and action plan more consistent for those support functions that had already planned and implemented their own changes independently of project implementation. Hence, during the implementation of the project, it proved necessary to identify points of contact with other areas of the organisation and jointly develop an action plan. Overall, the project was characterised by the moderate uncertainty of the high complexity of the environment (it was stable and heterogeneous – i.e., it was complex), which, according to the respondents, was not crucial for the formation of the subculture of the project team.

4.2. Case study 2 – a project in the consumer goods industry

The second project was carried out in the Polish branch of an international enterprise involved in producing and promoting consumer goods, including household goods, medicines, and personal care products. The enterprise in question has dozens of production facilities and sells its products worldwide. The enterprise's operations have been and continue to be highly repetitive, dominated by mass production on automated production lines in a three-shift system. Due to the nature of production, the implementation of projects according to a structured approach was – at least in the Polish branch – very sporadic. The project in question consisted of launching the production of a new type of household chemicals, which was later to be sold on the European market. The project manager used a very general definition, schedule and budget for the project and it can be said that his conduct was largely intuitive.

As far as the individual dimensions of culture are concerned, the project team differed from the rest of the organisation in terms of:

- the autonomy that members of the project team had: they made their own decisions on how to set up the production line, they conducted experiments on their own and they learned from many mistakes;
- a lower degree of formalisation of activities: the activities implemented in the project were not regulated in any way;
- the acceptance of risk: the members of the project team took relatively high risks because there was very little time between finding a technological solution and implementing it in mass production. Thus, there was no question of long tests, trials, etc. The team's work could therefore have ended in a major failure and costly production line downtime.

As regards the other dimensions of culture, project team members were no different from the rest of the organisation's workforce. First, both in the repetitive activities of the enterprise (i.e., the production of household chemicals on production lines) and in the project, the employees were supported by their superiors. The project manager was always available to the project team members and they could count on his assistance. It can be said that management's availability to rank-and-file employees has been an enduring part of the enterprise's organisational culture. Second, the project team members were no different from the rest of the organisation's workforce in terms of identifying themselves with their work. The work they did in the project was as important to them as the organisation they worked for. It should be noted that the main reason for working in the manufacturing plant as well as in the project team, according to the interviewee, was the salary received. Third, conflicts were not accepted both inside and outside the project team. Differences of opinion were unlikely to arise or were not communicated by the employees. The deciding vote was always given to the supervisor – the line manager or, in the case in question, the project manager. Fourth, there was no additional compensation for project performance. This was in accordance with the

enterprise's policy that employees were paid according to the enterprise's prevailing wage scale. There was no bonus tied to the enterprise's performance.

As can be seen, the project team differed from the rest of the organisation in terms of three dimensions of culture out of the possible seven dimensions. This indicates the presence of a relatively weak project team subculture. An attempt was made to account for the weakness of the project team subculture by analysing individual factors.

In the case of the properties of the project, the factors that foster the development of the project team subculture were as follows:

- the innovation of the project: there were and still are more than a dozen types of similar products in the organisation's offer but the new product was characterised by the use of a different component that facilitated the production process and gave the end user a better quality of washed dishes. This was a pioneering solution as no manufacturer of dishwasher tablets had yet used it. On this basis, it can be concluded that the project was of platform character;
- the level of the complexity of the project: the project was an assembly project. It was performed within a single department (the production department), with the intensive exchange of information mainly among its employees, without administrative staff and special paperwork or documentation. The project manager focused on costs, quality and getting production up and running relatively quickly;
- the pace of the project: the project had to be completed quickly, within a few weeks. Completing the project on time was essential for the enterprise's competitiveness and its position as a leader as no one in the market had yet offered such a solution. In Shenhar and Dvir's typology, it allows classifying the project as fast or competitive;
- the level of project technology: the project had a medium level of technological uncertainty. The project team was tasked with developing a new technology for combining existing product ingredients with a new, innovative component. The technology was unknown and had yet to be developed during project work.

What can be regarded as the main factor conducive to the formation of the project team subculture is the properties of the project – its innovation, pace and technological uncertainty. According to the respondents, the project was something unique in the analysed organisation and strongly differed from repetitive production processes. The tasks carried out in the project required autonomy, a low degree of formalisation of activities and risk-taking, which stood in contrast to the norms and values of the process part of the organisation.

The emergence of a specific project team subculture and its functioning in the enterprise was attributed by the respondents secondarily to the person of the project manager. The project manager was the quality director. This person had worked at the plant for several years and had been in management for about two to three years. He enjoyed great authority among all the employees. The source of this authority was mainly his personality as the quality director was a very professional but – at the same time – a very warm and likeable person. Hence, while the

project manager's formal authority was high, it was coupled further with his knowledge and experience gained within the organisation. Naturally, the duties of the project manager and quality director had to be carried out simultaneously. However, as the respondents viewed it, in the case of the project manager who is simultaneously "entrenched" in the line structure, his authority is based not only on the authority he has been given to implement the project but also on the potential power he enjoys in the line structure. Thus, he is not a "temporary" figure for the project team members; he can often be their line supervisor and effectively seek the resources necessary to complete the project. As a result, he not only has a more significant impact on his subordinates than a project manager dedicated solely to project management but, by increasing the chances of project success, he also gets people more involved in the team.

Ultimately, from the perspective of the respondents, the different norms and values in the project team may have developed in certain isolation from the daily performance of duties thanks to the organisational form of the project. In addition to the project manager – the quality director, the project team consisted of the production manager, production line workers and quality department employees – a total of fifteen people. The team, including the project manager, was subordinate to the plant management. Thus, given its location in the organisational structure, it might be stated that there was the project organisation in a line structure with a separate project team (task force) to facilitate cross-functional work.

Other factors that foster the formation of the project team subculture were rated relatively low by the respondents. This means that in the case of:

- the education and qualifications of the project team members, it should be noted that the project team members were no different from other employees of the enterprise. The project manager selected the most conscientious people for the team from the production staff, who he was confident would fully commit to the project team after their working hours. There was no project-related training in the project. Nor were people from outside the organisation included in the project;
- the acceptance of working in a project team: the interviewees said that participation in the project team came with additional compensation, which was the main motivator for their involvement in the project. Project work was not perceived by anyone as a distinction or something attractive. The team also met on Saturdays, which was quite a burden for the employees working three shifts. The young production manager and the quality director could be considered the people most involved in the project. The project was challenging but they also found it interesting, allowing them to develop their creativity, learn more about the plant and processes, expand their management knowledge and test it in practice;
- the environment: due to the short duration of the project, it could be considered stable and simple. During the execution of the task, not even once was the team confronted with a change in external conditions or, for example, problems brought by new previously unaccounted-for stakeholders.

5. Concluding remarks

The case studies presented above have illustrated the factors that foster the formation of the project team subculture and, based on interviews and questionnaires, allowed assessing the importance of these factors for forming this subculture. Thus, in the first case study, the formation of the project team subculture was fostered primarily by such factors as the properties of the project (in particular, its pace), followed by the acceptance of working in the project team, the education and qualifications of project team members and, ultimately, the organisational form of the project. On the other hand, according to the respondents, in the household chemical manufacturing project, the essential factors were the properties of the project, the figure of the project manager and the organisational form of the project.

While the organisational structure has long been regarded as a factor that fosters the emergence of organisational subcultures (Maanen, Barley, 1985; Trice, Beyer, 1993; Boisnier, Chatman, 2003; Schreyögg, Geiger, 2016; Schein, 2017), project properties, according to the respondents, seem to foster the emergence of project team subcultures to varying degrees. The strength of the project team subculture can therefore vary as each project is a new constellation of management challenges and the project management process cannot be reduced to the repetition of familiar steps and procedures. Hence, as the case studies show, organisations can have both project teams whose norms and values will be close to the organisational culture and project teams that differ from the organisational culture in many ways.

Secondly, the research conducted indicates a possible link that exists between the authority or power of the project manager and the presence of the project team subculture. However, this is not just about the manager's authority with regard to project management but the authority he or she enjoys within the organisation. Hence, the power of any project manager is also dependent on the support he or she obtains for the project (Prosci, 2018). In addition, the authority of any project manager may depend on whether he or she is a line employee, whether he or she is also a line manager in the organisation where the project is being implemented or whether he or she comes from outside the organisation (Kamiński, 2022). It can be assumed that the project manager, who is at the same time "entrenched" in the line structure, whose authority is based not only on the authority he has been given to implement the project but also on the potential power he enjoys in the line structure, will have a greater ability to shape the subculture of the project team. This is because he is not a "temporary" figure for the project team members; he can often be their line supervisor and effectively seek the resources necessary for the project. As a result, not only does he have a more significant impact on his subordinates but, by increasing the chances of project success, he also gets people more involved in the team.

Thirdly, while the respondents in the household chemical manufacturing project did not attribute much importance to the issue of the acceptance of working in a project team, the heavy industry project members attributed critical importance to it (acceptance) in forming a strong project team subculture. Thus, it remains an open question to what extent the weak subculture of the project team in the household chemical manufacturing project is precisely the result of the weak acceptance of the project work by those involved.

Fourthly, as it might be assumed, the education and qualifications of project team members should be addressed in an analogous way as a factor that contributes to the formation of a project team subculture. Indeed, the selection of people for the project team from among the organisation's employees, the low diversity of the team, and the lack of training or people coming from outside the organisation may have contributed to the weak subculture of the household chemistry project team.

Finally, the case studies presented in this paper have not provided answers to the question of to what extent the dynamics and complexity of the project environment are essential factors. In both cases, the project environment was not strongly different from that of the organisation, which contributed to the respondents' assessment of the project in this way.

In conclusion, it should be noted that the case studies presented above have illustrated the existence of the project team subculture. This is because in the organisations under consideration, the norms and values in the project team differed from those found in the organisational culture. These differences were the stronger, the stronger the shaping of the factors favouring the emergence of the subculture of the project team was. This means that, as might be assumed, if individual projects are unique, searching for norms and values in the project team is more relevant than making general recommendations at the project management subculture level or the organisational culture level, as mentioned in the introduction. The subculture of the project team thus becomes a level of analysis that is difficult to ignore and should be a permanent part of the study of cultural aspects of project management.

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PREFERENCE-DRIVEN CLASSIFICATION FOR COOPERATION AND RESOLVING DECISION-MAKER – AI CONFLICTS

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Purpose: The aim of the paper is to present sources and effects of decision-maker – AI conflicts and how a modified measure of quality of classification algorithms can be used in resolving them.

Design/methodology/approach: Identification of sources and effects of decision-maker – AI conflict was based on literature research while presentation of modified quality measure was based on numerical experiment.

Findings: Using modified measure can be used to reflect user's preferences and can become a base for building flexible human-AI communication. It also helps in lowering barriers of involving AI into decision processes.

Research limitations/implications: The scope of the research was limited to the classification task, which is only one of the tasks performed by AI algorithms.

Practical implications: Results of article can be used in building AI application for every classification problem where cooperation between AI and decision-maker is needed.

Originality/value: The research enhances understanding an influence of particular AI solutions on further working in business environment and present possibilities of using modified quality measure in improving decision-maker – AI cooperation.

Keywords: AI in decision-making, classification, user preferences.

Category of the paper: Research paper.

1. Introduction

Artificial Intelligence (AI) tools are rapidly entering various areas of life, science and business. In many cases, they have enabled tasks that previously could not be solved within reasonable limits due to complexity or data volume. AI changes almost every aspect of human work and AI applications appear in a variety of devices and systems – from smartphones to city control systems and medicine. Sometimes this happens gradually, almost imperceptibly, by augmenting previously known functions or supporting everyday activities, sometimes in

a spectacular way such as beating the world champion in an advanced logic game. AI changes our behavior, our work, our communication, our ways of solving tasks. Inevitably, AI enters also areas of decision-making that were previously the exclusive domain of humans. This creates inescapable conflicts between humans and AI.

The purpose of this paper is to present the sources and consequences of the decision-maker – AI conflict and how they can be mitigated by using a modified measure of classification quality that incorporates user preferences in its design.

The paper is organized as follows: the next section presents fundamental problems of human-AI cooperation, their sources and the ways proposed in the literature to overcome them. Then, it focuses on classification issues as one of the basic tasks occurring in decision-making processes. Classical measures of classification quality are presented, as well as the modified measure, that allows taking into account the preferences of decision-makers. In the next section, the performance of modified quality measure is presented using two datasets as an example. The consequences of the introduction of the measure for the possibility of solving conflicts and some problems of human-AI cooperation are presented in the discussion. The paper concludes with a summary and directions for future work.

2. Sources and consequences of human-AI conflicts

Conflict situations in decision-making processes have always been present. Different opinions, views or preferences, different management styles, different levels of risk appetite, different temperaments of decision-makers or levels of understanding and interpretation of data – these are the sources of conflicts that have been known for a long time (Schwenk, 1990). The situation changed when the computer system, which is an active and permanent element of the decision-making process, became a party to the conflict. In the case of classical IT systems, the computer was only the provider of the data or results of the various models, and the responsibility of the system was limited to delivering reliable and timely data. The problem of decision-maker-computer cooperation was exacerbated when the system began to play an expert role in the process. This is what happens with AI. The main source of problems with the use of AI in decision-making processes is the delegation of powers and the issue of responsibility for the decisions made (Ferreira, Monteiro, 2021). It is impossible to explain anything to the computer, nor convince it of anything. The computer cannot be moved and made softer, although it can be ignored or turned off. It has no self-interest, although it operates according to rules written by a man with a certain level of knowledge and specific beliefs.

On the one hand, there are purely physical or technical problems (control), where AI consultation with a human, e.g. due to the short time required to make a decision, is redundant or even harmful. In the case of physical phenomena in limited and closed world

the influence of the will of the decision-maker is small. When the key factors of the application of AI are physical and technical one they are relatively easy to define and measure. The more the result of decision-making process or the use of the result of AI modules depends on the human being, the more important the subjective factors become. Therefore, at the other end, there are problems that people find impossible to objectify and treat them as their exclusive domain. As long as AI is used to support simple technical activities in devices that facilitate everyday functioning (e.g. object recognition in a camera lens), these issues do not matter much. Their importance increases when decisions are made that affect the health, life or personal rights of others or have a social impact. In such cases, ethical, legal and economic questions arise immediately (Rodrigues, 2020; Zhang, Chen, Xu, 2022; Formosa, Rogers, Bankins, Griep, Richards, 2022; Čartolovni, Tomičić, Lazić Mosler, 2022). Human-AI problems and conflicts begin when the degree of automation of AI activities exceeds the threshold acceptable to the decision-maker (Mackeprang, Müller-Birn, Stauss, 2019).

The main reasons for difficulties of human-AI cooperation are: poor understanding of the meaning of the results (low interpretability), the inability to obtain a simple explanation of the results (black-box problem, low transparency), the inability to indicate to the algorithm the personal preferences of the decision-maker, no influence on the way the algorithm works or lack of confidence in the correctness of the result (Dafoe et al., 2020), (Leyer, Schneider, 2021). The situation was additionally aggravated by the spread of Big Data technology, where it become obvious that a human cannot beat a computer in the tasks of analyzing huge datasets.

The ways in which human and AI make decisions are completely different. The activity of AI is guided by the past, while human activity by the future. AI is based strictly on data, human has the ability to think abstractly, formulate a vision, predictive intuition, holistic view, the ability to take into account new factors unknown to the machine, creativity, the ability to improvise and quickly assess a new situation, operating in conditions of discontinuity, etc. Good cooperation between the decision-maker and AI consists in maintaining a balance between the capabilities of the computer and the use of natural human abilities (Jarrahi, 2018).

AI tools will remain useless if the knowledge they discover is not included in the decision-making process (Mikalef, Krogstie, 2019). If decision-makers are unwilling to cooperate or - despite their will – they are unable to interpret, justify, understand or apply the result delivered by AI, all efforts to implement it will be wasted (Janssen, van der Voort, Wahyudi, 2017), (Duan, Edwards, Dwivedi, 2019). When the human-AI conflict cannot be resolved, and AI prevails, the result of the lack of proper cooperation is a reduction in the creativity of decision-makers, laziness, resignation from the principles of ethics and morality, which leads to frustration and resignation. When humans prevail, the result is the rejection of AI tools and a waste of its potential. The imbalance between the analytical capabilities of a machine and the ability to synthesize that humans are capable of has negative consequences. Too little AI contribution wastes the discovered knowledge, while too much, marginalizes and degrades human.

Therefore, various patterns of human-AI cooperation are analyzed (Leyer, Dootson, Oberländer, Kowalkiewicz, 2020). Effective use of the opportunities offered by AI in decision-making processes requires meeting several conditions. These include (Mikalef, Krogstie, 2019), (Duan et al., 2019):

- the ability of the decision-maker to work with these tools,
- the ability to interpret the obtained results,
- embedding AI tools into decision-making processes and using its results in the subsequent steps of the these processes.

Lowering the barriers to introducing AI into decision-making processes and resolving conflict situations can be carried out in two ways: from the management side and from the IT side. From the management side through (Langer, Landers, 2021):

- raising awareness and training of decision-makers in human-computer cooperation,
 - building systems with an appropriate level of AI use,
 - allowing a person an appropriate scope of competence and freedom in making decisions,
- while from the IT side, among others by (Wang et al., 2020; Gunning et al., 2019; Samek, Montavon, Vedaldi, Hansen, Müller, 2019):

- bringing AI tools closer to the decision-makers (similarly to data reporting and visualization tools), so that they can be operated them on their own, without the intermediation or help of an IT specialist,
- building the convenient AI systems interfaces,
- making AI algorithms more flexible so that decision-makers can influence their operation,
- expansion of AI towards interpretable and explainable intelligence (eXplainable AI - XAI).

There is no single recipe for overcoming all problems. They are solved in small areas, in terms of particular tools or algorithms.

3. Classification in decision-making processes

AI techniques and tools cover a wide variety of tasks. One of them is classification of objects which refers to the problem of determining the class (group) (one of at least two) into which the analyzed case should be placed. The classifier algorithm (in short, the classifier), on the basis of the training data (previously known cases) about the class to which the given cases has been placed, builds the classifier (the classifier learning phase), according to which it is possible to classify current or future cases (the phase of using the classifier in a specific situation).

Classification is related to a myriad of decision problems, such as credit scoring, identifying employees or customers who want to leave the company (churn analysis), customer segmentation, medical diagnosis, etc. Developers of AI algorithms try to objectify the evaluation of classifier quality, and the basic tool for this evaluation is the confusion matrix (error matrix). It is defined as a matrix of combinations of actual classifications and those predicted by the algorithm. For binary (two class) classification, it can be represented as a matrix (Figure 1).

		Predicted class	
		A	$\neg A$
Actual class	A	Number of cases A classified properly as A (true positive – TP)	Number of cases A classified improperly as $\neg A$ (False negative – FN)
	$\neg A$	Number of cases $\neg A$ classified improperly as A (false positive – FP)	Number of cases $\neg A$ classified properly as $\neg A$ (true negative – TN)

Figure 1. Confusion matrix for binary classification.

Source: (Kohavi, Provost, 1998).

At first glance, the best classifier is the one in which the ratio of the number of correctly classified cases (actual A classified as A and actual $\neg A$ classified as $\neg A$) to the total number of classified cases is as high as possible. This measure of classification quality is referred to as *accuracy* (formula 1).

$$accuracy = \frac{TP + TN}{TP + TN + FP + FN} \quad (1)$$

Striving for higher accuracy means that we want to correctly classify as many cases of A as A and $\neg A$ as $\neg A$. This is the most commonly used measure to evaluate the quality of classifiers. However, in practice, this measure is found to be insufficient (Gilli, Schumann, 2015), (Campagner, Sconfienza, Cabitza, 2020) and other measures are also used that may be more useful in specific situations.

The first of these (*precision*) is the ratio of the number of instances of A correctly classified as A to all instances classified as A (formula 2).

$$precision = \frac{TP}{TP + FP} \quad (2)$$

The pursuit of higher precision means that we do not want to classify cases $\neg A$ as A, even at the expense of omitting some A cases.

The second measure (*recall*) is the ratio of the number of A cases correctly classified as A to all A cases (formula 3).

$$recall = \frac{TP}{TP + FN} \quad (3)$$

Striving for higher recall means that we want to classify as many cases A as A, even at the expense of classifying cases $\neg A$ as A.

Two next measures are *negative predictive value (npr)* (formula 4) and *true negative rate (tnr)* (formula 5). They are similar to the two previous measures but relate to the false cases.

$$npr = \frac{TN}{TN + FN} \quad (4)$$

$$tnr = \frac{TN}{TP + FN} \quad (5)$$

The meaning of these measures is difficult for average users to intuitively understand and apply. In everyday decision-making, they operate with terms they understand more, such as "I would like to take into account more cases when ...", whereas using raw algorithms they need know and interpret specific values.

Another obstacle to the proper use of AI is the inflexibility of the algorithms, which puts decision-makers in a situation where they can only accept the result delivered by the AI or - after taking into account their own knowledge - reject it. Meanwhile, decision-makers like to work online, conducting what-if simulation so that they can quickly test the effects of changes of the introduced parameters before making a final decision. However, as long as only a single-measure maximized classifier is available, this will not be possible. We illustrate the dilemmas facing the decision-makers with two examples.

In the case of credit risk assessment, a bank may identify as much more serious the risk of granting a bad loan than the risk of rejecting an application that, despite doubts, would be repaid correctly. In other words, it is more important to avoid the case of granting credit to a person/company that will have trouble paying it back than to lose the benefit of granting credit to a person/company that will pay it back without a problem. The simplest strategy would be to reject all applications because then the risk of granting bad credit disappears altogether. However, such a strategy is disadvantageous from the point of view of the bank's revenues, so the best for the decision maker would be such a classifier that rejects all doubtful applications, even at the expense of rejecting some reliable customers, with their number being as small as possible (maximize precision). In turn, when the bank is more inclined to risk, the classifier according to which the bank will be more willing to grant a loan will be more useful, even at the cost of granting it to a certain number of entities that will not be able to pay it back (greater recall).

In the opposite situation are diagnosticians, for whom the safest strategy is to refer all patients for further tests to be sure not to miss any case of disease (maximize recall). The problem arises when there are limits (cost, time) of tests and performing tests for all patients is not possible and/or the test itself is not indifferent to the patient's health. Then it is better not to test some patients than to test a healthy one. In such a situation, the best classifier for diagnosticians would be the one, which would focus on the patients who are actually ill and omit the healthy ones, even agreeing to omit some actually ill patients (maximize precision).

As can be noticed, this classifier will be different for different levels of limits, diagnostician preferences, and patient risk propensity.

Assessing classifier quality is a complex task. To solve it, many measures are used (Tharwat, 2018). One of the problem is that classical measures of classification quality refer only to the confusion matrix and are related directly to the numerical outcome of the classification. In many human independent problems it is very necessary, but in decision-making contexts it only exacerbates human-AI conflicts because decision-makers may argue that AI does not take into accounts additional preferences and as a result its solutions are detached from reality. Situation is even more complicated in the case of multi-class classification, when decision-makers want to set up preferences for many classes or each class separately. The main problem is that in the classical measures described above, there is no place to indicate decision-makers' preferences for individual classes (Kozak, Kania, Juszczuk, Mitreęga, 2021).

The proposed contribution to solving the problem of human-AI collaboration is the introduction of a modified classifier quality measure that allows taking into account the user's preferences (Kozak, Probiez, Kania, Juszczuk, 2022). This makes it possible to control the choice of classifier such that the resulting classifier best reflects these preferences (formula 6).

$$preference_driven_{\kappa} = \frac{1}{c} \sum_{i=1}^c (\kappa_i * precision_i + (1 - \kappa_i) * recall_i) \quad (6)$$

where:

κ_i – is the value of preference parameter for i -th class, while $\kappa_i \in [0,1]$,

c – is the number of classes.

For two classes using measures (4) and (5) *preference driven measure (pd₂)* could take the form of formula (7):

$$pd_2 = (\kappa_1 * prec + (1 - \kappa_1) * rec + \kappa_2 * npr + (1 - \kappa_2) * tnr) / 2 \quad (7)$$

The value of the parameters κ_i (vector of κ values or κ vector, for short) reflects the decision-maker's preference for balancing the expectation of classification precision with the desire to avoid missing interesting cases. A higher value of κ_i for particular class, indicates an expectation of a classifier that will identify fewer instances (cases) of A, but with a higher probability that they will indeed be A, while a lower value of κ_i indicates a desire to identify as many instances of A as possible, even if by doing so the classifier will identify as A, a number of instances $\neg A$.

Once the decision maker has indicated a value of κ vector, a new classifier for the decision maker will be indicated to use in the decision process. Since this operation is fast, this activity can be iterative - the decision maker, after analyzing the effects of the classifier, can adjust the

values of the κ_i parameters and run the simulation again. In this way, a learning loop will be realized in practice.

4. Numerical experiment

The purpose of the experiment is to investigate how changing the parameters in κ vector that describe the preferences of the decision-maker affect the choice of classifier. The experiment was conducted on two data sets: the first reflects the situation of the diagnostician described above, the second - the grantor in a bank.

4.1. Data description and experiment design

The first dataset (Breast Cancer Wisconsin (Diagnostic) Data Set) (<https://archive.ics.uci.edu/ml/datasets/breast...>) contains 569 cases of images with 32 attributes classified as “cancer/no cancer” and it is related to the case of diagnostician described above. The second dataset (German Credit Data Set) (<https://archive.ics.uci.edu/ml/datasets/statlog...>) contains data about 1000 cases of people classified as good or bad credit risk described by 20 attributes and it is related to the case of decision-maker in a bank.

Five ML algorithms have been selected for the experiments, and the results of which have a form known in management sciences and provide a high degree of diversity in the approach to the classification task. Three of them classify using decision trees: CART, C4.5, and Random Tree, and the other two generate decision rules: Decision Table and Rido. All selected algorithms are available in the free WEKA package. With its help, both sample sets were classified. As a result, for each of the data sets, five different classifiers were obtained, which can be assessed using classical measures of classification quality and the proposed measure taking into account the preferences of the decision-maker. The aim of the experiment is to test whether, when using a preference-driven measure, the classifier assessment depends on the values of κ vector given by the decision-maker.

4.2. Experiment results

Table 1 contains results of the experiment for the Breast Cancer Wisconsin (Diagnostic) Data Set (the best classifiers in terms of a specific measure are bolded). Contrary to the classical classification measures, which always return one value, the results for proposed preference-driven measure are different for different values in the κ vector. Table 1 shows numerical results for classical measures (accuracy, precision, recall) and the three sample κ vectors (p-d[default], p-d[0.7, 0.1], p-d[0.7, 0.1], where default values reflect the ratio of number of cases in each class to the number of all cases), while the full results are shown in Figure 2. Since the set of values w of the parameter κ_i is continuous, the evaluation results form surfaces.

Table 1.

Classifier evaluation results based on different measures - Breast Cancer Wisconsin (Diagnostic) Data Set

	CART	C4.5	Random Tree	Decision Table	Rido
Accuracy	0.9342	0.9442	0.9242	0.9285	0.9399
Recall	0.9432	0.9541	0.9672	0.9651	0.9476
Precision	0.9558	0.9604	0.9210	0.9286	0.9602
p-d[default]	0.9304	0.9398	0.9050	0.9120	0.9367
p-d[0.0,0.7]	0.9223	0.9357	0.9359	0.9363	0.9286
p-d[0.5,1.0]	0.9221	0.9356	0.9377	0.9375	0.9284

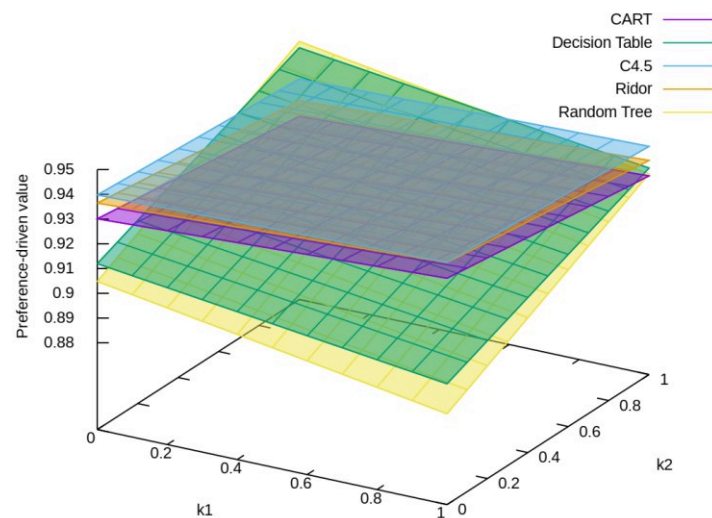


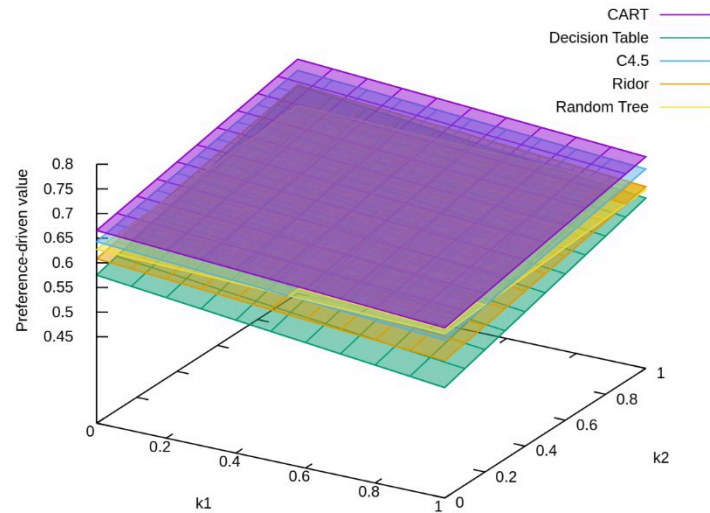
Figure 2. Solution space for Breast Cancer Wisconsin (Diagnostic) Data Set.

Figure 2 shows the evaluation for each classifier depending on κ_1 and κ_2 i.e. the exact values of the preference vector. As can be seen, the whole solution space changes the choice of classifier depending on the preference, e.g. for κ_1 close to 0.0 and κ_2 close to 1.0 the best classifiers will be Decision Table and Random Tree, while for κ_1 close to 1.0 and κ_2 close to 0.0 the best will be C4.5 and Ridor. It is also worth mentioning that for this dataset the accuracy measure indicates that the best classifier is built using the C4.5 algorithm, the same is true for the precision measure. However, the recall measure indicates the Random Tree algorithm as the best.

In the case of German Credit Data Set, the situation is slightly different (Table 2 and Figure 3). In this case, the CART algorithm turns out to be the best for each sample κ vector. However, it is worth noting, the change between the Random Tree, Decision Table and Ridor algorithms in subsequent positions in the ranking, where for κ_1 from about 0.5 to 1.0 and κ_2 from 0.0 to about 0.2 the classifier built using the Random Tree algorithm is the best rated, and for values of κ_1 about 1.0 and κ_2 about 1.0 Random Tree is the worst rated.

Table 2.*Classifier evaluation results based on different measures - German Credit Data- Data Set*

	CART	C4.5	Random Tree	Decision Table	Rido
accuracy	0.7520	0.7350	0.7010	0.7010	0.7120
recall	0.8814	0.8729	0.8114	0.8900	0.8671
precision	0.7890	0.7764	0.7728	0.7373	0.7569
p-d[default]	0.6588	0.6346	0.6226	0.5580	0.5970
p-d[0.7,0.1]	0.6418	0.6178	0.6168	0.5337	0.5790
p-d[1.0,1.0]	0.7041	0.6793	0.6373	0.6203	0.6436

**Figure 3.** Solution space for German Credit Data Set.

5. Discussion

The results of the experiment showed that the best classifier depends on the parameters provided by the decision-maker (in the case of breast cancer for p-d[default] it is C4.5, for p-d[0.7, 0.1] it is Decision Table and for p-d[0.7, 0.1] it is Random Tree, while in the case of credit risk it is CART for all three sample κ vectors). By choosing a specific classifier, the decision-maker has the ability to flexibly react and take into account the current decision-making context. The use of the measure in the proposed form will contribute to increasing the flexibility of ML algorithms, and thus facilitate building the foundations of interactive and iterative human-AI cooperation. It also will help to reduce the risk of falling into the potential pitfalls of introducing AI (Buschek, Mecke, Lehmann, Dang, 2021):

- lack of interaction – by introducing learning loop and real dialog,
- conflict of territory and agony of choice – the algorithm derives classifier that takes into account the expectations of the user,
- conflict of creation & responsibility – man and AI are co-creators of the solution, and the final decision-maker is indicated by man.

One of the principles of the human-AI collaboration environment is the use of hybrid techniques involving the user in the learning process (Wu et al., 2021). It is possible at any stage of the process; from data preparation to supporting the construction of a training model. Efforts to improve the influence of users on the construction of classifiers and include them in the learning loop are undertaken in many scientific studies. Examples of suggestions can be found in (Ware, Frank, Holmes, Hall, Witten, 2001) or (Talbot, Lee, Kapoor, Tan, 2009). In the first case, the classifier is actually built by the user himself using a graphical interface, and in the second, the classifier is selected from a predefined set of classifiers. In the solution proposed in the article, it is possible to choose the classifier on-line – immediately after the parameters are set by the user. In this way, it is possible to engage humans interactively in the learning loop, which has many advantages. On the one hand, it is possible to obtain and use additional knowledge in the system that can be used to improve AI, on the other hand, the decision-maker slowly gets used to the presence of AI and gradually incorporates it into his decision-making process (Hoi, Sahoo, Lu, Zhao, 2021). However, the condition for such action is real, not mocked, interactivity and the ability of the system to respond to changing user preferences.

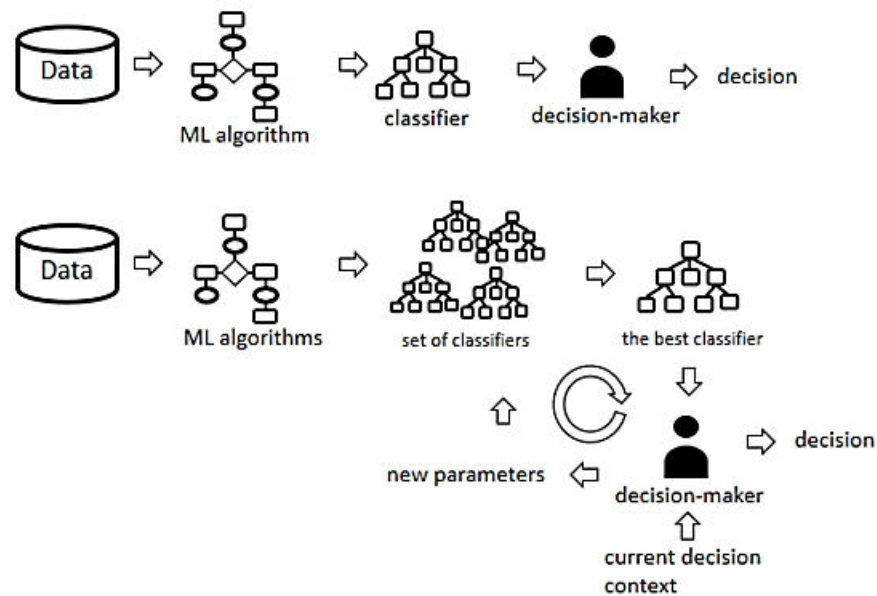


Figure 4. Difference in decision-making process after introducing parametrized classification measure.

Introducing the described vector of κ parameters to the decision procedure and the possibility of checking their effects leads to the construction of a learning loop (Figure 4) related to model training, the purpose of which is to build an appropriate classifier. Including the user in building AI solutions speeds up the learning process, improves its results and the end result is more credible for other people (Amershi, Cakmak, Knox, Kulesza, 2014).

6. Conclusions and future works

This paper presents the causes of human-AI conflicts and the problems of building a collaborative environment. The results show that an environment using a modified measure of classification quality does indeed take preferences into account and changes the classifier finally used. It is also shown that using a measure that takes preferences into account can help overcome some of the causes of these conflicts and build such an environment.

The use of the measure itself is automatic, but on the organizational side, it seems necessary to train decision-makers so that they can reflect complex decision contexts with parameters. On the IT side, it is also necessary to prepare an appropriate interface for the decision-makers, so that they can flexibly set the parameters of the algorithm for choosing the classifier without knowing the concepts strictly related to machine learning.

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GENERATION Z'S EXPECTATIONS TOWARDS THE EMPLOYERS

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Purpose: The main objective of the paper was to identify the expectations of Generation Z representatives in terms of HRM practices in the workplace.

Design/methodology/approach: The study was carried out as an on-line survey. U Mann-Whitney test was used in the data analysis. The study focused on the expectations of Generation Z representatives towards HRM practices and gender differences.

Findings: The highest level of acceptance was observed for HRM practices related to evaluation and development. At the same time, acceptance for respective IT solutions varied, with the lowest levels observed for the possibility of a humanoid robot conducting job interviews and use of gamification. There are differences in acceptance of HRM practices in terms of gender.

Research limitations/implications: The study was carried out only in Poland. The author intends to continue the research in other countries to allow the results to be compared internationally.

Practical implications: It is necessary to adequately adapt the implementation of HRM practices to the specific needs of Generation Z and gender. The ability to identify the HRM expectations of Generation Z representatives help future employers to programming and planning such practices in a way more suited and better communicated to employees.

Originality/value: The study identified specific expectations of Generation Z individuals currently entering the job market in terms of a range of HRM practices. The publication is addressed to future employers as a way of facilitating efforts aimed at properly developing HRM practices in organisations.

Keywords: HRM practices, generation Z, expectation of generation Z, gender differences.

Category of the paper: Research paper.

1. Introduction

The current job market is populated by representatives of a number of generations who have varied expectations towards their employers. A particularly noteworthy group consists of members of Generation Z currently in the process of beginning their professional careers.

Generation Z is currently making its first steps in the labour market. Its representatives include people born after 1995, who clearly stand out when compared to other employee age groups in terms of their professional expectations, with additional discrepancies emerging when factoring in their respective countries of origin (Scholz, Renning, 2019). It is therefore particularly important to know their expectations of future employers. This will enable employers to develop appropriate human resources strategies and take measures to harness the potential of young workers for enterprise development. It should be emphasised that now is the time to take decisions that can aim to build up cooperation with young workers.

HR practices are effective if employees behave in a way that is necessary for strategies to be implemented and various business goals achieved (Jiang et al., 2012). At the same time, employees who wish to hire the best need to be aware of the implications of generational differences. Hence, the task faced by businesses entails employing adequate HRM practices to facilitate the accomplishment of economic goals, while at the same time ensuring that the same are correctly perceived by the workforce.

What matters most to employers is the discrepancy in terms of employees' value systems, which are reflected in their respective professional goals, attitudes, and workplace behaviour. Given the fact that Generation Z is characterised by certain distinctive values and preferences, one needs to be aware of the expectations shown by its representatives if one is to adequately adapt one's HRM practices to suit the needs of both sides of the equation.

For this reason, the main objective of this paper is to identify the expectations of Generation Z representatives with regard to HRM practices encountered in the workplace. To this end, the following research questions were formulated:

1. What HRM practices are expected by Generation Z individuals?
2. What is the level acceptance for the implementation of IT tools in the processes of recruitment and selection?
3. Are there any significant gender related differences in terms of expectations towards HRM practices?

The paper consists of 4 parts including introduction, literature review, methods, results and discussion.

2. Literature review

Among the trends in the labor market, the key are demographic changes caused by the generation change. Among them, the representatives of Generation Z, who successively start their professional career, deserve special attention. The characteristic traits of its representatives include: openness and directness, mobility, broad understanding of modern technologies, capacity to multitask, and resourcefulness (Pracuj.pl, 2019; Aterima, 2017). What matters most

to Generation Z individuals is the ability to overcome challenges, pursue passions and interests, maintain a healthy work-life balance, and continuously develop. In terms of career advancement, they show a preference for planning it jointly with their employer, and their motivation in that regard stems from prospects for future promotion (Smolbik-Jęczmień et al., 2017). They tend to believe that their careers are conditioned primarily by knowing the right people, rather than their individual predispositions or choices. Representatives of this generation are acutely aware of the technological changes taking place all around them.

Other studies allowed the identification of main expectations towards employers, which include (Pracuj.pl, 2019; Aterima, 2017):

- attractive remuneration,
- engaging work tasks,
- a sense of being appreciated,
- high job satisfaction,
- expectations of fast career advancement.

In the self-assessment of their own professional competence, 68% of the respondents declared having skills useful in their work, 59% reported having adequate social competences, and 39% the necessary knowledge (Bartczak et al., 2020). Moreover, Generation Z representatives appraised their value as future employees as high (Bartczak et al., 2020).

Polish representatives of Generation Z also identified a number of challenges, of which the most notable included (Pracuj.pl, 2019; Aterima, 2017):

- difficulties in terms of direct communication,
- difficulties in focusing on a single task,
- the need for change (including of the employer, industry, specialisation),
- a critical attitude towards employers.

Certain discrepancies were observed between respective professional expectations depending on whether the given respondent was an active or prospective employee (Gajda, 2017). This suggests that having actual work experience can affect an individual's expectations by rendering them more realistic.

It is noteworthy that representatives of this particular generation pose a considerable challenge to employers, not least due to how different they are from previous generations with which they have been working to date. Hence, literature reports commonly underscore the need to identify the specific expectations of the youngest generation currently introduced into the job market (Bartczak et al., 2020).

An important aspect of interacting with the workforce entails reliance on Human Resources Management (HRM) practices. As noted by P.M. Wright and L.H. Nishii, their purpose is to allow an enterprise to shape and encourage desirable employee behaviour (Wright et al., 2013). P. Boselie, G. Dietz, and C. Boon observe that such practices are to stimulate a desirable change in employee attitudes (Boselie et al., 2005). And in the opinion of C. Ostroff and D.E. Bowen,

HRM practices assure that adequate signals are provided to employees to guide them towards conduct valued, expected, and rewarded in the given organisation (Ostrow et al., 2016). For this reason, HRM practices are typically defined as tools, norms, processes, and procedures that, if synergised and combined, effectively define the structure of human resources management policies adopted in an enterprise (Björkman et al., 2014). Overall, it can be concluded that HRM practices facilitate the enhancement of the working relationship between employees and the employer. This allows staff members to develop desirable attitudes and behaviours, while simultaneously becoming more aware of their own competences and available paths of professional improvement.

In the current complex and dynamic business environment, companies need their employees to remain flexible in adapting to varied and constantly changing requirements. This fact has led to an in-depth debate regarding HRM practices as such as well as the ways in which they are to be structured. Consequently, organisations have paid greater attention to the needs of their employees with a view to facilitating their engagement and satisfaction from the work tasks performed. The capacity to incorporate the interests of the employee within the scope of the so-called key management practices (e.g. high-efficiency work systems) has led to the emergence of new HRM trends (Gableta et al., 2015). It has therefore become that much more crucial to identify the expectations of prospective employees in order to adequately fine-tune requirements and methods of their communication.

In order to attract the best possible employees, the HRM department strives to establish a common language with the recipient of the message and a suitable way to reach highly qualified potential employees (Pietroń-Pyszczek, 2014). Therefore, it is important to know their expectations in order to prepare and communicate the HRM practices accordingly.

The development of information and communication technologies has led to an increased use of IT tools in the recruitment and selection process, enabling more data to be collected and analysed to support these processes. Solutions such as robots, artificial intelligence, advanced technologies are used (Vrontis et al., 2021). However, it is important to know whether applicants accept them. The level of use of social media when it comes to employee management, the ability to create a positive company image in the social media and use these media to verify information on candidates applying for positions (Karasek et al., 2020). Since it is more difficult for the members of this generation to adapt to the working conditions imposed on them and to organise their working time, employers expect new challenges to cope with demanding tasks (Gajda, 2019). New skills of employees are needed to perform tasks efficiently and to cooperate with new technological solutions of production and control and monitoring systems of manufacturing and service processes (Gajdzik, 2022). Therefore it is important to receive information about generation Z in the area of HRM practices in the field of development and assessment. Moreover, the characteristics of generations are different in the area of knowledge management (Bencsik et al., 2016). Additionally, preferences of Generation Z are differentiated by gender (Acheampong, 2020).

Based on the literature review, a research gap was identified in the area of Generation Z expectations regarding HRM practices and gender differences.

3. Methods

In an effort to answer the research questions posed, a critical literature review was conducted in preparation for the analysis of reports and results obtained from the study. The review led to the formulation of an original questionnaire that was subsequently distributed among representatives of Generation Z. The survey included questions that aimed to identify the respondents' expectations in terms of HRM practices, with specific queries addressing the applications of IT solutions in the areas of recruitment and selection, development, appraisal, and knowledge management. The study was conducted in the 1st half of 2020 in Poland. A total of 312 fully completed and questionnaires were returned, as well as 318 partially completed surveys that were not qualified for subsequent analyses. The nonparametric significance test employed for the two independent groups was the Mann-Whitney U test.

4. Results

The study was carried out as an on-line survey. On the basis of the review of literature an original survey questionnaire with 16 questions was developed. Based upon the review of literature, HRM practices in the following HRM areas were selected: using IT in recruitment and selection (four HRM practices), development (five HRM practices), assessment (three HRM practices), and knowledge management (four HRM practices). Responses to these questions were measured using a five-point Likert scale.

Table 1 contains detailed information on the respondents participating in the survey.

Table 1.
Structure of respondents

Gender of respondents [%]	
Female	73.74 %
Male	26.3 %
Length of using SM [%]	
Under 20 years	12.5 %
From 20 to 25 years	87.5 %
Work experience [%]	
Never work	14.1 %
I have work in the contract and seasonal/	82.1 %
Other	3,8 %

Source: Based on own study.

The results of the research regarding the expectations of the Z-generation representatives in the field of HRM practices in the area of IT use in recruitment and selection, development, evaluation and knowledge management are presented in Table 2.

Table 2.
Expectations for HRM practices

	Question	Total average	Total median	Women average	Man average
HRM practices in IT in recruitment and selection					
1.	I prefer submitting the application documents in electronic form rather than in paper form	4,50	4,15	4,20	4,00
2.	I accept that potential employers may verify the information contained in my CV on social media	4,00	3,47	3,39	3,71
3.	The recruitment interview may be conducted by a humanoid robot, not by a human	2,00	1,97	1,97	1,96
4.	Gamification should be used when selecting employees	3,00	3,05	2,91	3,46
HRM practices in development					
5.	I want to develop my skills in the field of creativity and innovation	5,00	4,41	4,41	4,43
6.	I want to expand my skills through self-development	5,00	4,64	4,69	4,50
7.	The ability to work as a project leader is an important element of development for me.	4,00	3,87	3,83	3,95
8.	I expect to use the latest IT technologies to develop my skills (e. g. virtual reality, gamification, learning platforms)	4,00	3,89	3,87	3,95
9.	I prefer the further development of my skills through lectures, workshops instead of distance learning	4,00	3,89	3,84	4,04
HRM practices in assessment					
10.	I want to receive continuous feedback on the activities that I can implement	5,00	4,51	4,54	4,44
11.	I would like to receive information on areas/spheres where my work needs to be improved	5,00	4,61	4,63	4,57
12.	I want to be judged for individual results	4,00	4,27	4,29	4,20
HRM practices in knowledge management					
13.	I think it makes sense to disseminate data on past failures and lessons learned among staff	3,00	3,33	3,23	3,61
14.	I want to work in the project team	4,00	3,62	3,60	3,67
15.	I want knowledge-sharing mechanisms to be used at my workplace	4,00	4,35	4,34	4,38
16.	I want to leave time for the development of innovative ideas in my area of responsibility	4,00	3,91	3,88	3,99

Source: Based on own study.

As follows from Table 2, the respondents looked the most favourably towards the prospect of submitting recruitment documents in electronic rather than hardcopy format. They were even less inclined to consent to having the information contained in their CVs verified against social media, and less yet to the potential applications of gamification in employee selection. However, the lowest acceptance scores were recorded for the possibility of job interviews being conducted by a humanoid robot rather than a human recruiter.

The analysis in terms of respective HRM practices revealed that respondents were the most open to possible self-development at work and only slightly less so to the development of competences in areas such as creativity or innovation. They were less inclined to expect the latest IT advances to benefit the development of competencies during lectures and workshops

held directly, rather than remotely. They were slightly less interested in assuming the position of project manager as an important element of such development.

The respondents' expectations with respect to the HRM practices considered in the analysis are presented in the graph. Overall, they were the most willing to receive information in areas/aspects of their work that need improvement, and only slightly less so in terms of ongoing feedback on the tasks they perform. The respondents were somewhat less willing to be evaluated based on their individual results.

The results revealed varied levels of acceptance with regard to the respective HRM practices related to knowledge management. The respondents would most like to see knowledge sharing mechanisms implemented in the workplace. Slightly fewer agreed that their job description ought to reserve time for coming up with innovative ideas, and fewer yet were willing to work as part of a project team. The lowest level of acceptance was recorded for the suggestion that "lessons should be learnt from mistakes by making them known to all employees".

In a further step of the analysis of the results, it was demonstrated that between expectations of HRM practices and gender. The presence of statistically significant differences was assessed using the non-parametric U Mann-Whitney test (Table 3).

Table 3.

U Mann-Whitney result test for expectations for HRM practices and gender

Question	Z	p	Z corrected	p
I prefer submitting the application documents in electronic form rather than in paper form	1,35080	0,176759	1,46175	0,143811
I accept that potential employers may verify the information contained in my CV on social media	-2,04558	0,040798	-2,11808	0,034169
The recruitment interview may be conducted by a humanoid robot, not by a human	0,56191	0,574176	0,59763	0,550087
Gamification should be used when selecting employees	-4,60810	0,000004	-4,99531	0,000001
I want to develop my skills in the field of creativity and innovation	0,19238	0,847446	0,21567	0,829244
I want to expand my skills through self-development	2,03243	0,042110	2,51622	0,011863
The ability to work as a project leader is an important element of development for me	-0,51001	0,610044	-0,53440	0,593068
I expect to use the latest IT technologies to develop my skills (e. g. virtual reality, gamification, learning platforms)	-0,77713	0,437084	-0,81277	0,416350
I prefer the further development of my skills through lectures, workshops instead of distance learning	-1,56048	0,118647	-1,65580	0,097762
I want to receive continuous feedback on the activities that I can implement	1,23385	0,217258	1,42381	0,154503
I would like to receive information on areas/spheres where my work needs to be improved	0,71000	0,477703	0,85924	0,390211
I want to be judged for individual results	1,02348	0,306080	1,11803	0,263556
I think it makes sense to disseminate data on past failures and lessons learned among staff	-2,33302	0,019648	-2,39773	0,016498
I want to work in the project team	-0,50780	0,611597	-0,53179	0,594873
I want knowledge-sharing mechanisms to be used at my workplace	-1,04045	0,298132	-1,15258	0,249086
I want to leave time for the development of innovative ideas in my area of responsibility	-0,80556	0,420499	-0,85264	0,393860

Source: own study.

The following HRM practices examined differed according to gender (Fig. 3):

- I accept that potential employers may verify the information contained in my CV on social media. More often men expected this HRM practice.
- Gamification should be used when selecting employees. More often men expected this HRM practice.
- I want to expand my skills through self-development. More often women expected this HRM practice.
- I think it makes sense to disseminate data on past failures and lessons learned among staff. More often men expected this HRM practice.

5. Summary and discussion

HRM practices facilitate the achievement of a company's business goals. This is because organizational procedures are not unlike a roadmap guiding employees towards more desirable behaviour, which in turn improves business performance (Edgar et al., 2014). However, representatives of the generation now being introduced into the job market, the so-called Generation Z, need such practices to be adapted to their particular requirements. Research results indicate that members of that age group have rather varied expectations as to the use of IT in the context of employee selection and recruitment. Overall, they tend to be more open to solutions they are already familiar with, while largely rejecting innovative alternatives. At the same time, respondents from this generation tend to value practices that facilitate self-fulfilment, feedback in areas/aspects that require improvement, and all opportunities to develop one's professional competencies.

The obtained results allowed the formulation of certain recommendations for employers. It is necessary to adequately adapt the implementation of HRM practices to the specific needs of Generation Z and gender, as well as to communicate the same with the same in mind. It is important that employees are guided towards desirable behaviour in an organised way, via a variety of communication channels including organisational documents, meetings with superiors, meetings with other employees, visual presentation tools (boards, websites) so that the message can reach all employees, regardless of personality or learning style preference. Moreover, it is worth enhancing HRM techniques by incorporating certain IT solutions, however, further efforts are needed to inform and convince employees of their functional value. As this particular generation tends to put significant stock in change, it is advisable to employ individualised and flexible strategies in managing employees. This, in turn, requires HRM departments to assume adequate roles and responsibilities. A particularly important facet in this context is the role of a change agent who can lead the efforts towards generating greater social capital within an enterprise.

A critical literature review and analysis the research results obtained led to the identification of the expectations of Generation Z towards HRM practices in the workplace. This allowed certain recommendations for employees to be formulated with a view to identifying HRM directions that may prove beneficial to employers and employees alike. One major limitation of the described study stems from the fact that it was only conducted domestically. In the future, studies are planned that will allow a more comprehensive, international comparison of results.

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A QUEUEING MODEL OF PATIENT SERVICE IN ACCORDANCE WITH THE S.T.A.R.T STANDARD

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Purpose: Currently, in Poland, the process of patient registration at the hospital emergency department (SOR) is carried out in accordance with the S.T.A.R.T. (*Simple Triage And Rapid Treatment*) standard. According to this procedure, based on a preliminary interview, patients are selected and assigned to one of five risk categories, described by colors: red, orange, yellow, green, or blue. Since this standard is relatively new (introduced in 2019), its analysis using quantitative, not only qualitative, methods are highly desired.

Design/methodology/approach: The so-called mean-value approach for studying the proposed queueing model is used in the paper.

Findings: For each category of patients, the mean number of patients present in the system, the mean queue length, and the average values of waiting time for admission by a doctor and time spent in the emergency department are found. Two priorities are considered: non-preemptive (absolute) and preemptive-resume (relative). Numerical calculations illustrate theoretical results.

Originality/value: Explicit representations for key queueing characteristics are found analytically. Moreover, illustrating numerical results simulating the "behavior" of a real hospital emergency department are presented and discussed.

Keywords: hospital emergency department, priority service, quality of service (QoS); queueing model, S.T.A.R.T. standard.

Category of the paper: research paper.

1. Introduction

Hospital emergency departments (SOR acronym commonly used in Poland), by definition, should meet the highest quality standards for patient care. They should also be perfectly managed to specialist medical equipment, patient service time, and human resources (medical personnel). Currently, in Poland, the process of patient registration at the hospital emergency

department is carried out in accordance with the S.T.A.R.T. (*simple triage and rapid treatment*) standard. The algorithm was initiated by the Newport Beach Fire and Marine Department and Hoag Hospital in Newport Beach (California, U.S.A.) in 1983. According to the S.T.A.R.T. procedure, based on a preliminary interview, patients are selected and assigned to one of five risk categories, described by colors: red, orange, yellow, green, or blue. Different modifications of the original approach were proposed later. For example, in 1996, the S.T.A.R.T.-S.A.V.E. (*Secondary Assessment of Victim Endpoint*) standard was worked out by Benson, Koenig, and Schultz (Benson et al., 1996), in which some additional factors determining "survivability" of a patient over time were implemented. In the literature, one can find many studies and comparisons regarding the original algorithm and its modifications to various aspects of patient service in hospital emergency departments, the quality of this service, and the possibility of its improvement (see, e.g., Baker, 2007; Kahn et al., 2009; Badiali et al., 2017; Fink et al., 2018; Ferrandini et al., 2018).

Queueing systems are commonly used in modeling different-type real-life phenomena. In particular, they are proposed for solving management and quality-of-service problems occurring in production engineering, computer and telecommunication networks, transport and logistics, medical sciences, and health care procedures (see, e.g., Bose, 2002; Ng, Soong, 2008; Chan, 2014; Shortle et al., 2018; Lakatos et al., 2019). By constructing an appropriate queueing model and determining its stochastic characteristics, it is possible to answer many questions regarding the quality of service and the level of use of the service station capabilities.

In the article, a queueing system with many classes of customers and priority service is proposed for modeling the process of qualifying and serving patients. The stream of incoming patients is described using the Poisson process, while the time of processing of a single patient is assumed to be hyper-exponentially distributed. For each category of patients, the mean number of patients present in the system, the mean queue length, and the average values of waiting time for admission by a doctor and time spent in the emergency department are found. Two priorities are considered: non-preemptive (absolute) and preemptive-resume (relative). Numerical calculations illustrate theoretical results.

2. Description of a queueing model

Arrival and service processes

Let us assume that patients arrive at the emergency department according to the Poisson process with a certain constant intensity λ . The Palm-Khintchine theorem justifies this assumption (see, e.g., Heyman, Sobel, 1982), according to which the superposition of many "rare" and independent streams of events (namely, here, streams of patients coming from different "directions") can be well approximated by the Poisson event stream. After arriving

patients are registered, a general interview is carried out, and on its basis, an initial assessment of their health condition and related risks is performed. The consequence of this procedure is the selection of patients and their division into five different classes marked with bands of different colors: red (R), orange (O), yellow (Y), green (G), or blue (B). The appropriate priority of patient service is associated with a specific class (color) determined by the patient's health condition. We will assume that patients marked in red have priority in handling (e.g., when performing laboratory or radiological tests) over all other patients, patients in orange "give way" to only "red" patients, etc. The principles of giving priority to handling specific patients are graphically presented in the following diagram:

$$\text{RED} > \text{ORANGE} > \text{YELLOW} > \text{GREEN} > \text{BLUE}$$

Figure 1. Priority rule in the considered queueing model.

Assume that q_j is the fraction of arriving patients qualified as j -type patients, where $j = R, O, Y, G, B$. Relating to splitting property of a Poisson process (Tijms, 2003), j -type patients arrive at the emergency department according to a Poisson process with intensity $\lambda_j \stackrel{\text{def}}{=} q_j \lambda$ ($j = R, O, Y, G, B$). Within a given class, patients are served in accordance with the FIFO (*First In First Out*) discipline, i.e., in the order in which they appeared in the emergency department. The queue of waiting patients is unlimited in advance. The service time for a single patient is closely related to her/his health condition. It is not necessarily the longest in the case of the highest priority patients (such patients are often referred directly to a specific hospital ward, e.g., for urgent surgery). In general, therefore, we will assume that the service time for a single j -type patient has a hyper-exponential distribution with the following probability density function (PDF):

$$f_j(t) \stackrel{\text{def}}{=} \sum_{i=1}^{k_j} p_i^{(j)} \exp(-\mu_i^{(j)} t), t > 0 \quad (1)$$

where $j = R, O, Y, G, B$. Values k_R, k_O, k_Y, k_G , and k_B denote numbers of possible complete diagnostic paths for a j -type patient. In practice, these numbers can be the same for all patients. However, it is not a rule. The value $\frac{1}{\mu_i^{(j)}}$ is the mean duration of the i th complete diagnostic path offered for the j -type patient ($i = 1, \dots, k_j$).

Let us note that the occupation rate ρ_j of the system relating to j -type patient (where $j = R, O, Y, G, B$) equals

$$\rho_j = \lambda_j \cdot E(B_j) = \lambda_j \cdot \sum_{i=1}^{k_j} \frac{p_i^{(j)}}{\mu_i^{(j)}} \quad (2)$$

where B_j stands for the service time of a j -type patient. To ensure the existence of the stationary state of the system, let us assume that

$$\rho \stackrel{\text{def}}{=} \rho_R + \rho_O + \rho_Y + \rho_G + \rho_B < 1 \quad (3)$$

Priority rules

In the studied queueing model of patient service at the hospital emergency department, we will consider the following two models of the priority rule (discipline):

- *absolute priority* (preemptive-resume priority) in which an arriving higher-priority patient interrupts the ongoing service of a lower priority patient,
- *relative priority* (non-preemptive priority) in which the ongoing service process of a lower priority patient cannot be interrupted by a higher priority patient arriving at the hospital emergency department.

For each priority rule, we will analyze the four main stochastic characteristics (performance measures) affecting the quality of service (QoS) for $j = R, O, Y, G, B$, namely:

- the mean number of j -type patients present in the system (we will denote it by $E(L_j)$),
- the mean number of j -type patients waiting in a queue (denoted by $E(Q_j)$),
- the mean sojourn time of a j -type patient (denoted by $E(S_j)$),
- the mean waiting time (for beginning the service) for a j -type patient (denoted by $E(W_j)$).

Moreover, in dependence on the type of a priority rule, we will use the superscript *abs* or *rel* in relation to the absolute or relative priority, respectively. So, for example, $E(S_R^{rel})$ stands for the mean sojourn time of a red-type patient in the case of the relative priority rule.

3. Analytic formulae for performance measures

Since the service time of a single patient has not got the memoryless property (is not exponential), we will introduce the so-called *residual service time*, which is the time needed to complete the ongoing (at the arrival moment of a patient) service. In general (see, e.g., Adan, Resing, 2015), it is possible to express the mean residual service time by using the first two moments of the service time. Indeed, we have

$$E(R_j) = \frac{E(B_j^2)}{2E(B_j)} \quad (4)$$

where $E(R_j)$ and $E(B_j^2)$ are the mean residual service time of the j -type patient and the second moment of its service time ($j = R, O, Y, G, B$), respectively. Adjusting the formula (4) to the hyper-exponential service times (see (1)), we have

$$E(R_j) = \frac{\sum_{i=1}^{k_j} \frac{p_i^{(j)}}{[\mu_i^{(j)}]^2}}{2 \sum_{i=1}^{k_j} \frac{p_i^{(j)}}{\mu_i^{(j)}}} \quad (5)$$

The representations for mean values of the number of patients (of each type) present in the considered system, number of patients waiting in the queue, waiting, and sojourn times are essentially dependent on mean residual service times, occupation rates, and average service times and arrival rates. In the case of relative priority, the following formulae are accurate (see Adan, Resing, 2015) – we adjust the formulae to the notation introduced in the paper:

$$E(S_j^{rel}) = \frac{\sum_{i \in \{R, O, Y, G, B\}} \rho_i E(R_i)}{(1 - \sum_{i \geq j} \rho_i)(1 - \sum_{i > j} \rho_i)} + E(B_j) \quad (6)$$

and

$$E(W_j^{rel}) = \frac{\sum_{i \in \{R, O, Y, G, B\}} \rho_i E(R_i)}{(1 - \sum_{i \geq j} \rho_i)(1 - \sum_{i > j} \rho_i)} \quad (7)$$

where $j = R, O, Y, G, B$.

Now we will apply the well-known (see, e.g., Bose, 2002) Little's formulae $E(L) = \lambda E(S)$ and $E(Q) = \lambda E(W)$, where L, λ, S, Q , and W stand for the number of customers (here: patients) present in the system, the arrival rate, the sojourn time, the waiting time and the number of customers (patients) waiting in the queue, respectively. We get from (6) and (7) the following representations:

$$E(L_j^{rel}) = \frac{\lambda_j \sum_{i \in \{R, O, Y, G, B\}} \rho_i E(R_i)}{(1 - \sum_{i \geq j} \rho_i)(1 - \sum_{i > j} \rho_i)} + \rho_j \quad (8)$$

and

$$E(Q_j^{rel}) = \frac{\lambda_j \sum_{i \in \{R, O, Y, G, B\}} \rho_i E(R_i)}{(1 - \sum_{i \geq j} \rho_i)(1 - \sum_{i > j} \rho_i)} \quad (9)$$

In the formulae above, the notation $\sum_{i \geq j} \rho_i$ stands for the sum over all groups of patients with the priority that is higher than or equal to j . Similarly, in the case of $\sum_{i > j} \rho_i$, we take higher priorities than j .

In the case of the absolute priority we have (Adan, Resing, 2015)

$$E(S_j^{abs}) = \frac{\sum_{i \geq j} \rho_i E(R_i)}{(1 - \sum_{i \geq j} \rho_i)(1 - \sum_{i > j} \rho_i)} + \frac{E(B_j)}{1 - \sum_{i > j} \rho_i} \quad (10)$$

and

$$E(W_j^{abs}) = \frac{\sum_{i \geq j} \rho_i E(R_i)}{(1 - \sum_{i \geq j} \rho_i)(1 - \sum_{i > j} \rho_i)} \quad (11)$$

where $j = R, O, Y, G, B$.

Hence, utilizing Little's laws, we obtain

$$E(L_j^{abs}) = \frac{\lambda_j \sum_{i \geq j} \rho_i E(R_i)}{(1 - \sum_{i \geq j} \rho_i)(1 - \sum_{i > j} \rho_i)} + \frac{\rho_j}{1 - \sum_{i > j} \rho_i} \quad (12)$$

and

$$E(Q_j^{abs}) = \frac{\lambda_j \sum_{i \geq j} \rho_i E(R_i)}{(1 - \sum_{i \geq j} \rho_i)(1 - \sum_{i > j} \rho_i)} \quad (13)$$

4. Numerical examples

In this section, we present illustrative numerical examples for some chosen sets of system parameters. The different sets of system input parameters correspond to the real-life scenarios of traffic intensity and patient service in the hospital emergency department. These parameters can be successfully estimated statistically based on concrete "learning" observations in a time window of a fixed width. In all computations (visualized in figures), we investigate the behavior of a given characteristic (e.g., the waiting time) in dependence on the intensity of patient arrivals. Let us note that these examples are illustrative and describe all possible practical situations only to a limited extent.

Scenario no. 1

In the first scenario, we assume that the number of possible diagnostic pathways for the most severely ill patients (red-type) is the highest, equal to 5. Then it decreases by one for the following categories (types) of patients. For patients in the lightest condition (blue-type), there is only one diagnostic path (the service time for such a patient is then described using one exponential random variable with a fixed parameter value). Moreover, we assume that random variables describing the pathways are different for different-type patients. So, we take a set of values presented in Table 1 as the input set of system parameters.

Table 1.

Model parameters for Scenario no. 1

Patient type (j)	Parameter			
	Number of diagnostic paths (k_j)	Frequency (q_j)	Parameters of different-path service times ($\mu_i^{(j)}, i = 1, \dots, k_j$)	Frequencies of choosing a particular path ($p_i^{(j)}, i = 1, \dots, k_j$)
Red	5	0.10	(0.10, 0.20, 0.30, 0.40, 0.50)	(0.4, 0.3, 0.1, 0.1, 0.1)
Orange	4	0.15	(0.25, 0.35, 0.40, 0.50)	(0.4, 0.3, 0.2, 0.1)
Yellow	3	0.20	(0.30, 0.40, 0.50)	(0.5, 0.4, 0.1)
Green	2	0.15	(0.40, 0.55)	(0.6, 0.4)
Blue	1	0.40	(0.50)	(1.0)

In Figure 1, the behavior of the mean sojourn time in dependence on the arrival rate of incoming patients is presented in the case of relative priority. Similar results for the absolute priority can be observed in Figure 2. Particular colors of lines in figures correspond to the patient type (red, orange, yellow, green, and blue). The values of the arrival intensity λ are taken in such a way as to satisfy the stationary condition of the system ($\rho < 1$). In Figures 3-4, similarly, the behavior of the mean number of patients (of each type) present in the system is shown in the case of relative and absolute priority, respectively.

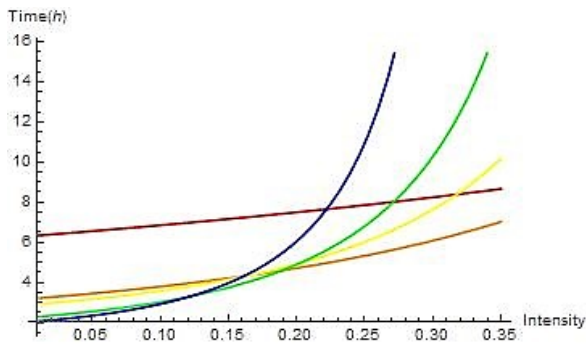


Figure 1. Mean sojourn time for Scenario no. 1 and relative priority

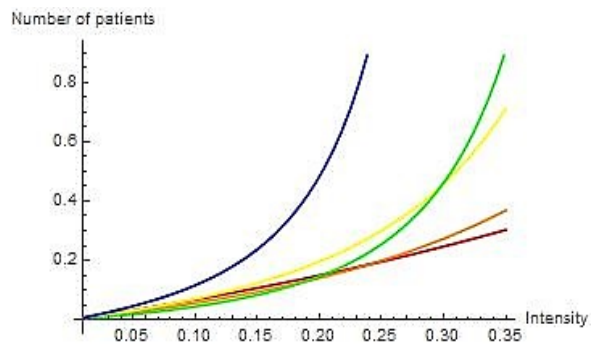


Figure 2. Mean number of patients for Scenario no. 1 and relative priority

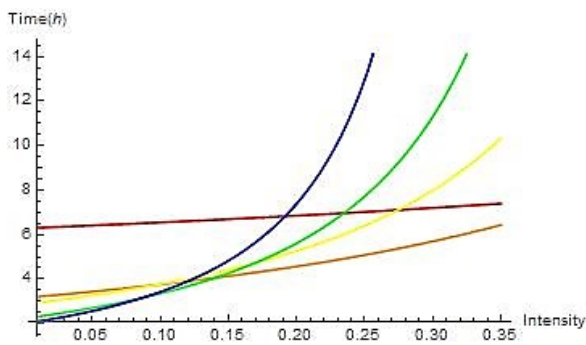


Figure 3. Mean sojourn time for Scenario no. 1 and absolute priority

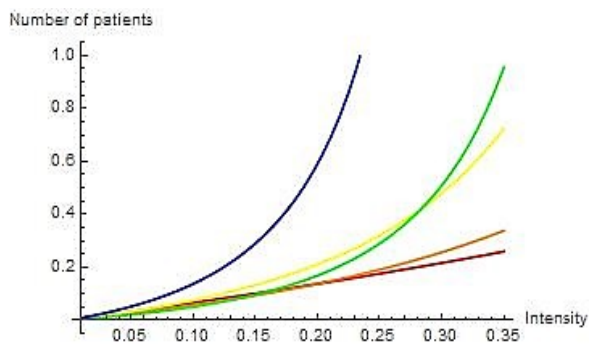


Figure 4. Mean number of patients for Scenario no. 1 and absolute priority

Let us note a significant difference between the behavior of individual characteristics for the relative and absolute priorities. Indeed, in the absolute priority for red-type patients, other-type patients "do not exist". The result is that for the highest possible arrival intensities, e.g., the mean sojourn time for a red-type patient is visibly above 8 hours in the case of relative priority and about 7 hours in the case of absolute priority.

Scenario no. 2

In Scenario no. 2, we leave the number of possible diagnostic paths, the parameters of their distributions, and the frequencies of occurrence of successive types of patients unchanged. In this model, however, we will assume that the longest-lasting diagnostic paths (i.e., those with the lowest values of parameters $\mu_i^{(j)}$) appear the least frequently in practice, and most often

those in which the diagnostic and therapeutic process lasts the shortest. The parameters of the model under consideration are presented in Table 2.

Table 2.
Model parameters for Scenario no. 2

Patient type (j)	Parameter			
	Number of diagnostic paths (k_j)	Frequency (q_j)	Parameters of different-path service times ($\mu_i^{(j)}, i = 1, \dots, k_j$)	Frequencies of choosing a particular path ($p_i^{(j)}, i = 1, \dots, k_j$)
Red	5	0.10	(0.10, 0.20, 0.30, 0.40, 0.50)	(0.1, 0.1, 0.1, 0.3, 0.4)
Orange	4	0.15	(0.25, 0.35, 0.40, 0.50)	(0.1, 0.2, 0.3, 0.4)
Yellow	3	0.20	(0.30, 0.40, 0.50)	(0.1, 0.4, 0.5)
Green	2	0.15	(0.40, 0.55)	(0.4, 0.6)
Blue	1	0.40	(0.50)	(1.0)

In Figures 5-6, the mean waiting times and the mean numbers of patients waiting in the line are visualized, respectively, for the case of the relative priority, in dependence on the accumulated arrival intensity λ . Corresponding results for the absolute priority are presented in Figures 7-8.

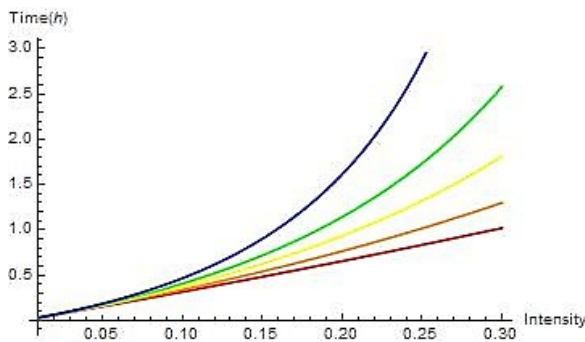


Figure 5. Mean waiting time for Scenario no. 2 and relative priority

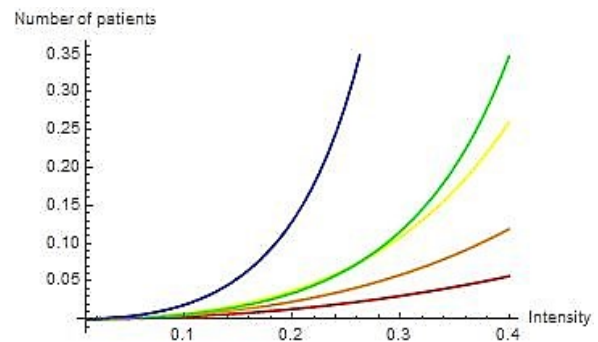


Figure 6. Mean number of patients waiting in the queue for Scenario no. 2 and relative priority

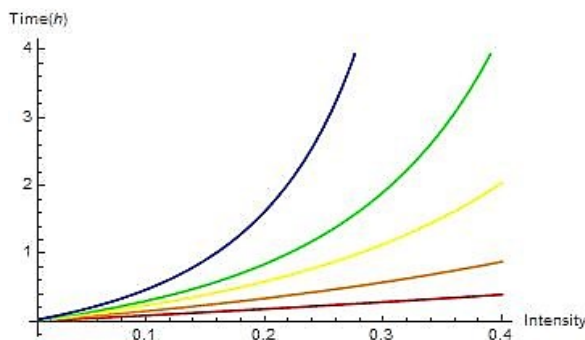


Figure 7. Mean waiting time for Scenario no. 2 and absolute priority

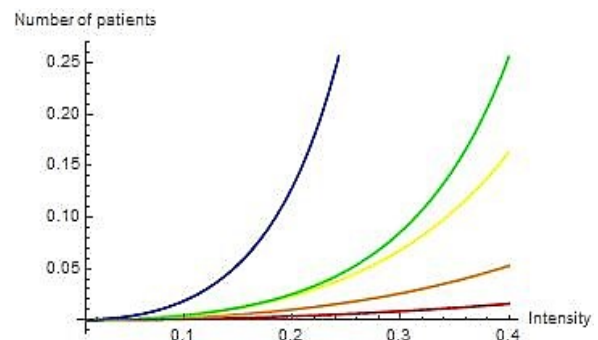


Figure 8. Mean number of patients waiting in the queue for Scenario no. 2 and absolute priority

Let us observe that in the case of Scenario no. 2, the mean waiting time and the mean number of patients waiting in the line (queue) for any lower-priority patient are always less than the corresponding values for a higher-priority one.

Scenario no. 3

In the last scenario, let us consider the situation in which the frequencies of occurrence of each type of patient are the same and equal 0.20. We have five different diagnostic paths for any patient, described by exponential distributions with the same parameters. The essential difference is that the frequency of choosing the longest-lasting one is the greatest for the red-type patient and the smallest for the blue-type patient. All values of parameters of the considered model are presented in Table 3.

Table 3.

Model parameters for Scenario no. 3

Patient type (<i>j</i>)	Parameter			
	Number of diagnostic paths (<i>k_j</i>)	Frequency (<i>q_j</i>)	Parameters of different-path service times ($\mu_i^{(j)}, i = 1, \dots, k_j$)	Frequencies of choosing a particular path ($p_i^{(j)}, i = 1, \dots, k_j$)
Red	5	0.20	(0.10, 0.20, 0.30, 0.40, 0.50)	(0.35, 0.25, 0.20, 0.15, 0.05)
Orange	5	0.20	(0.10, 0.20, 0.30, 0.40, 0.50)	(0.30, 0.25, 0.20, 0.15, 0.10)
Yellow	5	0.20	(0.10, 0.20, 0.30, 0.40, 0.50)	(0.10, 0.20, 0.40, 0.20, 0.10)
Green	5	0.20	(0.10, 0.20, 0.30, 0.40, 0.50)	(0.10, 0.15, 0.20, 0.25, 0.30)
Blue	5	0.20	(0.10, 0.20, 0.30, 0.40, 0.50)	(0.05, 0.15, 0.20, 0.25, 0.35)

In Figures 9-10 the results for the mean sojourn time and the mean number of patients present in the system are shown, respectively, for the relative priority. The corresponding results for the absolute priority are presented in Figures 11-12. Let us note that in the considered model, an "approximate" equilibrium occurs in the case of the mean sojourn time, i.e., for the certain intensity of patient arrival, the mean waiting time is approximately the same for all-type patients.

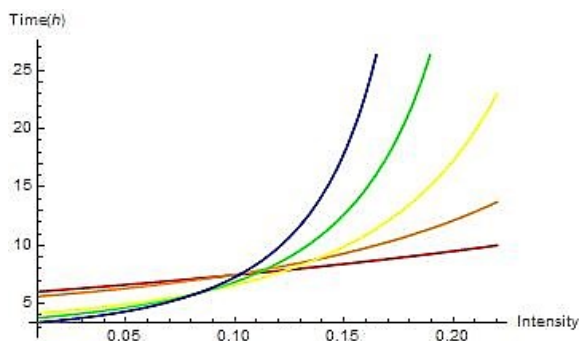


Figure 9. Mean sojourn time for Scenario no. 3 and relative priority

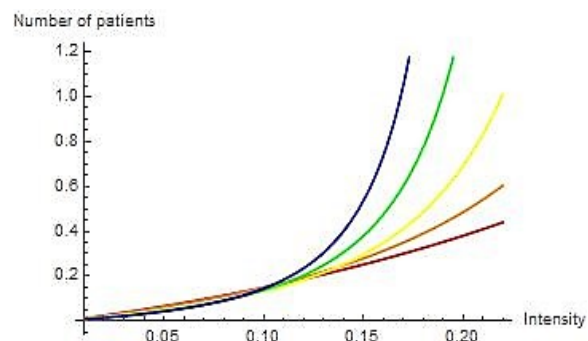


Figure 10. Mean number of patients for Scenario no. 3 and relative priority

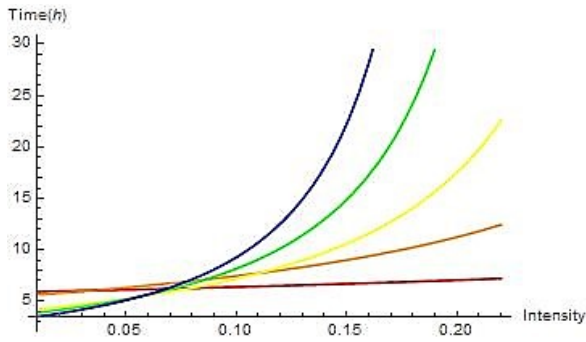


Figure 11. Mean sojourn time for Scenario no. 3 and absolute priority

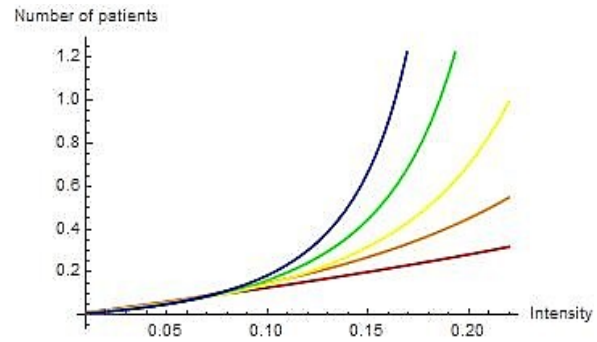


Figure 12. Mean number of patients for Scenario no. 3 and absolute priority

5. Conclusions

The paper proposed a queueing model of patient service in a hospital emergency department, compliant with the currently used S.T.A.R.T standard. The model assumed two types of priority patient service depending on their health condition: service with absolute priority and relative priority. The results for the average sojourn time of the each-type patient, the average waiting time for the start of the diagnostic process, as well as for the mean number of patients present in the system and the mean number of patients waiting in the queue were obtained. Analytical results were illustrated by numerical calculations considering three different scenarios. The proposed model creates vast application possibilities for a more precise assessment and optimization of the work of the hospital emergency department in various conditions that are planned in the future.

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SUSTAINABLE MOBILITY WITHIN GREEN SMART CITIES – A CHALLENGE FOR LOCAL GOVERNMENTS. CASE STUDY OF TRI-CITY

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Purpose: Verification of the status, potential and directions of development and identification of challenges for Tri-City local governments.

Design/methodology/approach: The case study of the Tri-City, based on the analysis of the literature on the green smart city concept and the documents of the municipalities of the Tri-City, secondary sources in the form of research communications of a similar scope. Author will first deal with the determinants of the green smart city concept, and within that the determinants of smart mobility.

Findings: The green smart city concept in urban space management for local authorities it is primarily a mobility policy, and within it, two main areas of action. The first is a infrastructure policy, the second is to shaping the transport behaviour of city residents. Infrastructural decisions are directly dependent on the local authorities, while the transport behaviour of the inhabitants can be influenced by the local authorities by shaping the creative class.

Social implications: The management of urban space in terms of sustainable mobility policy should lead to a change in mobility behaviour of the agglomeration's residents. One of the aims of the local authorities should be to define and selection of influence tools on the creative class of Tri-City, which through its mobility behaviour will change the mobility patterns of other residents. The decisions of the local government in the area of infrastructure solutions, the network of public transport and raising environmental awareness of the Tri-City residents, a change in communication behaviour of the Tri-City community should be occurred. This change should be led in the direction of resignation from travelling by car in favour of solutions that are more conducive to sustainable development.

Originality/value: The article presents the strategic objectives and directions of activities of the local governments of Tri-City, comparing them with the concept of green smart city. It indicates that the element that connects all areas of this concept is the policy of sustainable mobility of the residents of the city, which should be implemented through investment in infrastructure and building the creative class, which is a role model for ecological behaviour of the residents of Tri-City.

Keywords: smart mobility, green smart city, Tri-City.

Category of the paper: Case study.

1. Introduction

According to the policy of sustainable development, the management of urban spaces by local governments should aim to reduce the negative effects on the environment and create comfortable living conditions for the local community. For urban spaces, sustainable development means fitting into the green smart city concept, which includes the municipality as an organisation and the processes within it (smart economy, smart governance), the population and residents (smart people) the environment (smart environment), as well as the environmental behaviours of residents (smart living, smart mobility). The Tri-City case study based on the analysis of the literature on the green smart city concept and the documents of the Tri-City municipalities, secondary sources, in the form of research communications of similar scope, will first treat the determinants of the green smart city concept, and – within it – the determinants of smart mobility, and then indicate the status, development potential and challenges for Tri-City local governments in this regard.

2. Green smart city – the development direction of city space management

The direction of environmental activities at various levels of the economy, especially local, is conditioned by the deteriorating state of the environment and the need to reduce or avoid harmful changes. Public expectations concerning the activities of local governments are driven by increased social sensitivity to the quality of the environment and, consequently, are reflected in attitudes. Such attitudes bring the management of urban spaces closer to the smart city concept. The smart city concept is rooted in sustainable development and the sharing economy contributing to the creation of an innovative city. An innovative city is more effective in meeting the quality of life needs of its residents; however, the ability to apply smart city concepts to local government policies depends on the city's financial potential (Łaźniewska et al., 2021).

The smart city concept is a concept focused on smart management of space and community, however, no longer sufficient in terms of caring for the environment. A current requirement of urban space management is an environmental approach, taking into account first the perception of the effects of decisions and policy objectives through the prism of the impact on the state of the city's natural environment. The areas of activities that characterize the smart city transformation process towards a green smart city should also include those aimed at the energy and environmental efficiency of existing buildings, the introduction of renewable energy sources on a municipal scale, and the introduction of smart mobility plans. Indeed, these areas of activity are the most effective way to reconcile the following objectives (Casini, 2017):

- environmental (reduction of energy consumption and emissions),
- economic (reduction of management costs for citizens and public administration, development of businesses and increase in employment levels),
- social (improving well-being and quality of services).

So, green smart city is the highest level of green development and management of urban spaces, one that is most open to new solutions and cooperation. A parallel issue is to improve the skills and environmental competences of the city's residents – further training in the use of infrastructure, transport, tourism, natural environment, education, research and business cooperation, among others (Łaźniewska et al., 2021). Thus, taking into account the challenges for local governments in the field of smart mobility, urban space management in the green smart city concept means, first of all, investing in transport and municipal infrastructure, and secondly, it means reducing the number of trips residents make by environmentally unfriendly modes of individual transport, i.e. cars. Measures to encourage users to change their transport preferences and behaviours (mobility management policies) should, by definition, define the city's overall vision for promoting sustainable transport and encourage residents to use cars less frequently in favour of sustainable modes of transport (Przybyłowski, 2017), thus creating the desired urban mobility model. Urban mobility models are constantly changing. In particular, the high dynamics of transformation is characteristic of agglomeration areas. Mobility is shaped by multiple factors – in particular, by the media and by imitating the behaviours of individuals and social groups, which requires a broad approach to urban functions. A variety of activities are carried out in metropolitan areas to carry out higher urban functions, such as administration, culture, art, science and education. The implementation of these functions falls within the concept of the smart city and creates conditions for the development of the creative class (scientists, engineers, artists, designers and architects, programmers, opinion makers, legal professions, hi-tech sectors, health care financial services industry and management professionals). The creative class, due to its status and social exposure, is a driving force of local and regional development, as it has the opinion-forming potential, so the creative class can participate in the creation of urban mobility behaviours patterns embedded in the concept of green smart city, as its members (Krawczyk, Kos, Tomanek, 2020):

- have a stable financial situation, hence they will be less negative about restrictive measures in line with the green smart city paradigm, e.g. limiting access of older cars (or diesel cars) to the city centre,
- because of their international contacts (e.g., working for a global enterprise) and greater propensity to travel, they are eager to draw on foreign models in the context of solving local transport problems – such as congestion,
- are aware of the negative impact of transport on the surroundings (including the natural environment) and are able to change their own transport habits,

- feel no apprehension when dealing with modern technology and adapt new solutions faster than the rest of society,
- are open-minded and tolerant, which also manifests itself in the acceptance of the transport-related behaviours of others who, for example, use bicycles to commute to work.

Mobility management policy is also the local government's fulfilment of statutory, mandatory actions under legal acts. One such piece of legislation setting the course for changing the urban spaces towards a green smart city is the Act of 11 January 2018 on electromobility and alternative fuels (Dz.U. 2018, poz. 317). The law imposes, among other things, the obligation to create charging sites in newly built multi-family and public buildings, development rules and conditions and obligations for the deployment of alternative fuel infrastructure for transport, rules for the functioning of clean transport zones in cities, information obligations for alternative fuels (Zawieska, 2019). In addition, the law imposes obligations on state authorities and local government units regarding the number of battery electric vehicles in the fleet of vehicles used by these units, the number of zero-emission buses in the fleet of vehicles used in public transport, creating a framework for planning activities leading to minimum conditions that fall under the green smart city concept.

3. Towards green smart city - Tri-City case

The Tri-City is a polycentric metropolitan area. It is located in the Pomeranian Province of Poland, on the shores of the Gdańsk Bay and the Puck Bay. To the south, the urban spaces of the Tri-City is defined by the landforms of the Kashubian Proglacial Stream Valley and the Tri-City Landscape Park. Such a location is, on the one hand, from the point of view of the green smart city concept, advantageous, as it creates conditions for fairly free access to environmental resources, which, by the way, is inscribed in the consciousness of residents who commonly enjoy leisure activities in coastal areas, but on the other hand, it creates a constraint by setting and limiting the directions of urban expansion. The total area occupied by the urban centre thus defined as of 2021 was about 414 km² and was inhabited by approx. 749,800 residents – Gdańsk 470,633, Gdynia 244,104, Sopot 35,049 (GUS, 2022). Due to the awareness of local government authorities, not only of the main urban centres, but also of the municipalities drawn to the Tri-City forming the Gdańsk-Gdynia-Sopot Metropolitan Area, a strategy for the Gdańsk-Gdynia-Sopot Metropolitan Area was developed in 2015, in which the most important determinants of spatial development and management were considered (Strategia..., 2015):

- the metropolitan area is a polycentric and bipolar area with a linear development axis along the main transport axis,
- deconcentration and dispersion of settlements are present within the metropolitan area, involving an exodus of residents from the metropolitan core and other cities,
- the public transport system of the metropolitan area is based on railway connections (SKM, PKP Przewozy Regionalne, PKM), which clearly improve transport accessibility of the metropolitan core and regional centres,
- the metropolitan area is characterised by one of the Poland's largest, very diverse potential for tourism, sports and leisure; the most important assets include its coastal location, cultural offer, historical monuments, cultural diversity, and natural and spa qualities,
- the quality of the environment plays a key role in the development of the metropolitan area from the point of view of securing high living standards for its residents – poor air quality (especially as a result of low emissions, resulting in exceeding the permissible level of particulate matter content, among others) is a threat,
- thanks to the potential of the Metropolitan Area, functional-spatial relationships are formed, manifested in regular or occasional commuting and the use of metropolitan educational, commercial, cultural, leisure and medical offerings.

Based on the conditions indicated above, the strategy defines a strategic goal in the form of: "The goal of Strategy 2030 is to create mechanisms to strengthen the cohesion of the Metropolitan area through coordination of activities, intersectoral cooperation and obtaining compromise solutions for the better development of each of the entities that make up the Metropolitan area," and includes specific objectives for the various areas that are part of the green smart city concept (Table 1).

Looking at the development objectives of the Gdańsk-Gdynia-Sopot Metropolitan Area, it can be clearly identified that the main area for improving the quality of life in the city and developing into a green smart city is the issue of transport – both public passenger and individual, as well as cargo, which is a result of the coastal location, which makes it necessary to bring them in and out of ports. The importance of this area is reinforced by two facts. The first is that "in general, transport accounts for a quarter of Europe's greenhouse gas emissions and is considered a major cause of urban air pollution" (Rasiński, 2018), while the second is that the quality of transport is determined by mobility management policies (including infrastructure), which is the responsibility of the state or local governments.

Table 1.

Specific strategic objectives for the development of the Gdańsk-Gdynia-Sopot Metropolitan Area

Area	Sub-area	Purpose
Society	Education	Development and improvement of the quality of education
		Matching higher and vocational education with labour market needs
	Residents	Increased cultural participation and improved social skills
		Support for families and reduction of migration outflows
		Attracting and supporting new residents
Innovative and competitive economy	Promotion and investment	Creation of infrastructure for investment and economic promotion, including industrial production
		Supporting local businesses in the global market
		Supporting network links within key clusters (including the shipbuilding cluster, transport-freight forwarding-logistics and ICT) as well as regional smart specialisations
	Innovation and entrepreneurship	Promotion of innovation and entrepreneurship
		Increasing the effectiveness of research and development activities through internationalisation and commercialisation of research results
		Supporting the metropolitan labour market
		Development of tourism and leisure industries (including promotion of internal tourism in the metropolitan area)
Sustainable space	Transport	Strengthening the function of an international transport hub, including through the development of seaports
		Improving internal transport accessibility and improving the public transport network
		Improving external transport accessibility
		Improving management and prioritisation of metropolitan public transport, multimodal and active mobility
	Spatial planning	Improving land use efficiency based on a polycentric settlement system
		Creating industrial and service zones
	Environment	Protecting the environment and reducing environmental risks
		Improving the efficiency of water, sewage and waste management.
		Developing renewable energy and increasing energy efficiency

Source: Strategia Obszaru Metropolitalnego Gdańsk-Gdynia-Sopot do roku 2030. Retrieved from: [https://www.metropoliagdansk.pl/upload/files/Strategia%20OMGGS%202030\(2\).pdf](https://www.metropoliagdansk.pl/upload/files/Strategia%20OMGGS%202030(2).pdf), 10.05.2022.

Strengthening the function of Gdańsk-Gdynia-Sopot Metropolitan Area as an international transport hub, including through the development of seaports is implemented and results from the fact that seaports located in Gdańsk and Gdynia handle passenger and cargo traffic. A ferry service is operated to from Gdańsk to Nynäshamn and from Gdynia to Karlskrona. By far the larger operator is the Gdynia-based Stena Line, offering 14 trips per week, while Polferries from Gdańsk is only 7 sailings per week. Both ferries are passenger and car ferries, and both also handle cargo traffic including container traffic on semi-trailers, which puts more strain on road infrastructure. Both are located in the system of the primary transport network of national and international importance and are integrated into a system that, through sea and land connections, is an integral part of the European transport network. A number of transport links leading through the ports of Gdańsk and Gdynia are particularly important for the European Union's transport routes. These include (Grzybowski, 2010):

- trans-European roads (TEN roads):
 - A1 highway (Gdańsk/Gdynia – Łódź – Katowice) with branches,
 - Grudziądz-Poznań, Toruń-Warsaw and Łódź-Wrocław roads,
- trans-European railways (TEN railways),
 - Gdańsk/Gdynia – Warsaw – Katowice – Zebrzydowice railway main line, with a Warsaw – Dorohusk branch line,
 - Gdańsk/Gdynia – Bydgoszcz – Katowice railway main line with Inowrocław – Poznań, Zduńska Wola – Wrocław branch lines,
 - Gdańsk/Gdynia – Elbląg – Braniewo – Kaliningrad railway line.

It is clear that port transport service creates infrastructure challenges, both in terms of rail and road infrastructure. Railway infrastructure viewed through the prism of the city creates a problem of land use intensity, "dividing the city" and creating problems at the interface with road infrastructure. However, from the point of view of the city's residents, the most important thing is the road infrastructure, which is simultaneously used for individual transport. From this point of view, it should be said that Gdańsk (New Port, Northern Port and DCT) has a much better connection with the main road traffic direction, that is, east and south with the connection of the Major Henryk Sucharski Road (DK 89) with the S7 national road, in the direction to Elbląg and then east and south and west to the S6 and then A1 south and west DK 22. The important thing is that the ports of Gdańsk can be served in a way that has little impact on city centre traffic. A certain problem is the use of the Sucharski Road by residents for daily commuting to neighbouring communities located south of the city.

In Gdynia, on the other hand, the main element of road infrastructure is the "Eugeniusz Kwiatkowski Road," which is a municipal connector to Morska Street (which is part of the Tri-City's urban traffic axis) and the S6 road, which was built in the 1970s as a ring road for the Tri-City, and is now practically part of it. This results in increased car traffic of Tri-City residents giving up on the main urban road transport axis DW 468 (Gdańsk Central Station – Gdynia Chylonia intersection with S6). The development of the importance of Gdańsk-Gdynia-Sopot Metropolitan Area included in the strategic objectives will definitely exacerbate the problems of road communication in Gdynia, since the Kwiatkowski Road (built in the mid-1970s), which is in dire need of repair, is at the same time the main connection between the city centre and its districts that are some of the city's main dormitory districts (Obłuże, Pogórze, Oksywie, Kossakowo). The challenge for the city is to build two transport solutions to handle the transport of the Port of Gdynia. The first is railways, including the modernisation of existing railway lines 131, 201 and 202 through the Tri-City to Słupsk and the construction of a connection to the Solidarity Transport Hub Poland. Railway investments in the Port of Gdynia area will contribute in the future to connecting it to the network being built as part of the Solidarity Transport Hub Poland (including a node in the vicinity of the Solidarity Port). Goods arriving on ships will be able to be transshipped in the port of Gdynia onto rails, then reach Gdańsk, and there via the Solidarity Transport Hub Poland railway line (the so-called "spoke"

No. 1), i.e. CMK-North, reach the Solidarity Port and the intermodal transshipment terminal located in its vicinity (Pomorski Urząd Wojewódzki).

The second is the so-called Red Road. The new road connecting the Kwiatkowski Estacada, which is overloaded by port transit, with the Tri-City Ring Road and on to the A1 highway (Figure 1) is an opportunity not only for the port's development, but above all to allow residents free passage on the most important artery leading to the city's northern districts. The road has needed costly repairs several times in recent years, and representatives of the Ministry of Infrastructure have regularly received signals from Gdynia about the increasingly necessary Red Road. For many years, the local government of Gdynia has been applying for funds from the State Treasury (Gdynia moje miasto) and it seems that recently, thanks to an agreement signed in April 2022, planning work can begin and construction has a chance to start (Pomorski Urząd Wojewódzki). Such a solution is in line with the investment already underway involving the construction of the Metropolitan Ring Road through the extension of the S7 expressway (Straszyn – Chwaszczyno) and the construction of the so-called "Kashubian Road", (Gdynia Wielki Kack – Bożepole Wielkie). This will improve the situation of the metropolitan cities by taking transit traffic out of the Tri-City ring road. The planned completion date for the "Kashubian Road" is the summer of 2022 (trojmiasto.pl), and the S7 road extension is the second quarter of 2025 (Serwis Rzeczypospolitej Polskiej)

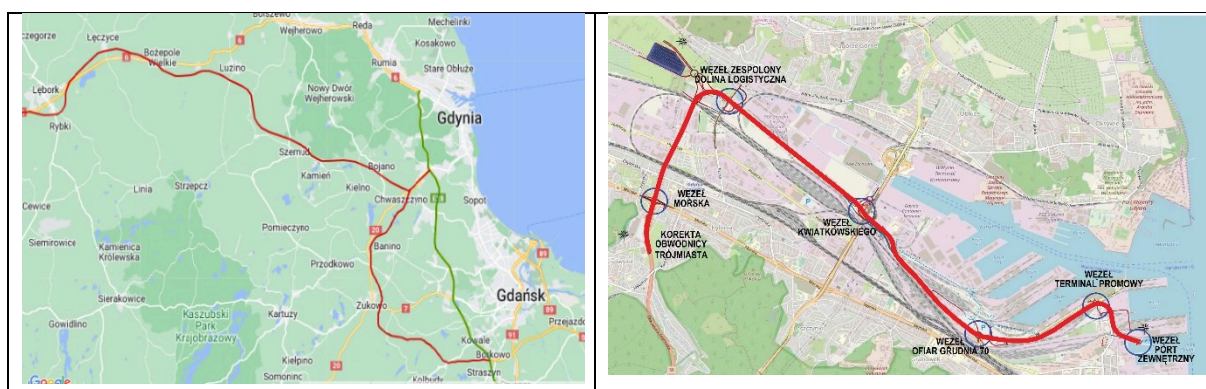


Figure 1. The course of the Metropolitan Ring Road – "Kashubian Road" and the Red Road in Gdynia. Source: Co na drogach Retrieved from: <https://conadrogach.pl/drogi-ekspresowe/mapa-samochodowa/>, 10.05.2022; Gdynia moje miasto. Retrieved from <https://www.gdynia.pl/co-nowego,2774/znamy-przebieg-drogi-czerwonej,553460>, 27.05.2022.

The aforementioned investments are aimed at relieving the Tri-City Ring Road, as well as the traffic axis of the Tri-City agglomeration, namely – provincial road DW 468. This road, connecting all cities, constitutes a parallel infrastructure system to the Rapid Urban Railway (SKM) network, providing passenger transport in Gdańsk, Gdynia and Sopot, as well as inter-city communication, fitting in with the second objective of the Gdańsk-Gdynia-Sopot Metropolitan Area strategy – "Improving internal transport accessibility and improving the public transport network." The use of this road by individual car users generates problems of emissions, noise and congestion, understood as the mutual obstruction of traffic by vehicles,

which is a consequence of the objective relationship between the speed of movement and the volume of flow, under conditions when the capacity utilisation rate of the transport system is approaching its limits. The specific mechanisms associated with the formation of congestion in the transport network are exacerbated in sections characterised by intermittent traffic flows, such as those located in dense urban networks. There are seven primary sources of interference leading to congestion in the road network, namely (Żochowska, Karoń, 2012):

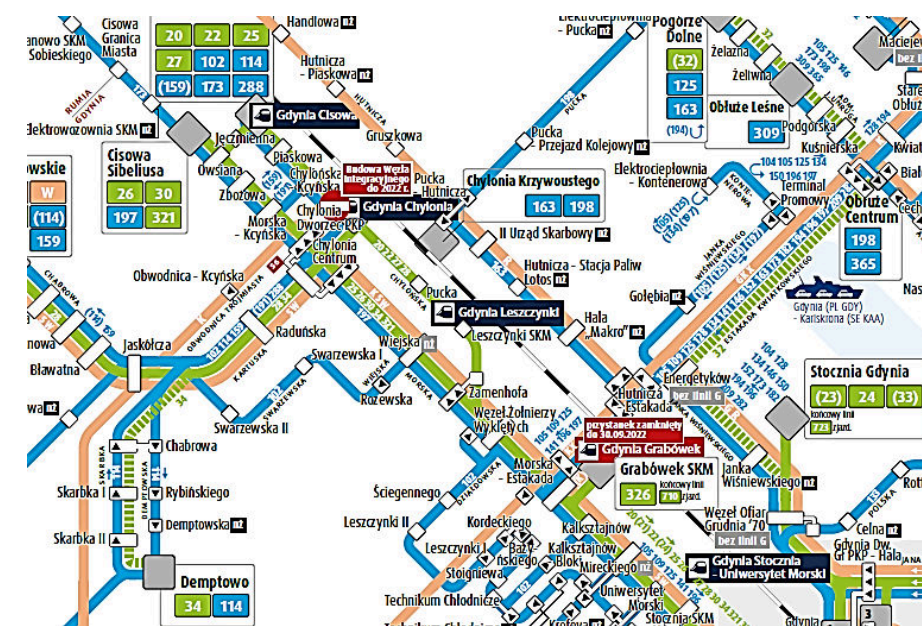
- limited capacity of network elements – e.g., number of roadways, number of lanes,
- traffic incidents – collisions, accidents and vehicle crashes,
- road works – often leading to traffic reorganisation,
- traffic control devices – improperly configured traffic control programs and incorrect selection of traffic control systems,
- mass events – leading to an unusual increase in traffic near the places where these events take place,
- temporal and spatial irregularity of demand – resulting from the variability of traffic on particular days of the week in specific relations.

The reasons indicated above should induce individual car users to switch to public transport. The nature of urban commute, involving many short-distance journeys, predestines it for the popularisation of alternative means of transport. Behavioural changes and the emergence of new travel patterns based on environmentally friendly modes of transport are also needed. Smart residents, an important component in the smart city concept, should be the most receptive to such changes and innovations. In order to achieve the required efficiency, a transformation of urban spatial and energy policies is also needed, implemented together with the idea of a smart and green city (Przybyłowski, 2017).

Encouraging individual car users, especially those who make daily trips to and from work while working in and living in different cities within the Tri-City metropolitan area, is a policy that slows traffic on this road. In March 2021, the speed limit on Gdańsk's main thoroughfare stretching between the city centre and Sopot was lowered from 70 to 50 km/h, despite the fact that this is a 9-kilometer stretch of three-lane Zwycięstwa and Grunwaldzka avenues, and despite the fact that (in a survey conducted by www.trojmiasto.pl) 61% of respondents favoured keeping the higher speed limit. Councilpersons voted in favour of lowering the speed limit and the city management confirmed that increasing traffic safety is a priority in shaping traffic policy in Gdańsk. Therefore, the architects of changes in traffic organisation use tools intended to reduce traffic (trojmiasto.pl).

Within the framework of intercity transport, the basis of the function in the Tri-City is fulfilled by the SKM Rapid Urban Railway, which connects Gdańsk and Wejherowo. The basic section of SKM routes is line 250 Gdańsk City Centre – Rumia, which runs parallel to the "long-distance" line 202 Gdańsk Central Station – Stargard. In addition, SKM operates occasional passenger services on the Gdańsk Central station – Gdańsk Expo Stadium route.

The frequency of trains on the Gdańsk City centre – Gdynia Cisowa section is every 7.5 minutes in the service peak, and every 15 minutes off-peak. Such a network of connections in terms of their frequency meets the expectations of Tri-City residents, especially those whose destinations are located near this transport route, contributing to lower emissions. However, commute within each city represents disconnected systems, as they are based on different solutions. Gdańsk relies on bus and tramway transport to build its transport networks, while Gdynia relies on bus and trolleybus transport and is one of three cities in Poland with trolleybus transport. The others are Tychy and Lublin, with Gdynia's trolleybus service being the oldest in operation, as it was established in 1943, and in terms of the number of fleet in use, it is ranked second, but with the largest network of lines. Gdynia is a city that is constantly upgrading its trolleybus infrastructure and fleet. It is constantly introducing innovative technologies and ensuring the development of environmentally friendly public transport (Rasiński, 2018). An example of such an environmentally friendly solution and at the same time freeing the transport network from the grid is the introduction of battery-equipped trolleybuses into the fleet, serving lines in Sopot and Obłuże (trójmiasto.pl) (Figure 2).




Note.  Stop and route of the trolleybus line (off-grid).

Figure 2. Examples of trolleybus lines outside the overhead grid (as of early May 2022).

Source: Zarząd Komunikacji Miejskiej w Gdyni. Retrieved from: <https://zkmgdynia.pl/files/Schematy%20sieci%20MZKZG/SchematMZKZG.pdf>, 10.05.2022.

The origins of the Gdańsk tramway network date back to 1873, when the first horse-drawn tramway was introduced from the city centre (Targ Sienny) to its outskirts towards Sopot (Pomorska Street), where a tramway depot was located. The network was electrified very quickly, as early as 1896, the horse-drawn tramway was taken out of service (trójmiasto.pl). Expansion of the tramway network (Figure 3) was carried out with maintenance of the main

axis of intercity communication – parallel to the DW 468 road (connection from City Centre to Pomorska Street by a line in its course or parallel and a parallel line closer to the sea, serving the districts of Zaspas and Przymorze), and in a transverse direction connecting Stogi, Piecki-Migowo, Chelm, Ujeścisko with City Centre, which is to perform a complementary function to the SKM network.



Figure 3. The current layout of the tramway network in Gdańsk.

Source: Wikipedia Retrieved from: https://pl.wikipedia.org/wiki/Tramwaje_w_Gda%C5%84sku, 10.05.2022.

Sopot does not have its own public transport, it is served by the communication facilities of neighbouring cities of Gdańsk and Gdynia. Tri-City residents have already gotten used to the fact that Gdynia and Gdańsk buses are operated in Sopot, but tourists coming to the resort for a holiday do not know how to get around by public transport in Sopot. There is information at bus stops about which bus serves which line and which tickets to use. The information is in available Polish and English, however, despite this in Sopot, tourists have trouble using the public transport (Sopot nasze miasto). The solution to this issue is metropolitan tickets, which are offered to residents as single-use and monthly tickets, while clearly differentiating between network operators. A special case are metropolitan tickets, which in a form particularly dedicated to tourists are 24- or 72-hour tickets (Table 2).

Table 2.*Price list and scope of the network covered by the 24- and 72-hour metropolitan tickets*

Specification	Scope included	Regular price ticket	Reduced price ticket
24-hour metropolitan ticket	Paper and phone, municipal valid for ZTM Gdańsk and ZKM Gdynia and MZK Wejherowo (applications: GoPay, jakdojade.pl, moBiLET, mPay, SkyCash and zbiletem.pl)	PLN 16	PLN 8
	Paper and telephone rail/municipal for two operators valid on trains of railway operators: SKM and POLREGIO and for: ZTM Gdańsk or ZKM Gdynia or MZK Wejherowo (applications: GoPay, jakdojade.pl, moBiLET, mPay, SkyCash and zbiletem.pl)	PLN 22	PLN 11
	Paper and telephone rail/municipal for all operators valid on trains of railway operators: SKM and POLREGIO and for: ZTM Gdańsk and ZKM Gdynia and MZK Wejherowo (applications: GoPay, jakdojade.pl, moBiLET, mPay, SkyCash and zbiletem.pl)	PLN 25	PLN 12.50
72-hour metropolitan ticket	Paper and phone, municipal valid for ZTM Gdańsk and ZKM Gdynia and MZK Wejherowo (applications: GoPay, jakdojade.pl, moBiLET, mPay, SkyCash and zbiletem.pl)	PLN 32	PLN 16
	Paper and telephone rail/municipal for all operators valid on trains of railway operators: SKM and POLREGIO and for: ZTM Gdańsk and ZKM Gdynia and MZK Wejherowo (applications: GoPay, jakdojade.pl, moBiLET, mPay, SkyCash and zbiletem.pl)	PLN 50	PLN 25

Source: Metropolitalny Związek Komunikacyjny Zatoki Gdańskiej. Retrieved from: <https://mzkgz.org/bilety-jednorazowe-i-czasowe>, 24.05.2022.

The transport and fare solutions indicated above are designed to encourage tourists and residents of the Tri-City, as well as neighbouring municipalities, to use public transport. This is also reinforced by cities' conscious policies on the use of environmentally friendly means of personal transport by residents such as bicycles, scooters, etc. The intersection of individual and public motorised transport (cars, buses, tramways) and individual environmentally friendly transport (bicycles, scooters) raises the risk of traffic accidents. To prevent this, infrastructure in the form of bicycle paths is being expanded and measures are being taken on road infrastructure. To this end, among other things, speed bumps are being installed, TEMPO 30 zones are being designated, or traffic light system upgrades are being implemented. "This is our response (as stated by Magdalena Kiljan, a spokesperson for the Gdańsk Roads and Greenery Management Board) to the increasing number of requests and proposals from residents of Gdańsk who care about making the street, sidewalk and bicycle path in their immediate vicinity safe" (trojmiasto.pl). In addition, one can point to the creation of facilities for users of environmental means of individual transport in the form of building ground crossings, an example of which are the crossings with traffic lights at the Upland Gate and the Gdańsk Medical University just located along DW 468 (Puls Gdańska).

The infrastructure solutions indicated above at the intersection of traffic routes improve traffic safety with personal transport devices and traffic support devices, however, three elements treated in parallel are necessary. Firstly, the already mentioned infrastructure, secondly, legal framework, and thirdly, the ability to use the personal transport provided. The network of bicycle paths in the Tri-City in 2021 was approx. 293 km – Gdańsk approx. 203 km, Gdynia 68 km, Sopot 22 km (GUS) – Figure 4.

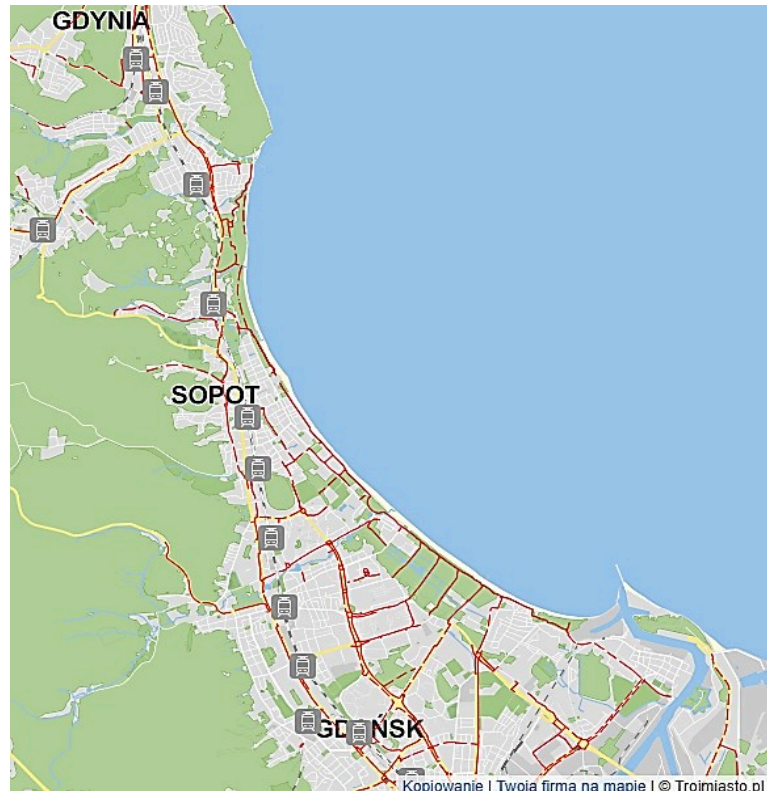


Figure 4. Map of bicycle paths of the Tri-City agglomeration.

Source: Trojmiasto.pl Retrieved from: <https://rowery.trojmiasto.pl/Mapa-drog-rowerowych-Portalu-Trojmiasto-pl-n89661.html>, 24.05.2022.

Until recently, the regulations of the Road Traffic Law (Ustawa z dnia 20 czerwca 1997) treating the bicycle as the only means of individual transport were sufficient, but the development and continued spread of, for example, scooters required regulation. As a result, on May 20, 2021, an amendment to the Road Traffic Law and other laws came into force, which introduced concepts into the law (Ustawa z dnia 30 marca 2021 r.):

- an electric scooter as an electrically powered, two-axle vehicle, with handlebars, without a seat or pedals, structurally designed to be driven solely by the rider on the vehicle,
- personal transport equipment (PTE) as an electrically powered vehicle, excluding an electric scooter, without a seat and pedals, structurally designed to be used exclusively by the driver on the vehicle,
- a traffic support device (TSD) as a device or sports and recreational equipment designed to move a person in a standing position, powered by muscle power.

Regulating the use of bicycles, scooters, a personal transport device, a traffic support device has put the traffic issue in order, however, it is also necessary to create opportunities to use these means for that part of the urban community that cannot afford to purchase their own means. Here, city bicycle and scooter rental systems play an important role. On the streets of Gdańsk, Gdynia and Sopot, electric scooters from several companies can be spotted standing every day. It is worth noting that Quick scooters were introduced to the Tri-City by a local company from Gdynia. The service area of all operators is very similar (Puls Gdańska). Tri-City authorities have invested in the city's bicycle-sharing system. In 2019, MEVO, the city's unmanned bicycle rental system, was established. In 2021, the system was terminated by malfunctions related to, among other things, the app and the delivery of an insufficient number of bicycles, however, the idea itself, which met with great approval from the Tri-City community, will be reintroduced. In February 2022, a contract was signed with the new operator of the MEVO system, *CityBike Global*. According to the plan, 4099 bicycles are to be made available in late spring of 2023, 3099 of which will be electric, and the remaining thousand will be traditional bicycles to be used within the boundaries of the Tri-City Metropolitan Area (Trojmiasto.pl).

In April 2022, the Gdynia City Council voted a resolution on the principles of providing a targeted subsidy for the purchase of an electric bicycle. Starting in 2019, residents and local businesses can rent cargo bicycles for free as part of the city's rental service, and a subsidy for the purchase of such a bicycle is in place starting in 2020. Also, some officials, as part of their duties during field trips, use this very means of transport. Interested residents who would like to use an electric bicycle for daily transport will be able to buy one, receiving up to a 50% subsidy. According to the provisions of the resolution, natural persons residing in Gdynia will be able to apply for the subsidy – each resident of Gdynia may use it once. The subsidy is available in an amount equivalent to 50% of the purchase value of the bicycle, but no more than PLN 2500. (Gdynia moje miasto).

Reinforcing the behaviours of urban residents toward the use of environmentally friendly modes of transport – both public transport and individual transport is aimed at changing transport-related behaviours. The basis for effective action and the challenge of pursuing local governments is to recognise the current state and develop incentive policies. In the case of the Tri-Cities, transport-related behaviours were studied in 2020. According to this survey, according to respondents' declarations, 81% of them say they have a personal car in the household (83% of men and 79% of women), in addition, 86% of respondents say they have a bicycle in the household. The distribution of declarations of ownership of a motorcycle or moped is interesting, as a total of 9% of respondents declare ownership of a motorcycle or moped in the household, while the gender distribution shows that it is almost 8% of men and 9% of women. Ownership of a scooter in the household was reported by 25% of respondents (23% of men and 27% of women). In terms of using a personal car on a daily basis, 85% of respondents say they do so. For 74% of respondents, the main motivation for their daily

commute is work, study (school, university). When a trip consists of only 1 stage (such trips account for 60% of typical daily trips, according to the survey), the most popular mode of transport is the passenger car indicated by 64% of respondents, followed by walking 16% and bicycling 12%. For a trip consisting of 2 stages, respondents pointed to public transport modes of bus/tramway/trolleybus as the most popular mode of commute (37%), followed by passenger car (20%) and train (19%). It is worth noting that 22% of respondents do not use a personal car (24% of women and 20% of men). In contrast, 53% of respondents use a personal car because they believe it allows them to travel faster than other means of transport (48% of women and 57% of men), and furthermore, 42% say that when travelling by personal car they can choose their own route and time of travel. In terms of elements that could induce the residents of the Metropolitan Area to travel sustainably (by public transport, bicycle, on foot, shared modes of transport), the most frequently indicated elements were higher frequency of public transport lines (58% of responses), combining schedules of different modes of transport (51% of responses) and shorter travel time by public transport (50% of responses) – each of these elements was indicated by more than 50% of respondents (MRC Consulting).

4. Conclusions and discussion

A framework for the environmental management of urban spaces, in line with Green Deal objectives, is a part of the green smart city concept. This concept, assuming the reduction of negative environmental impacts, poses challenges to local governments, which, depending on the existing conditions and development aspirations of municipalities, sometimes require reconciling objectives which, at first glance, seem contradictory – as is the case with the Tri-City agglomeration. The Tri-City agglomeration's aspirations in the strategy to be an important transport hub, based on the ports of Gdańsk and Gdynia, create challenges in terms of having rail and road infrastructure suitable for the planned passenger and cargo traffic. Gdańsk is in a far better position than Gdynia, as it already has the infrastructure to handle the existing potential of its ports. In the area of road infrastructure, the only certain problem is the congestion that occurs during the commute to work and home of Gdańsk residents living in the southern districts of the agglomeration, as these sections are used for this type of travel. In Gdynia, on the other hand, large investments are required to secure the commute capacity to and from the port, located right in the city centre. The challenge, therefore, is the construction, including the provision of funds for it, of the so-called "Red Road", relieving the "Kwiatkowski Estacada", which needs a major repair and handles the traffic of the dormitory districts of Gdynia. The Red Road, along with the necessary expansion of the 201 and 202 railway infrastructure, represents the biggest challenge in terms of both financing, planning and implementation. Planning work is fortunately already underway, but completion is still a long

way off. Some help in solving the problems of transport service at the Port of Gdynia will be the commissioning, in late summer or early autumn of this year, of the so-called "Kashubian Road", which will allow to take vehicular transit traffic out of the city's northern districts.

All cities of the Tri-City agglomeration, within the framework of their urban spaces, subscribing to the concept of the green smart city, must introduce measures aimed at changing the communication behaviours of residents in the direction of reducing travel by cars in favour of the use of public transport and individual, environmental means of transport such as bicycles, scooters, etc. Thus, the challenge is to build appropriate infrastructural solutions (bicycle paths – here the situation is relatively good), systems to encourage their use (city bicycle – after the unsuccessful first attempt, work is underway to restore the bicycle rental system) or subsidies for the purchase of electric bicycles, and to introduce convenient solutions within the transport network. Tri-City has a convenient transport solution (Rapid Urban Rail, Pomeranian Metropolitan Railway) connecting the cities of the agglomeration, so solutions to slow down traffic on the main road axis DW 468 extending the time of travel by car should cause a shift of passenger traffic to this means of transport. However, such measures are insufficient, and it is necessary to build public awareness of pressing environmental issues. So the challenge in this area is to define and create environmentally friendly behaviours among the creative class. This part of the urban community, by the fact that the rest of the population imitates their behaviours, should become part of smart mobility connecting all areas of the green smart city.

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THE POTENTIAL OF SELECTED REGISTRATION MODULES OF THE INTEGRATED IT ENVIRONMENT IN THE PRACTICAL BUILDING OF FINANCIAL MONITORING OF THE ENTERPRISE

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Purpose: The aim of the paper is to understand the spectrum of information generated by registration IT systems for the implementation of financial monitoring in enterprise management.

Design/methodology/approach: To accomplish the objective of the study, the critical analysis of literature, descriptive analysis and case study were used. The article presents the information functionality of the registration module in the SAP system in relation to the implementation of financial monitoring in the integrated environment. The theoretical part presents the role of information from IT systems in financial monitoring. In the subsequent part of the study, the attention is paid to information opportunities of the integrated registration systems in enterprises. The case study shows the selected areas of information from the SAP system related to the implementation of the purchase process.

Findings: The publication deepens the understanding of the spectrum of information generated by registration IT systems for the implementation of financial monitoring in enterprise management. The main contribution of the article is the in-depth understanding of the possibility of financial monitoring construction using registration IT systems.

Originality/value: The problem of the potential of registration modules of the integrated IT environment in the practical building of financial monitoring of the enterprise is not new. However, it is still very important and up-to-date due to its impact on decision-making in terms of the implementation of modern IT systems supporting enterprise management.

Keywords: financial monitoring, enterprise management, registration IT systems, information.

Category of the paper: literature review and case study.

1. Introduction

Digitization of information systems in contemporary enterprises contributes to increased efficiency of the operation of business management processes (Cabała, 2020). Among the premises for the implementation of the integrated IT environment, among others, the following

are listed: enterprise development, increased productivity, striving to achieve a competitive advantage (Grabowska, 2014), or a change in management methods. When selecting registration systems in the IT environment, the key role is played by the scope of information, which can be obtained using them.

The current state of knowledge in this field is subject to constant exploration by researchers and practitioners of management, which brings about that it is characterized by methodological multiplicity (Spalek, 2018). The lack of a generalized approach towards the potential of registration modules of the integrated IT environment in the practical building of financial monitoring of the enterprise brings about that it has never received a uniform assessment or the method of measurement. The above arguments caused that an attempt was made to conduct a theoretical analysis and carry out empirical observations to fill in an observed gap by deepening the understanding of how to use the potential of registration modules of the integrated IT environment while building financial monitoring to streamline enterprise management processes. On this basis, the primary objective of the study was formulated, i.e., to understand the spectrum of information generated by registration IT systems for the implementation of financial monitoring in enterprise management.

2. Registration IT systems as a source of information in financial monitoring – the area of liabilities towards suppliers

Running contemporary enterprises makes managers face high demands in terms of their competences and powers (Otoła, 2013). The development of IT applied in enterprises provides companies with wide opportunities to improve and accelerate the processing of individual tasks (Skowron-Grabowska, Szczepanik, 2015).

In the enterprise management system, information can be seen with ambiguity. According to Z. Martyniak, information can be treated as a product or a process leading to receiving this product (Martyniak, 2000, p. 5). Information as a product is the content of a specific meaning about something, for someone and due to something, expressed by linguistic or (and) non-linguistic signs (Martyniak, 2000). J. Czekaj believes that “information as a process means an ordered set of subsequent, interdependent changes of the states of data or output information, taking place under the influence of the combination of actions of employees participating in this process and the functioning of technical means used by them, aimed at receiving “the product” in the form of information, corresponding to the needs of the relevant user” (Czekaj, 2000, p. 24).

Information on facilities and enterprise management processes is subject to various criteria of classification. Based on the study by J. Kaźmierczak, one may give several examples of classification of such information. One of the primary criteria for classifying information in

management processes is the method of its acquisition. It is possible to distinguish the primary information here, being the product of the research procedure and secondary information coming from available resources, such as, studies, scientific publications, instructions, technical documentation (Kaźmierczak, 2000, p. 188).

In relation to the defined concepts, Figure 1 is a graphical presentation of the circulation of information discussed in the process of management between the supplier and the information user. In this process, the sources of information were identified, thus the place of its acquisition, channels of information flow to the recipient and the processes of its processing and use.



Figure 1. Diagram of information flow between its supplier and user.

Source: (Kaźmierczak, 2000, p. 188).

It is worth pointing out that Figure 1 also illustrates the channel of the flow of demand for information necessary to make a decision and coming from the management unit. In the presented circuit, the role of the information holder is played by both the recipient and the supplier of information. Moreover, the presented diagram of information flow enables the effective implementation of the decision-making process in the functioning of individual management processes of the enterprise. Depending on the nature of the data sources and the purpose of information it can be differently used in enterprise management. The skillful acquisition, collection and storage of current and reliable information allows for conducting effective financial monitoring in the enterprise.

In this context, the control function of enterprise management arises, which requires constant monitoring. According to H. Kościelniak “monitoring is an information mechanism which enables the tracking of quantitative and qualitative changes of some, previously established observation objects, using specific registration techniques” (Kościelniak, 2010, p. 45). When implementing monitoring in the enterprise, economic information is acquired, which is “the result of observation or measurement characterizing an economic phenomenon or an economic process and allowing for its assessment to make decisions correcting the conducted operation or beginning this operation” (Kostera, 2008, p. 159). On the other hand, financial monitoring is defined as a process of continuous economic and financial analysis, supporting financial decisions and operationalization of the goodwill (Caputa, Szwejca, 2008, p. 239).

To sum up, it is worth pointing out that the scope of the functioning of IT systems in enterprise management provides a wide range of possibilities of the effective implementation of financial monitoring process (Tomski, 2015). The financial monitoring process can be implemented by the ERP II (Distribution Resource Planning II) systems, which are created to plan the enterprise resources based on its components. The system defined as ERP II is “an integrated multi-access IT system to support enterprise management, comprehensive in terms of functionality, and open, being a set of applications typical of the sector, which generate values for customers and shareholders by sharing and optimizing processes both inside the enterprise and between enterprise partners”. The functionality of the ERP systems in terms of planning allows for the verification of the implementation of these plans for the purposes of financial monitoring in the enterprise. Moreover, modern financial and accounting systems have in-built transactions for the preparation of selected reports of financial monitoring concerning each sphere of the enterprise activity, which is covered by the computer-aided management in the appropriate IT module in the computer system (Nowicka-Skowron et al., 2011). The practical functionality of financial and accounting modules in the integrated IT environment in terms of the implementation of financial monitoring in the enterprise is presented in the subsequent part of the study based on the implementation of the purchase process in the SAP system.

3. Research methodology

In this study, the triangulation of research methods was applied. The choice of critical analysis of literature was determined by the occurrence the research gap in terms of using the potential of registration modules of the integrated IT environment when building financial monitoring for streamlining the processes of enterprise management. Critical analysis of literature allows for highlighting the existing approaches, both theoretical and research-based

(Sekaran, Bougie, 2010). Moreover, critical analysis of literature enables the demonstration of the method for preparing research works aimed at extending the existing knowledge or developing a specific research field (Levy, Ellis, 2006). For this reason, critical analysis of literature should be treated as a synthetic, objective, and reliable summary of the specific theoretical area (Rowley, Slack, 2004).

Using the descriptive method is to describe cognitive activities and their products (Popper, 2005). Therefore, the descriptive method performs an idiographic function in empirical cognition, which consists in the description of a single organization or structure (Popper, Hansen, 2014). It can be applied to describe an event, phenomenon, process, or strictly defined research problem. Such a methodological approach allows for the formulation of research questions and their verification in the subsequent procedure (Schjoedt, Bird, 2014).

The case study method enables examining current relationships. As a research method, a case study is characterized by the occurrence of a range of activities following each other and affecting the correctness, accuracy and detail and timeliness of the research. When considering the specificity of carrying out the research, the choice of a case study contributes to significant extension of the analyzed and examined problem (Eisenhardt, Graebner, 2007). At the same time, a case study is a method enabling multifaceted analyses, which would not be possible when using a different research method.

4. Characteristics of the research object

The research object was selected based on the targeted selection. The primary criterion for selecting the entity for the study was direct access to empirical data allowing for making observations. The surveyed enterprise is a part of an international cement concern, conducting business activities in more than 50 countries worldwide. The entire concern uses the ERP II SAP system. The examined enterprise has a modern machine park. The basic products offered by the surveyed entity are cements, aggregates, and concretes. The production process is composed of many phases, the reflection of which as well as quantitative and qualitative records and management information can be found in selected modules of the SAP system.

Cement production is a complex process, requiring high expenditure of energy and raw materials as well as specialized machinery and equipment. Therefore, obtaining the required quality of the final product requires not only an appropriate technology and procedures, but also support using the integrated IT system. For this reason, the process of information flow in the surveyed enterprise is codified, which allows for generating a broad spectrum of information transmitted from individual decision-making cells throughout the information channel. The application of coherent information carriers ensures the effectiveness of planning the conducted activity and monitoring the accomplishment of the intended objectives.

5. The spectrum information in terms of accounting in the SAP system for the implementation of financial monitoring – a case study

The primary document allowing for the implementation of financial monitoring in the SAP system is a purchase order, which, among others, includes information concerning:

- the vendor's data (vendor),
- parameters and quantities of the materials ordered (material, short text, PO quantity),
- delivery dates (deliv. Date),
- unit prices (Net price).

In the SAP system, orders can be generated using the ME21N transactions. Orders are primarily created by employees of the purchasing department, but other authorized employees may also have access to this transaction. Each order generated contains information allowing for the identification of a person introducing data into the system and the date of the order creation. The basic information from the order generated in the SAP system is presented in Figure 2.

The screenshot shows the SAP Standard PO 4500000262 interface. The header section includes the document type 'Standard PO', the PO number '4500000262', the vendor '102126 Boomtown Tire & Wheel', and the document date '20.11.2021'. Below the header is a table of items with columns for S., Itm, A, I, Material, Short Text, PO Quantity, OUn, C, Deliv. Date, Net Price, Curre..., Per, OPU, Matt Group, Plnt, and Stor. Location.

S.	Itm	A	I	Material	Short Text	PO Quantity	OUn	C	Deliv. Date	Net Price	Curre...	Per	OPU	Matt Group	Plnt	Stor. Location
<input type="checkbox"/>	10			RHMT1000	Road Helmet	2EA	D		09.12.2021	25,00USD	USD	1	EA	Safety Gear	DC Miami	
<input type="checkbox"/>	20			KPAD1000	Knee Pads	2EA	D		09.12.2021	37,50USD	USD	1	EA	Safety Gear	DC Miami	
<input type="checkbox"/>	30			BRKT1000	Brake Kit	2EA	D		09.12.2021	70,00USD	USD	1	EA	Raw Materials	Plant Dallas	

Figure 2. Standard purchase order in the SAP system.

Source: Own study based on the data from the SAP system.

In the order generated in the SAP system, the order history is created in which one may find information concerning whether a goods receipt was issued for the order and if an invoice receipt was entered in the books. Each of these documents can be displayed directly from the order and additional information can be read. The contra-entry of a goods receipt or an invoice can be also seen in the order, if they were issued. The order history is visible separately for each item of the order, which is presented in Figure 3.

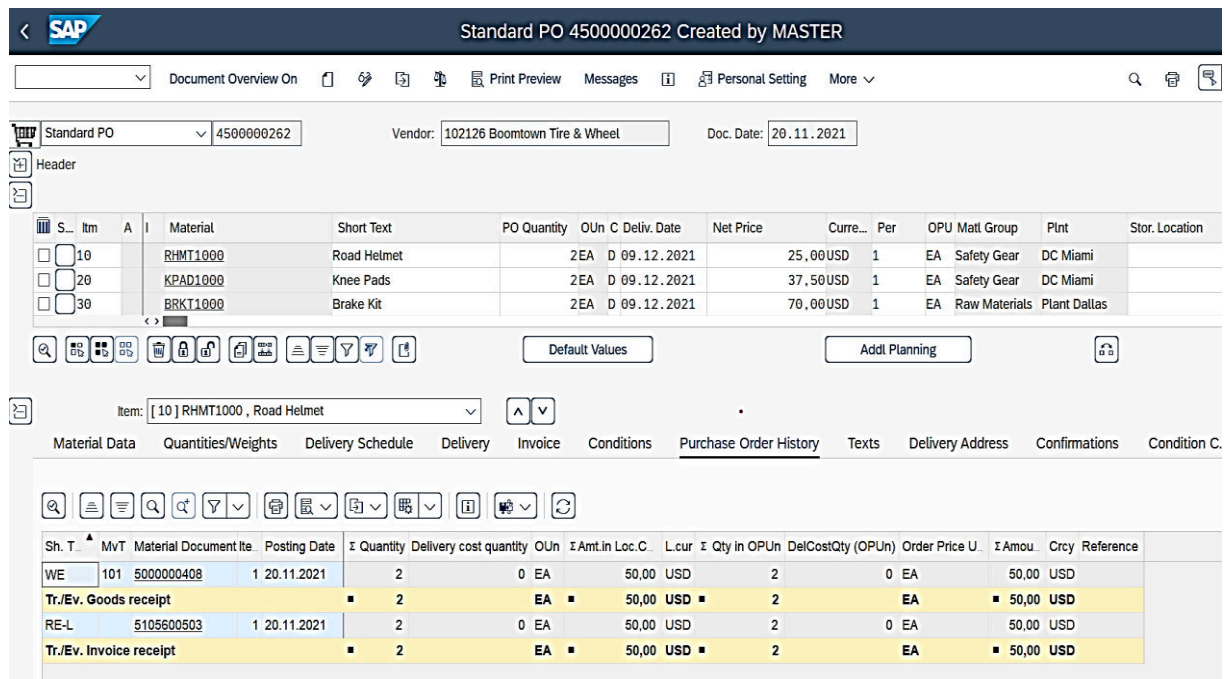


Figure 3. Standard purchase order in the SAP system – purchase order history.

Source: Own study based on the data from the SAP system.

In the “Status” ribbon, one may find general information concerning:

- how many units were ordered (Ordered)?,
- how many units were delivered (Delivered)?,
- how many units are still to be delivered (Still to deliv.),
- how many units are invoiced (Invoiced)?,
- whether there were prepayments (Down paymts.).

Moreover, each of the listed pieces of information is also presented in terms of value.

The order status is presented in Figure 4.

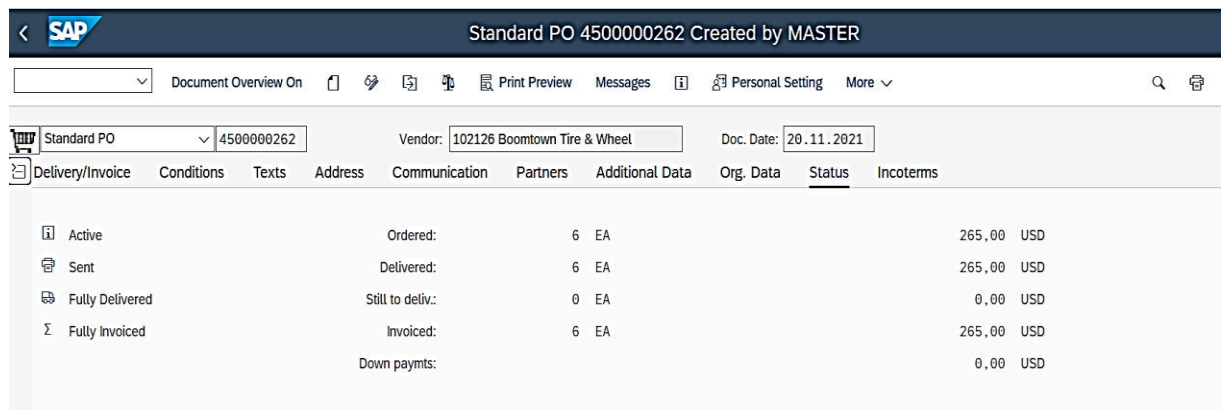


Figure 4. Standard purchase order in the SAP system – order status.

Source: Own study based on the data from the SAP system.

The invoice entered in the books can be seen on the supplier’s balance, which is displayed through the FK10N transaction. After completing the information on the vendor number, economic unit and marketing year, the vendor’s balance is displayed in the adopted T-account layout, which is reflected in Figure 5.

Vendor: 102126 Boomtown Tire & Wheel
 Company Code: US00 Global Bike Inc.
 Fiscal Year: 2021
 Display crncy: USD

Bals Special G/L

Period	Debit	Credit	Balance
Balance Carry...			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11	990,50	1.698,80	708,30-
12			

Figure 5. Vendor balance display in the SAP system.

Source: Own study based on the data from the SAP system.

After clicking on the field at the intersection of the Credit page and the period considered, e.g., 11, the system redirects the user to the “credit” operations performed in the period 11. In Figure 6, it is shown that 4 invoices in the MIRO transaction were entered in the books in the period considered (accounting the invoice in the reference to the order), which the RE document type informs about. Moreover, Figure 6 shows that these documents are not settled since this is indicated by the red symbol next to each item, i.e., its status.

St	Type	Doc. Date	Net Due Dt	Clearing	Amount in Local Crcy	LCurr	DocumentNo
<input type="checkbox"/>	● RE	03.11.2021	03.12.2021		190,50-	USD	5105600129
<input type="checkbox"/>	● RE	27.10.2021	03.12.2021		0,30-	USD	5105600156
<input type="checkbox"/>	● RE	20.11.2021	20.12.2021		265,00-	USD	5105600503
<input type="checkbox"/>	● RE	24.11.2021	22.01.2022		443,00-	USD	5105600617

Figure 6. Vendor line-item display in the SAP system.

Source: Own study based on the data from the SAP system.

The discussed process of financial monitoring concerning liabilities towards suppliers presents some of work in the SAP system, which involves:

- employees of the purchasing department (order),
- employees of the warehouse department (goods receipt),
- employees of the accounts payable department (invoice booking).

The SAP system allows for the process recognition and presentation of economic events thus enabling the constant monitoring of the situation of the analyzed enterprise (Łęgowik-Małołepsza, Turek, 2018, pp. 19-32). Online access to the system enables decision-making based on current and up-to-date information. The SAP system creates structured data sets, constituting a logical whole.

At the next stage of the monitoring of liabilities towards suppliers, it is possible to generate the report known as “the report of non-invoiced deliveries”, which is presented in Figure 7. This report is a very useful tool in the SAP system since it provides essential information about what materials were ordered, from which supplier and for what value. In this transaction, it is possible to obtain information if a goods receipt was issued for the specific item of materials and if an invoice receipt was entered in the books. Using this transaction, one may find quickly if there were deliveries in the enterprise for which no invoice was entered in the books.

No. of Material: 15

Material	PO value	GR value	Invoice Amount
Total	2.430,80 USD	2.290,80 USD	2.215,80 USD
BRKT1000	280,00 USD	140,00 USD	140,00 USD
BRKT1009	210,00 USD	210,00 USD	210,00 USD
HXNT1511	0,30 USD	0,30 USD	0,30 USD

Figure 7. Vendor analysis: Purchasing values: drilldown in the SAP system.

Source: Own study based on the data from the SAP system.

To sum up, it is worth pointing out that the presented purchase process in the SAP system shows the practical functionality of financial and accounting modules in the integrated IT environment in terms of the implementation of financial monitoring in the enterprise. It presents an exemplary process implemented in the SAP system. The sources and types of information necessary for the effective implementation of financial monitoring in the enterprise were identified at each of the discussed stages of the purchase process.

6. Discussion

The introduction of the SAP system and its implementation in financial monitoring is associated with a wide range of advantages, among which significant cost savings related to process optimization deserve a special attention. The monitoring of employees' work in the SAP system, which is conducted at the highest level of technological advancement, contributes to the rapid identification of areas requiring improvements. IT opportunities in terms of generating advanced reports to implement financial monitoring in the enterprise significantly exceed other financial and accounting systems available in the market. Practically unlimited possibilities in terms of configuring reporting transactions are applied not only in financial monitoring but also in terms of the broadly understood management accounting, thus providing necessary information to make effective managerial decisions.

Among the disadvantages of the SAP system, the costs of the SAP system should be listed. Unfortunately, the costs of the system often constitute such a barrier that many enterprises are unable to overcome. It happens that the costs of the SAP system exceed the benefits resulting

from its implementation. It also happens that employees cannot efficiently use the IT functionalities of this system. The listed drawbacks can be the effect of the lack of relevant on-the-job training. The diversity of the available reporting transactions offered by the SAP system, which enable making rational decisions to conduct financial monitoring in the whole concern, is often unrecognized and, at the same time, unused in the enterprise. Therefore, the recommendation for the surveyed enterprise is to implement a series of on-the-job training courses in the detailed operation of the SAP system in individual organizational units of the surveyed enterprise to search for new, useful transaction codes increasing the IT functionality of this system.

7. Conclusions

The objective of the study was to understand the spectrum of information generated by registration IT systems for the implementation of the financial monitoring in enterprise management. In the case study concerning the implementation of the procurement process in the SAP system, the assumed objective was accomplished. In the study, it was indicated in what transactions the information necessary for the implementation of financial monitoring in the area selected for the research is required. Deciding on when and in what form to implement the financial monitoring and how to use the possessed IT system is an individual business of each enterprise. The decision-making process in this area depends on many factors, such as, the market in which the enterprise operates, the sector, information needs. Entrepreneurs ought to skillfully use the potential of registration modules in the integrated IT environment for the accomplishment of the assumed operational and strategic objectives. Building the financial monitoring of the enterprise based on information generated by the integrated IT system allows for assessing endogenous and exogeneous conditions, created in changing conditions of the environment.

In the light of the conducted considerations, it is worth pointing out that the monitoring of the procurement process allows the surveyed enterprise to streamline the processes of procurement and production. Additionally, it indirectly translates into customer satisfaction. The main contribution of the article is the in-depth understanding of the possibility of financial monitoring construction using registration IT systems. Therefore, the organization of information flow in financial monitoring should support decision-making processes in the enterprise. At the same time, information flow in financial monitoring ought to be a determinant of rationality, determining the potential of the applied IT system. The further direction of the research should apply to the application of financial monitoring in the integrated IT environment since it may become an important component for building the enterprise strategy.

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BEHAVIOURAL ASPECTS OF THE USE OF TELEMEDICINE SYSTEMS IN HEALTHCARE ENTITIES

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Purpose: Entities operating in the healthcare system, being subject to developmental phenomena on the one hand, and crisis phenomena on the other, face problems that should be solved in the context of efficient implementation of organisational goals and, in the same time, in line with the best interests of the beneficiaries of this system (especially consumer of healthcare services). One of the problems is the development of telemedicine systems. The research objective of the article is to identify (on the basis of the cited cases) behavioural factors that are a condition the implementation of these systems and have their source in the attitudes of stakeholders.

Design/methodology/approach: The study is based on a review of the literature on telemedicine, and mainly the implementation of these solutions in the practise of healthcare entities. An important element of the study is the presentation of specific cases in which problems with the implementation of telemedicine solutions have emerged.

Findings: In the process of implementing telemedicine solutions in healthcare facilities, many different problems can be noticed, which are caused by behavioural factors. These factors are associated with virtually all types of stakeholders focused around the healthcare system. The behavioural factors are not the only ones that weight on the final success of introducing telemedicine solutions of varying technical advancement to the healthcare system, but they are so important that they should be taken into account in the decision-making processes of entities operating in healthcare.

Social implications: The social impact of the considerations made in this article may be manifested in improving the quality of healthcare services and, by taking into account behavioural factors that constitute barriers to development, but also stimulants of development, turn out to be important for individual stakeholders of the healthcare system.

Originality/value: The importance of this article is based on the fact that there are relatively few studies raising behavioural issues in the literature on telemedicine. The recipients of this type of article are decision-makers who should take into account behavioural factors in their strategies for the development of healthcare facilities and practical activities.

Keywords: telemedicine, behavioural factors, health system stakeholders.

Category of the paper: Viewpoint, Case study.

1. Introduction

The events surrounding the Covid-19 pandemic have highlighted quite a few problems that exist in the healthcare systems worldwide. Virtually every country faced challenges that had to be overcome in order to protect citizens from the spread of the virus and, at the same time, not to worsen the situation in terms of the diseases treated so far and in terms of preventive healthcare. The pandemic and its health effects require us to take a close look at the resources allocated to healthcare by individual countries. Even a cursory look at the situation allows us to conclude that funding in healthcare systems is insufficient in relation to the needs of the population – this is true of virtually all countries, with a really bad situation in some regions. The coronavirus pandemic has exposed weaknesses in healthcare systems, but it is not the only crisis that affects them.

Reports describing the situation in the Polish healthcare system emphasise the need to increase competence in risk analysis, systemic challenges, and strategic action planning (Zybala, 2009). Another significant problem, not only in Poland, is the aging of the population and the decline in the availability of physicians and other health professionals (Telemedyczna Grupa Robocza, 2018). The weaknesses of the healthcare system, as well as technological developments, the increasing awareness of individual members of the society of their own needs, and the associated growing expectations towards those entities that can improve the quality of life, result in many challenges for healthcare providers. These challenges must be addressed in the context of an efficient achievement of organisational objectives (including, but not limited to, efficiency), and at the same time be in the best interests of the beneficiaries of the system (mainly consumers of healthcare services). It is also worth mentioning that a well-functioning healthcare system is also of interest to the state as such (state administration) – for it is up to the state to provide adequate medical care and preventive care appropriate in a given situation to give the public in that state a sense of well-being. The tasks of the state and individual entities operating in the healthcare system can be assisted by a variety of entities from other sectors, which, for example, provide the appropriate hardware and software for increasingly complex equipment. Also, higher education, especially in the field of medicine and nursing, but also, for example, biomedical engineering, can contribute in the long run to providing adequate human resources for the healthcare system.

All the above factors are compounded by technical and technological advances, which in the field of healthcare systems result in the rapid development of telemedicine. This development results in entities providing relevant technical and IT solutions entering the healthcare system in search of an attractive growth sector, as they consider telemedicine as an industry that will provide possible economic success for themselves.

One should keep in mind, however, that healthcare entities, with their modern telemedicine solutions, are on the supply side of the healthcare market. On the demand side are first and foremost the consumers of medical services, and their attitude – either of acceptance or of rejection of telemedicine solutions – largely determines the success of the development of a complete healthcare system based on new technologies.

2. Stakeholders in the healthcare system

The healthcare system in a given country is directly responsible for the health of the country's citizens and residents. The basic determinants of human health include (Sygit, 2017):

- individual psychosocial development,
- information, knowledge, and skills necessary to preserve health,
- healthy lifestyles and favourable conditions,
- healthy environment,
- agencies and organisations working to promote health, and
- policies that promote and protect health.

As can be seen from the above list, the final outcome in terms of people's health is equally dependent on their attitudes related to prevention, taking care of their own health and maintaining healthy habits, as well as the situation in the broader human environment. The important point is that the well-being of people living in a specific country is a function of the assumption that the socio-economic system and, in the health space, the healthcare system exist to serve people and not the other way around (Getzen, 2013, p. 351). Referring to this original assumption, it is worth using the concept of stakeholders when describing the healthcare system and its tasks, as well as the tools with which it pursues its objectives. This concept is not intended solely for the healthcare system and is superior to the system, but explains the goals and attitudes of the entities that have a stake in some part of the socio-economic system or whose activities relate to the existence and development of some specific entity. Stakeholders are those individual entities or groups that can influence or are influenced by the activities of an organisation that is seeking to achieve its goals (Littlewood, 2020).

The healthcare sector is primarily represented by healthcare providers and businesses that offer services, products, and equipment necessary for medical treatment (including the most technologically advanced ones). On the other hand, there are recipients who should be divided into individual clients (they are mainly patients and their families) and collective clients (including the National Health Fund, companies offering occupational health services and additional benefits to their employees, which are considered as a part of an incentive system, as well as insurance entities). Also worth mentioning are the inspection and supervision authorities (e.g., the State Sanitary Inspectorate). Pharmaceutical manufacturers and

pharmaceutical product traders are also important players in this sector. This list should be enlarged by adding any organisation representing the interests of particular groups, whether it be patients, medical entities, or businesses (Klich, 2015).

The basic groups of stakeholders (individual and institutional) that can be distinguished in healthcare – in the broadest sense – are thus formed by the following entities:

- direct consumers of the sector's services – not only patients, but also their families and all (healthy) people who seek to improve their well-being, e.g., through prevention,
- healthcare professionals, who include primarily doctors, nurses, and midwives, but also lower-level staff (including paramedics, medical caregivers, and technical staff with a medical education),
- non-healthcare personnel in healthcare facilities (including managers and administration workers, IT specialists, and technicians with non-medical training),
- healthcare entities (including hospitals, clinics, outpatient clinics, pharmacies – both public and operating in the private sector),
- insurance providers offering both group and individual insurance,
- companies operating in a broadly defined IT sector, which provide hardware and software related to modern technologies used in healthcare entities, and
- state (at both central and local government levels).

The interests of the aforementioned stakeholder groups change depending on what entity is the reference point, which means that the key to a diagnosis of stakeholder needs is to identify the process to be carried out in a given situation and to identify the entities involved in carrying out the process. Stakeholders' expectations toward a specialised hospital are somewhat different from those towards a medical facility offering primary care services (an outpatient clinic), and still different from those towards a medical facility offering, for example, aesthetic medicine procedures. The expectations are also different in the case of a patient who seeks to improve his or her health or a person who thinks about preventive healthcare when his or her health is good and does not require direct intervention by a physician. The situation of a person using the services offered by the healthcare sector is often crucial in terms of the requirements for the supply side. For example, as studies have shown (Calton, Abedini, Fratkin, 2020), patients requiring palliative care highly value the possibility to save time and preserve their strength by using remote care (via video calls) – but this requires the right equipment and willingness on the part of the provider to make such contacts with the patient.

In general, it can be said that there are very different entities in the healthcare system who perform diverse functions, are in diverse situations, and therefore have diverse expectations of the system. Different interests and often conflicting views on solving healthcare problems have specific consequences for the development and processes of implementation of telemedicine tools as well.

3. The essence of telemedicine

The basic definition of telemedicine has been provided by the American Telemedicine Association (ATA). According to ATA, telemedicine is the ‘use of medical information exchanged from one site to another via electronic communications to improve a patient’s clinical health status’ (American Telemedicine Association). WHO, on the other hand, defines telemedicine as ‘the delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities’ (WHO, 1997). There are also opinions that telemedicine, in the narrow sense of the word, does not include, for example, e-patient or e-referral type sites, as well as various phone apps that are used to monitor activities to preserve or improve health. However, given the effects of these tools and their reliance on remote data transmission technologies, it can be assumed that in the long term and indirectly they contribute to improving the health of the population and, therefore, can be considered as telemedicine tools. This consideration is also justified by the perception of these tools by the consumers of healthcare services. For them, telemedicine includes all information technology tools and means of access to such services, which also includes aspects of e-health that are not associated with ‘traditional’ telemedicine.

The basic types of (‘pure’) telemedicine tools include (KIR, 2016):

- telecare – care for chronically ill or dysfunctional patients involving the measurement of vital signs,
- telediagnosics – which includes telecardiology, tele-ECG, teleCTG, tele-endoscopy, and tele-USG,
- teleconsultation – usually consultation of an image with a specialist (such as a dermatologist),
- tele-education – this tool also includes the exchange of information on treatment options, and
- teleprocedures and teleoperations – performed using remotely controlled robots.

In the covid pandemic conditions of 2020-2022, probably the most popular types of telemedicine were tele-advice, e-referral, and e-prescription (as complementary elements to a basic ‘doctor’s visit’). Undoubtedly, these solutions will continue to be used for a long time because they have worked in practice, but they are not the only telemedicine tools, or even the most relevant ones, from the point of view of the entire healthcare system. It is worth mentioning that based on a survey conducted by the Ministry of Health (Ministerstwo Zdrowia..., 2020), the overall level of satisfaction with the tele-advice option was very high. The satisfaction with the advice received was also high. The level of satisfaction with tele-

advice was certainly influenced by the level of threat associated with in-person visits at medical facilities and the uncertainty about the consequences of face-to-face meetings with healthcare professionals. In this context, the behavioural factors affecting the level of acceptance of telemedicine solutions become evident: as it turns out, the Covid-19 pandemic highlighted specific factors that affect the level of satisfaction with, and acceptance of, the only way to use the services offered by medical facilities that was available during that period.

It is worth noting that the EU's healthcare policy had already recommended exploiting the potential of modern technologies in medical services long before the pandemic (Rossa-Tarchalska, Maśliński, 2021). Already the 1957 Treaty of Rome included the first provisions on the need to coordinate the activities of European countries in the field of public health (Wojtczak, 2017), and the 2004 documents already explicitly mention the inclusion of e-health solutions in both public health policies and the healthcare system of EU countries in general.

As a result of the coronavirus pandemic, tele-advice solutions (technically, but also legally) have often been, and continue to be, implemented in a reactive manner and without adequate tools that have been prepared and preceded by consultation with patients and the medical community. This may (and unfortunately often does) lead to a quality of these services that does not meet the expected standards (Rossa-Tarchalska, Maśliński, 2021).

However, it is not only the need for, and the possibilities provided by, the development arising from technical and technological advances that determine whether telemedicine is used in the activities of healthcare entities. Telemedicine as a subject of consideration concerns a wide area of issues, primarily technical, legal, and economic ones, the aspects of which must be taken into account in a comprehensive manner. An equally important aspect is the attractiveness of telemedicine solutions to users, including healthcare professionals, but especially to the ultimate consumer of healthcare services. The attractiveness to healthcare professionals consists of the availability of the tools at their workplace, their ease of use, the service available during use, the level of streamlining of patient care processes, but most importantly the training that can help overcome the fear of using new technologies. For the consumer, on the other hand, the attractiveness of using telemedicine consists, of course, of its accessibility (especially in the context of the recent restrictions on physical access to healthcare facilities as a result of the Covid-19 pandemic, but also accessibility viewed as a function of the level of skills in using the Internet and IT technologies and equipment in general), the quality of the service itself, and the level of acceptance of remote delivery of medical services related to patient wellbeing. This is because not everyone is ready to the same extent to trust the specific solutions that telemedicine offers. Digital exclusion, as a result of reluctance (or lack of the required skills) to use modern IT technologies, and behavioural aspects (willingness, level of trust, and attitude) are the main psychological factors affecting the use of telemedicine tools.

The pandemic has made it clear to all people concerned that the continued operation of healthcare entities must rely on the use of modern technologies. It is believed that three areas of the healthcare sector will be revolutionised by new technologies in the coming years (KIR, 2021). The greatest technological changes will take place in tele-advice and remote care, digitisation of records and processes, and the area of cyber security in healthcare. The trust of the customers of medical facilities must be earned by ensuring basic cybersecurity standards, which include, first and foremost, protecting sensitive data from unauthorised access, but also safeguarding against tampering with patients' diagnostic data. Data security activities should include activities in the areas of IT (selection of reliable IT system and hardware vendors, systematic risk analysis, detection of unauthorised access, countering such practices, etc.), law (adopting regulations that secure data and allow prosecution of the perpetrators of cybercrimes), international standards, e.g., ISO 27001 (standards for building information security management systems), and the so-called soft-law (industry standards and codes of conduct for individual entities in the healthcare system) (Rojszczak, 2021).

4. Behavioural determinants of the implementation of telemedicine systems in the healthcare sector – practical aspects

When considering the feasibility of implementation of telemedicine solutions in healthcare systems, behavioural aspects prove to be very important. They concern the attitudes of individual institutional entities or, more specifically, the persons involved in the provision and use of telemedicine tools, as well as their consumers, towards the phenomena associated with these tools and, more broadly, with the functioning of the healthcare system as a whole.

Some of the basic theoretical models that can have practical relevance in understanding the behavioural aspects of the conduct of individual entities in the implementation of telemedicine solutions in the healthcare system are the Theory of Planned Behaviour (TPB) (Ramirez-Correa et al., 2020) and the Technology Acceptance Model (TAM), as well as the Unified Theory of Acceptance and Use of Technology (UTAUT) which constitutes a generalisation and development of the latter (Harst, Lantzsch, Scheibe, 2019). These models identify the basic variables that are the behavioural factors that influence the level of acceptance of technologies and their use in specific situations, in this case the use of telemedicine solutions in the healthcare system. These include attitudes, subjective norms, and a sense of control, as well as expected performance (the degree of belief that a technology will benefit the user), expected effort (the degree of difficulty of using the technology), social impact (the strength of a person's belief that people who are important to him or her would also use the technology), and favorable circumstances (the strength of the belief that there is adequate infrastructure and support for the use of the technology) (Sołtysik-Piorunkiewicz, Zdonek, 2015).

Healthcare is a complex economic system, which, through organised activities carried out with the use of financial, material, and informational (including legal) resources, serves the purpose of ensuring, most importantly, the good health of the population and an adequate quality of life in general (Suchecka, 2016). Due to the imperfect mechanisms for allocation of scarce resources, the system suffers from a permanent imbalance, which leads to an escalation of discontent and differing attitudes, often radical, towards the system as a whole. Differing attitudes also apply to telemedicine systems and their implementation. As research conducted in Ghana's health care system has shown, the propensity to implement telemedicine systems increases as both physicians and patients become more satisfied with the use of these systems. The following reasons may prevent the effective use of telemedicine systems: unavailability of services, information security issues and privacy concerns, organisational shortcomings, but also socio-cultural factors and lack of motivation on the part of hospital managers (Kissi et al., 2020). The latter two obstacles are strictly behavioural.

An additional problem is that in the healthcare system the patient only to a marginal extent has the characteristics of a rational human being; it can even be argued that, driven by fear for his or her health and a lack of specialised knowledge, the patient has fewer characteristics of *homo economicus* than the average person in other sectors of the economy. Such a completely irrational attitude also characterises the physician who is the provider of a service with an uncertain ultimate effect on the consumer. Therefore, in his conduct the physician must use his or her knowledge and experience, but fear and uncertainty of the outcome also come into play. The above aspects are also compounded by the individual values that guide both patients and physicians, as well as other healthcare professionals in their lives (Golinowska, 2015).

The individual, personal characteristics of those using telemedicine systems are also important to the effectiveness of the implementation of telemedicine systems for widespread use. The level of acceptance of technological innovations tends to decline with age and depends on the level of education and social status: the lower the level, the greater the delay in using telemedicine solutions (Dorsey, Topol, 2020).

Another behavioural aspect of the activities of healthcare entities, manifested mainly in the allocation of resources in that sector, is the issue of a sense of fairness in the distribution of costs and benefits. Due to permanent resource limitation, it is of paramount importance that the distribution of costs and benefits be done on the basis of social consensus; however, anyone who analyses the availability of public and private healthcare, both financially and in terms of staff, is aware of how difficult it is to achieve it. Nevertheless, it must be said that in the Polish healthcare system this consensus is guarded, most importantly, by the constitution, but also by state institutions and finally by individual service providers. The latter have the responsibility to ensure the right cost/effect ratio (Rudawska, 2007). In general, the conflict between the solidarity-based approach in the society with the sovereignty and individual expectations of the consumer is most fully revealed in the healthcare system (Nojszewska, 2011). This problem is the basis for the design of a country's social policy, but also must be considered as a starting

point for the country's strategy for the provision of healthcare services in individual healthcare entities.

One of the challenges faced by healthcare managers is to prepare a strategy for the implementation of telemedicine systems based on the organisational culture of the entity in such a way that the benefits for the stakeholders of these systems can be precisely defined (Khodadad-Saryazdi, 2021). This perspective applies to both the healthcare entity itself (internal stakeholders) and the benefits to external stakeholders.

Given the market-related context, the strategy of healthcare entities concerning the use of telemedicine tools should also take into account marketing issues. Marketing of telemedicine services can be based on the promotion of their ease of use or the belief that some well-known people have already used certain tools. It is also important to keep in mind that what is allowed and what is forbidden in the promotion of medical services is strictly regulated by law. The contemporary healthcare market is competitive at the level of services of both public and non-public entities (both sectors can in fact serve the same patients, because they can be financed directly from public funds through contracts with the National Health Fund), which makes it necessary to build competitive advantages. In this context, providing a facility with modern equipment and facilitating the use of healthcare services by patients thanks to telemedicine or, more broadly, e-health solutions become the basis for building long-term relationships with the community. One of the entities that are actively developing telemedicine services and constantly expanding the scope of their applications is Medcover. This entity also promotes itself at industry events (e.g., congresses) where it presents its achievements, the level of its use of modern technologies, and the relationships with patients built on the basis of the use of telemedicine solutions (Okoniewska, 2022).

Intentionally built long-term relationships result in patient loyalty, which should be an important area of interest for healthcare providers. In order for this to be possible at all, healthcare facilities should hire people who understand the need to build relationships with the community (and have relevant training) and are able to work creatively and effectively with each other. This demonstrates the need to focus on the motivation of employees and to manage them appropriately so that the staff adopt certain organisational solutions that benefit the efficiency of the healthcare facility with understanding and commitment (Chalimoniuk-Nowak, 2022). Limited motivation is also a behavioural factor that determines acceptance of the implementation of telemedicine systems in healthcare facilities.

Attitudes toward the use of telemedicine systems in healthcare entities are also influenced by the availability of adequate infrastructure: sometimes the Internet is simply too impaired to permit the realisation of the full potential of telemedicine. As shown in a study carried out in Indonesia, about 50% of the users of telemedicine systems believe that the quality of the Internet connection needs to be improved in order to get the full benefits of telemedicine tools (Indria, Alajlani, Fraser, 2020). The situation in Poland in terms of the availability and quality of the Internet is slightly better. According to Statistics Poland, 92.4% of households in Poland had

Internet access in 2021 – an increase of 2 percentage points compared to 2020. It is worth noting that access of households depending on the place of residence did not differ substantially: the rate of access was 93.8% in large cities and 91.8% in rural areas (Statistics Poland, 2021). These overall figures show that the level of digital exclusion in the Polish society is not very high. However, it cannot be expressly stated that households' access to the Internet means that Poles easily and willingly use tele-advice services. One must be aware that a large percentage of households use the Internet only for remote learning. This is evidenced by the fact that 99.7% of households with children had Internet access, compared to 88.8% of households without children (Statistics Poland, 2021). One should also keep in mind that in addition to remote learning and access to the healthcare system, Poles have become active online largely for the purpose of dealing with the public administration.

5. Conclusion

As is evident from the processes of implementation of telemedicine solutions in the healthcare entities that are described above, the situation of reduced availability of face-to-face doctor's visits as a result of restrictions related to the Covid-19 pandemic has created a great need for tele-advice services. However, it also drew widespread attention to telemedicine as a whole. It turns out that telemedicine is not an innovation that first emerged during the pandemic, but has been developing for many years (with varying intensity and in diverse directions) and applied with success in many areas of healthcare. It is also a high-value market that is still in a growth phase; therefore, it is a good idea to identify more and more accurately both the drivers of its development and the barriers that stand in the way of that development.

The growth of telemedicine and its applications in the practice of the operation of healthcare systems faces various problems, including those of a behavioural nature. Individual stakeholders in healthcare systems are not willing to accept to the same extent all aspects of the use of telemedicine solutions. The willingness to use specific advances in telemedicine technology depends on a number of factors, but what is very important is the fact that it is not only patients who are sometimes distrustful or reluctant to undergo medical interventions using telemedicine. There are people, including physicians and those who work with them in offering healthcare services, who are reluctant about or even actively resist the implementation of telemedicine systems in their workplaces. Some of these barriers, which are present on both the demand side and the supply side, are strictly behavioural. These barriers stem from, among other things, an attitude of aversion to modern technology, the separation between the patient and the doctor, the lack of faith in the effectiveness of 'remote treatment', and lack of knowledge about the full use of technological advances in improving health. On the other hand, physicians and nurses, as well as all kinds of paramedics and technicians operating telemedicine

systems demonstrate resistance that is due to their low motivation to use technological innovations. This resistance is often also the result of their lack of knowledge about the effectiveness of the impact of telemedicine on patients' actual well-being. All this means that technological, financial, and behavioural barriers alike must be overcome in order to develop telemedicine systems and streamline their implementation in healthcare entities.

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ALTERNATIVE INVESTMENTS - MEASURING RISK AND INVESTMENT EFFICIENCY

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Purpose: The aim of the work is to compare various forms of investing in a changing economic environment. When the level of inflation is significant, it is very difficult to find an investment with a high expected rate of return and a low level of risk. Investing efficiency analysis is an important element of business activity, it contributes to the multiplication of the assets of institutions and private persons.

Design/methodology/approach: In the work, the profit rate was determined and the NPV was calculated taking into account inflation. Changes in the precious raw materials market and the real estate market were analyzed.

Findings: Rate of return on selected investments were calculated and the optimal possibilities of allocating funds were indicated.

Research limitations/implications: The article examines only selected investment opportunities: in gold and on the real estate market. In finance, there are also other options for investing, for example on the capital market, in investment funds, in treasury bonds.

Practical implications: The conclusions recorded in the work may be used by investors in the future, when the economic situation is not stable, but the decision-maker will have to solve the problem of allocating the accumulated capital.

Social implications: The results contained in the work may be helpful in making individual and collective investment decisions, they may be used to multiply capital, protect funds against the effects of inflation.

Originality/value: The article compares the effectiveness of various investments during the crisis and selects the most profitable forms of investment. The article is addressed to decision makers in the investment process.

Keywords: investment process, efficiency, NPV, investment risk.

Category of the paper: research paper.

1. Introduction

Effective capital placement and investment are issues often discussed in the literature on economics and finance. There are many different forms of capital placement. However, they differ in the expected rate of return on investment as well as the level of risk and uncertainty. According to W. Rogowski, the investment is a long-term one risk allocating funds to achieve future benefits (Rogowski, 2004). Safe and profitable investment of capital is one of the important economic issues (Begg, Dornbusch, Fischer, 2007; Taylor, Mankiw, 2009).

The aim of the study is to compare various forms of investing in the years 2000-2021. The chosen time period, the first twenty years of the 21st century, was marked by significant instability due to many economic characteristics. The financial crisis of 2007-2009 and the coronavirus pandemic in 2020-2021 are certainly important periods. In the aforementioned periods, economic conditions changed significantly and the amplitude of fluctuations of many economic indicators increased. Investors have often looked for ways to safely invest their capital so that it does not lose its value (Dorosz, 2014; Kołodko, 2010).

The analysis of the method, effectiveness and risk of investing is an important element of business activity, as it contributes to the multiplication of the assets of companies, institutions and private persons. The choice of the form of investment is not easy, it significantly affects the investment result and the achieved rate of return on investment. The decision maker can choose from many options, including: setting up a bank deposit, buying bonds, investing on the stock exchange, purchasing precious metals or placing his savings on the real estate market. This paper focuses on three selected forms of investing capital, namely the profitability of setting up a bank deposit, buying gold and investing in real estate. Various investment variants were compared to determine the investment efficiency. It has been shown that in the first twenty years of the 21st century it is possible to invest with a positive profit, but the investing process is burdened with risk, uncertainty of the future state of the economy and a high level of inflation which significantly reduces the profit.

The conclusions recorded in the work may be used by institutional and individual investors in the future, when the economic situation will not be stable, and the decision-maker will have to solve the problem of locating the accumulated capital.

2. Research methodology

2.1. Investment effectiveness assessment - rate of return

The profitability assessment of an investment project can be carried out with the use of various calculation methods (Nowak, 1997; Marcinek, 2001; Rogowski, 2004; Dobija, 1997).

The most intuitive method is to calculate a simple rate of return. This rate determines the ratio of the annual profit to the value of the initial capital:

$$R = (Z / K) 100\% \quad (1)$$

where:

R - annual rate of return,

Z - annual (net) profit,

K - starting capital.

The above formula uses annual figures. However, in the case of investment activity, individual years may differ significantly from one another. Then it is advisable to determine the average rate of return according to the formula:

$$R_p = (Z_n / K_n) 100\% \quad (2)$$

where:

R_p - average rate of return,

Z_n - average annual net profit,

K_n - average annual capital employed.

2.2. Taking into account the volatility of interest rates and the level of inflation in the assessment of investment effectiveness

The investment period is often long enough that interest rates will change during it. This should be taken into account when determining the effectiveness of the investment. If we mark the profit with the symbol Z , and the invested capital with the symbol K , then the following formulas can be used:

Effective interest rate $r_{ef}(n) = Z_n / K_{n-1}$

- For a simple interest rate (r - nominal interest rate): $r_{ef}(n) = r / (1 + (n-1)r)$.
- For compound interest $r_{ef} = r$.
- For compound interest with capitalization in subperiods: $r_{ef} = (1 + (r^{(m)}/m))^m - 1$,
($r^{(m)}$ - nominal interest rate of capitalization in sub-periods, m - number of sub-periods in the base period).
- For compound interest with capitalization over periods: $r_{ef} = (1 + mr_{(m)})^{1/m} - 1$,
($r_{(m)}$ - nominal interest rate of capitalization over periods),

Average interest rate

- For a simple interest rate $\bar{r} = \frac{1}{n} \sum_{j=1}^m n_j r_j$ (r_j - interest rate for period n_j)
- For compound interest in arrears $\bar{r} = \sqrt[n]{\prod_{j=1}^m (1 + r_j)^{n_j}} - 1$
- in sub-periods $\bar{r} = \sqrt[n]{\prod_{j=1}^m \left(1 + \frac{r_j}{m_j}\right)^{n_j m_j}} - 1$
- in excess $\bar{r} = \sqrt[n]{\prod_{j=1}^m (1 + m_j r_j)^{n_j / m_j}} - 1$

In the economic reality, an important element is the decrease in the value of capital resulting from inflation. When inflation is not taken into account in determining the profitability of an investment, the obtained result is not a correct and accurate measure of investment effectiveness. The following financial mathematics formulas can be used to add inflation to your analysis:

The actual interest rate on the capital

$$r_i = (r - i) / (1 + i) \quad (3)$$

where:

i - inflation,

r - capital interest rate.

Inflation rate

$$i = (r - r_i) / (1 + r_i) \quad (4)$$

- m-period inflation rate $i(m) = \prod_{k=1}^m (1 + i_k) - 1$
- average inflation rate $\bar{i} = \sqrt[m]{\prod_{k=1}^m (1 + i_k)} - 1$

2.3. Deterministic NPV method

In finance, the inflows and outflows of money (i.e., income or expenses, outlays) that occur at regular intervals are referred to as cash flows. Let CF_0 denote the payment (income or expense) at the beginning, and denote CF_i ($i = 1, 2, \dots, n$) the payment falling at the end of the i -th period. To calculate the current value of the stream of money (CF_0, CF_1, \dots, CF_n), each element of this stream should be reduced to the present (i.e. discounted), and then the values obtained in this way should be added up. We will then get the following formula for the present value of the cash flow:

$$PV = CF_0 + \frac{CF_1}{1+r} + \frac{CF_2}{(1+r)^2} + \dots + \frac{CF_n}{(1+r)^n} = \sum_{i=0}^n \frac{CF_i}{(1+r)^i} \quad (5)$$

In the formula above, r is the interest rate. The formula for the future value is:

$$FV = CF_0(1+r)^n + CF_1(1+r)^{n-1} + \dots + CF_{n-1}(1+r) + CF_n = \sum_{i=0}^n CF_i(1+r)^{n-i} \quad (6)$$

When planning an investment, you should assess whether it is profitable. Let CF_0 denote the expenditures that we have to incur to start the investment (initial outlays) and CF_1, CF_2, \dots, CF_n denote the expected investment income or related expenses in subsequent time periods (e.g. months, quarters, years). The number n , i.e. the number of time periods considered, is called the economic lifetime of the investment. Let us assume that the interest rate is constant and equal to r in the considered period of time. The net present value of the investment called the quantity:

$$NPV = \sum_{i=0}^n \frac{CF_i}{(1+r)^i} \quad (7)$$

When assessing the profitability of an investment, we adopt the following rule:

- if $NPV > 0$, the investment is profitable and it is worth implementing it, because the anticipated revenues, discounted at the moment of starting the investment, exceed the initial expenditures;
- if $NPV < 0$ - the investment is not profitable;
- when $NPV = 0$, the expected profit is at zero level.

When comparing several investment variants or comparing many different investments, we apply the NPV maximization principle, i.e. we implement a project for which the NPV has the highest positive value.

2.4. Probabilistic NPV method

Net Present Value (NPV) is an easy and effective method of assessing the effectiveness of an investment project, provided that all $\{CF_i\}$ terms are precisely defined. However, economic practice shows that the adopted condition is rarely met. Predicting future revenues and expenses can prove to be difficult, sometimes even impossible. Then successive elements of the cash flow stream can be treated as random variables with a known probability distribution: $randomCF_0, randomCF_1, \dots, randomCF_n$, with a finite expected value and a finite variance. However, each investment project is specific, its success largely depends on the method of managing its subsequent stages and on the tendency or aversion to taking risk. Thus, the distribution of the discussed random variable is subjective and can be determined by experts. The model in which the stream of cash flows is treated as the implementation of a random variable in the literature has been called the probabilistic model of net present value

from investments - PNPV (Przybycin, 2011). PNPV is then a random variable. The probabilistic NPV is defined as follows:

$$PNPV = \sum_{i=0}^n \frac{randomCF_i}{(1+r)^i} \quad (8)$$

In the case of a probabilistic NPV, it is possible to quantify the risk of an investment project. We determine the expected value of PNPV according to the formula:

$$E(PNPV) = \sum_{i=0}^n \frac{E(randomCF_i)}{(1+r)^i} \quad (9)$$

and its standard deviation as (10):

$$S(PNPV) = \sqrt{\sum_{i=0}^n \frac{S^2(randomCF_i)}{(1+r)^{2i}} + \sum_{i=0}^{n-1} \left(\sum_{j=i+1}^n r_{i,j} \frac{1}{(1+r)^i} \frac{1}{(1+r)^j} S(randomCF_i) S(randomCF_j) \right)} \quad (10)$$

where the variance of the random variable PNPV is under the root, and the symbol r_{ij} is the correlation coefficient of random variables $randomCF_i$ and $randomCF_j$.

When the random variables $randomCF_i$ form a system of independent random variables, then the standard deviation is reduced using the following form:

$$S(PNPV) = \sqrt{\sum_{i=0}^n \frac{S^2(randomCF_i)}{(1+r)^{2i}}} \quad (11)$$

As a measure of the risk of an investment project, we can then determine the coefficient of variation, defined as follows:

$$V_{PNPV} = S(PNPV) / E(PNPV) \quad (12)$$

The above-defined coefficient of variation determines the risk size of the investment project per unit of the average value of the PNPV random variable. The known value of the VNPV coefficient of variation allows risk management investment project. Depending on the investor's willingness or aversion to risk, the decision-maker will select projects with a coefficient of variation assuming higher or lower values. The higher the value of the coefficient of variation, the greater the potential risk of the project.

2.5. The investment risk analysis

The risk level of an investment project has a significant impact on the financial result of this project, hence the growing interest in risk management methods in the investment process (Ostrowska, 2002). The investment literature clearly distinguishes between the concepts of risk and uncertainty. The risk can be measured. Risk is a situation in which the probability of achieving greater or less than expected results can be considered and the probability distribution of deviations of these results from their expected values is known. Uncertainty cannot be measured. Uncertainty is a situation in which the probability distribution of the discrepancy of

the results from their expected values is unknown and cannot be estimated. Thus, it can be written that risk is a measurable uncertainty.

Effective methods of managing investment risk include models for assessing the economic effectiveness of investment projects, for example the NPV or PNPV model.

In the process of investing, it is noticed that the higher the expected rate of return on investment, the greater the risk of loss. Thus, a risky investment can bring big losses, but on the other hand, it can give the investor above-average profits. The concept of a risk premium is then introduced. In the investment process, we determine the expected rate of return on investment and take a risk in such a size that the risk premium corresponds to the individual requirements of the investor.

3. Empirical analysis

The empirical analysis was based on the data for the years 2000-2022. In the article we will calculate the profitability of investing in two selected goods: gold and real estate. In the years 2000-2022, a growing trend in gold prices can be observed (Figure 1). The chart clearly shows the price increase after the financial crisis of 2007-2009 and the increase caused by the coronavirus pandemic and the armed conflict in the east.



Figure 1. Gold price chart in PLN per gram.

Data source: www.mennica.com, own study.

In the analyzed period, the price per square meter of flats commissioned for use also changed significantly (Table 1). In the analyzed period, the lowest price was recorded in the first quarter of 2003, and the highest in the third quarter of 2021. During this time, the price increased by more than 158%, representing an average annual increase of approximately 8.8%.

Table 1.

Price for 1 square meter of usable floor space of a residential building put into use

Year	1 Quarter	2 Quarter	3 Quarter	4 Quarter	Year	1 Quarter	2 Quarter	3 Quarter	4 Quarter
	in PLN					in PLN			
2022	5 252	x	x	x	2010	4 372	4 433	4 657	3 979
2021	4 944	5 112	5 347	5 134	2009	3 895	3 924	3 783	3 964
2020	4 567	5 000	4 987	5 012	2008	2 970	3 186	3 478	3 631
2019	4 388	4 484	4 376	4 597	2007	2 683	2 650	3 041	2 890
2018	4 132	4 294	4 385	4 139	2006	2 560	2 445	2 557	2 619
2017	4 424	4 014	4 097	4 145	2005	2 505	2 336	2 528	2 388
2016	4 177	4 063	3 976	4 000	2004	2 412	2 562	2 386	2 195
2015	3 926	4 066	3 961	3 925	2003	2 071	2 332	2 117	2 432
2014	4 129	4 141	3 880	3 984	2002	2 400	2 400	2 484	2 330
2013	4 019	3 879	3 975	4 228	2001	2 350	2 490	2 700	2 500
2012	4 130	4 103	3 915	3 837	2000	2 245	2 280	2 300	2 300
2011	3 797	3 819	3 988	3 829	x	x	x	x	x

Data source: www.stat.gov.pl.

In this period, the level of inflation changed significantly (Figure 2). There is clear evidence of a strong rise in inflation since the beginning of 2021.

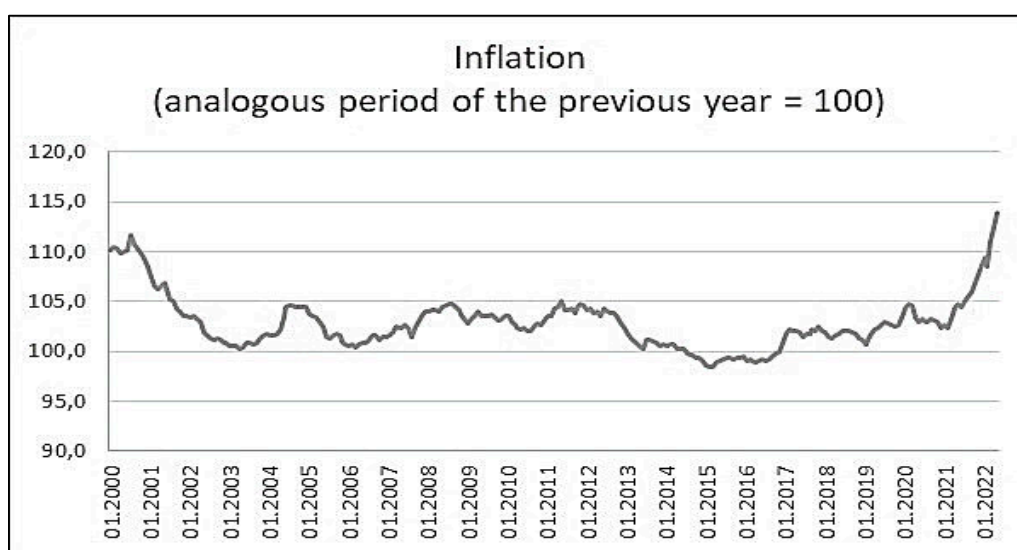


Figure 2. Inflation in Poland in the period 01.2020-05.2022, monthly data.

Data source: www.stat.gov.pl, own study.

The values of the reference rate of the National Bank of Poland also changed, which significantly affect the amount of return on investment (Table 2).

Table 2.
Reference rate of the National Bank of Poland

valid from the date of:	reference rate	valid from the date of:	reference rate	valid from the date of:	reference rate
18.11.1999	16,5	26.08.2004	6,5	09.06.2011	4,5
24.02.2000	17,5	31.03.2005	6	10.05.2012	4,75
31.08.2000	19	28.04.2005	5,5	08.11.2012	4,5
01.03.2001	18	30.06.2005	5	06.12.2012	4,25
29.03.2001	17	28.07.2005	4,75	10.01.2013	4
28.06.2001	15,5	01.09.2005	4,5	07.02.2013	3,75
23.08.2001	14,5	01.02.2006	4,25	07.03.2013	3,25
26.10.2001	13	01.03.2006	4	09.05.2013	3
29.11.2001	11,5	26.04.2007	4,25	06.06.2013	2,75
01.12.2001	11,5	28.06.2007	4,5	04.07.2013	2,5
31.01.2002	10	30.08.2007	4,75	09.10.2014	2
26.04.2002	9,5	29.11.2007	5	05.03.2015	1,5
30.05.2002	9	31.01.2008	5,25	18.03.2020	1
27.06.2002	8,5	28.02.2008	5,5	09.04.2020	0,5
29.08.2002	8	27.03.2008	5,75	29.05.2020	0,1
26.09.2002	7,5	26.06.2008	6	07.10.2021	0,5
24.10.2002	7	27.11.2008	5,75	04.11.2021	1,25
28.11.2002	6,75	24.12.2008	5	09.12.2021	1,75
30.01.2003	6,5	28.01.2009	4,25	05.01.2022	2,25
27.02.2003	6,25	26.02.2009	4	09.02.2022	2,75
27.03.2003	6	26.03.2009	3,75	09.03.2022	3,5
25.04.2003	5,75	25.06.2009	3,5	07.04.2022	4,5
29.05.2003	5,5	01.01.2010	3,5	06.05.2022	5,25
26.06.2003	5,25	20.01.2011	3,75	09.06.2022	6
01.07.2004	5,75	06.04.2011	4	08.07.2022	6,5
29.07.2004	6	12.05.2011	4,25		

Data source: www.nbp.pl.

A popular form of investing is investing capital in precious metals, including gold. It is widely believed to be a safe capital investment. The average inflation in the years 2000-2022 was 2.8605%, in 2010-2022 it was 2.3320%, and in the period 2020-2022 it increased to the level of 5.4207% (Table 3). The average reference rate in 2000-2022 was 6.0662%, in 2010-2022 it was 3.1759%, and in the period 2020-2022 it decreased to 2.7577%. It is worth noting that in the period 2020-2022 the average inflation rate was higher than the average NBP reference rate. The effective interest rate in the analyzed periods was as follows: in the period 2000-2022 it was 0.0312%, in the period 2010-2022 it was 0.0082%, and in the period 2020-2022 it was negative at the level of - 0.02526%. On the basis of data from the Mint of Poland, gold was purchased at the earliest possible date in January - in 2000, 2010 and 2020, respectively. The results of investment efficiency with and without the average inflation rate are presented in Table 3. Investing in gold has proven to be profitable in each of the time periods considered. However, high inflation absorbs some of the profit. In each of the analyzed periods, the NPV value was positive, so the investor had no problem making a decision.

Table 3.
Investment efficiency in gold

Investment period	January 2000 – January 2022	January 2010 – January 2022	January 2020 – January 2022
Form of investment	Investment efficiency - annual rate of return in investment period (in %)		
Investing in gold - selling gold in January 2022 at the price of the National Bank of Poland, excluding inflation	24,1328	10,6441	11,3072
Investment in gold - sale of gold in January 2022 at the price of the National Bank of Poland, including inflation	20,6808	8,1227	5,5838

Source: Own study.

During global crises, there is a greater interest in investing capital in the real estate market. In Poland, prices per square meter of commercial premises are gradually increasing. The purchase of real estate may protect the owner of the capital against the effects of inflation and a decrease in the value of the capital held. Table 1 shows the prices in PLN for 1 square meter of usable floor space of a residential building put into use in Poland in the years Q1 2000-Q1 2022. It can be seen that prices increased from quarter to quarter. It is also worth noting that when analyzing more accurate data on prices in individual regions, cities and agglomerations of Poland, it can be noted that prices were different in different cities. As a rule, prices per square meter in metropolitan areas are significantly higher than in small towns.

Table 4.
Investment efficiency on the real estate market

Investment period	Investment efficiency - annual profit rate in the investment period (in %)		
	Q1 2000–Q1 2022	Q1 2010–Q1 2022	Q1 2020–Q1 2022
Investment in real estate - purchase of real estate in the first quarter of 2000, 2010 and 2020, respectively, and its sale in the fourth quarter of 2021 at the price of 5,134 per m ² , excluding inflation	6,0883	1,6773	7,4995
Real estate investment - purchase of real estate in the first quarter of 2000, 2010 and 2020, respectively, and its sale in the fourth quarter of 2021 at the price of 5,134 per m ² , including inflation	3,1380	-0,6397	1,9718

Source: Own study.

If one were to invest in flats commissioned for use in the Q1 of 2000, 2010, 2020, then taking into account interest rates and inflation, the value of these flats in the Q1 2022 would be equal to Table 4. However, the prices of flats in the analyzed period increased significantly. It is worth comparing the capitalized value of the initial capital from the Q1 of 2000, 2010 and 2020 and the average price per one square meter in the Q1 of 2022.

It should be emphasized, however, that the market prices of real estate both on the primary and secondary market differ significantly depending on the location of the real estate and its standard. The prices taken into account for 1 m² of usable floor space of a residential building commissioned for use, provided by the Central Statistical Office, only showed certain trends on the real estate market. However, it should be remembered that investing in this market may not always result in a positive financial result. Taking into account the high level of inflation in 2022 and economists' forecasts regarding the expected level of inflation in subsequent periods, inflation should be taken into account in investment problems, as it has a significant impact on the result of investments.

4. Summary

In the analyzed examples, the data selected for the calculations were collected from the websites of the Central Statistical Office, NBP and the Mint of Poland. These are data for the historical period. However, it should be remembered that not all values are always known or determined in the investment process. In many cases, future cash flows are not known, but their probabilities can be predicted based on historical data. NPV allows you to assess which investment is profitable based on historical data. When investing, however, we do not know future values, e.g. gold prices or real estate prices. Then PNPV can be useful provided that the distribution of the rates of return of the analyzed quantities is known. Then it is worth using, in addition to the classic methods, also probabilistic methods, for example PNPV. There is always a risk involved in the investment process. There is no profit without risk. When taking a risk, the investor also takes into account the potential loss. Both in the investment market and in the precious metals market, it is possible to obtain a positive, but also a negative rate of return on investment. Nowadays, when the level of inflation is significant, it is very difficult to find an investment characterized by a high expected rate of return and a low level of risk. However, as it was shown in the paper, such investments are possible even in the period of large fluctuations in the economy.

The next stage of the research will be to analyze the distribution of rates of return on simulation examples and to adjust the investment method to the obtained distributions. It seems that using the PNPV method it is possible to obtain information on the choice of the investment method in relation to the obtained empirical distribution of rates of return.

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THE CONCEPT OF USING ARTIFICIAL INTELLIGENCE IN THE PROCESS OF BUILDING A MARKETING COMMUNICATION STRATEGY (AVATAR MODEL)

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Purpose: The presented research purpose (and thus the article's creation) result from considerations of the topicality of the traditional channels of contact with clients proposed in the literature. Furthermore, due to the dynamics of changes in the environment and the highly intensive scientific and technological development, it was decided to investigate which channels of marketing information are popular and used by young people (hence the proposed age range of the respondents).

Design/methodology/approach: In the research process, a classic questionnaire was used, which was presented to the respondents in an innovative, modern form. Avatar invited the participants to participate in the study, asking applicants to provide their date of birth. After verifying that each person actually exists and meets the assumed criteria of the research group, AVATAR presented a questionnaire, which included questions about the assessment of classic and modern methods of marketing communication (as described later in the publication). The thematic scope of the article covers the analysis of trends in the field of marketing communication among young people and includes the assessment of modern, creative and innovative methods of influencing a potential customer. In this context, it should be emphasised that the choice of the respondents is not accidental - they are young people, and therefore their opinions and assessments will be a valuable source of information for modern enterprises' marketing and commercial departments.

Findings: Due to time constraints, the research concerned selected tools and methods of marketing communication, evaluating a set of classic forms of communication, which were extended to more modern methods (internet, social media) and innovative tools. Due to the positive appraisals of the project, it should be assumed that other cities and municipalities in Poland should be equipped with the AVATAR tool, which in turn will allow for the recommendation of further research on a group of respondents in the same age group, but coming from different regions of the country (geographically) and various centers (rural, urban, agglomeration).

Originality/value: During the research, it was found that among young people, the traditional channels of marketing information are not only losing their importance but are even going unnoticed. Among the proposed set of eleven classic forms of marketing, almost all were rejected, except for the so-called word-of-mouth marketing. It should be emphasised, however, that the respondents stated that word-of-mouth marketing is evolving for the benefit of the internet (opinions about the product, company, or service) and messages transmitted via social

media. Therefore, the next part of the study was devoted to analysing and evaluating the innovative avatar tool as a potential carrier of marketing information and a tool for transmitting interactive advertising messages. The research also established that all innovations are positively perceived by respondents aged 20-29, regardless of the city they come from (in this case, the innovation was an avatar).

Keywords: avatar, marketing, communication, innovation, client.

Category of the paper: Research paper.

Introduction

The publication entitled "The concept of using artificial intelligence in the process of building a marketing communication strategy (avatar model)" presents the possibilities of an interactive avatar tool in the field of shaping relationships with potential customers, treated as an essential and innovative element in building a company's marketing strategy. The study will present the results of research carried out as part of an EU-funded project on the possibility of using a modern and interactive avatar to facilitate contact with a potential customer. It is worth noting that the research work and device tests were carried out in two local government units in Poland - positive test results preceded by modifications to the original tool provide a basis for formulating a thesis that the tested avatar model can be implemented both in enterprises and other institutions serving customers. This thesis is confirmed by the current global trends in the development of both modern marketing and other areas of social life, development based on virtualization, digitization, augmented reality or assumptions of industry 4.0. Moreover, it suddenly turned out that during the pandemic, the avatar tool provided comprehensive customer service without needing to contact employees, which is its added-value (albeit unintended).

Considering the avatar tool's specificity, we decided to use it to research changes in marketing communication channels.

The publication's main aim is to show how young people (age group 21-29 years old) perceive traditional marketing communication channels. Based on the main goal, two specific goals have been defined:

1. The first detailed objective: is to determine, based on the conducted research, the trends in the field of marketing communication.
2. Second detailed objective: determine how the respondents evaluate the innovative avatar tool using the device as a modern medium for conveying informational and advertising messages.

The goals presented above obligated the author to define two working hypotheses, which were analyzed in the course of empirical research:

H1: It should be assumed that traditional marketing information channels do not fulfil the function assigned to them among young people.

H2: It should be assumed that young people are departing from traditional forms of communication in favour of innovative, modern methods of transmitting (exchanging) information.

Such hypotheses were verified during our empirical work, and the research conclusions are presented in the final part of the article.

Methods

The method of a scientific experiment was used in the first stage of empirical. The scientific experiment was to build an avatar tool and start testing it. During the tests lasting 2 years, the avatar model was actively modified in order to discover the cause and effect relationships and interactions between the avatar tool and the applicant. The use of the scientific experiment method was due to the fact that the research involved a repeated phenomenon (an avatar service for the clients).

The four phases were distinguished in the research process:

1. The first phase: isolating the phenomenon that is to be the subject of research - here the possibility of using the avatar tool for the process of interactive service of applicants.
2. The second phase: determining the conditions of a given phenomenon - here, defining the catalog of matters that can be dealt with by the device.
3. The third phase: it was to cause changes to the identified conditions of the phenomenon, which in this particular case consisted in extending the catalog of cases and increasing the functionality of the solution (e.g. adding a sign language).
4. Phase four - identification of the necessity to introduce changes and modification of the system.

The second stage of the research work was to prepare the research using the questionnaire method. In the questionnaire, in accordance with the methodology of its preparation, a set of questions addressed to selected groups of respondents was used. The aim of the survey was to find out the answers to the questions related to the acceptability of traditional forms of marketing message. Importantly, the survey was carried out with the use of papers carried out in a scientific experiment - the survey was carried out by the avatar tool.

Avatar as a modern marketing communication tool

The idea of creating an avatar tool appeared when the needs of JST customers (applicants) were defined. As part of developing the solution concept, problems in the process of customer service in the management of public services were defined based on the available literature (Maśloch, 2021). As indicated by J. Trischler and D. Scott, the process of public service management focuses on meeting the following requirements (Trischler, Scott, 2016):

- customer orientation, who ultimately evaluates the quality of the service provided,
- continuous improvement, broadening knowledge, innovation in solving problems, using the opportunities offered by the employees of the organization,
- development and commitment of employees, which is associated with an organizational culture based on trust and the transfer of full competencies to employees,
- management based on processes and facts, consisting in the effective use of resources, obtaining the desired results, managing information that should be true, complete, reliable and professional,
- leadership and consistency of goals. Leaders at all levels of a public organization are responsible for its development, promoting its values, its mission and vision,
- partnership development. Mutually beneficial relations between partners result in full integration in creating knowledge, implementation of plans and public goals, using generally accepted rules of conduct,
- public responsibility, ethical approach and behavior of employees, meeting the expectations of customers, employers and society,
- result orientation, where excellence depends on the ability to balance and satisfy the interests of groups, people responsible for the functioning of a public organization.

The customer service process consists of many interrelated activities that determine customer satisfaction when purchasing a product (service). The last step of the process usually begins with an order and ends with the delivery of the product to the customer (Turban, Outland, King, Lee, Liang, Turban, 2018).

The psychological aspect plays an important role in customer service (applicant), especially among the elderly. It is worth emphasizing that psychological needs are an area for most customer service employees in LGUs, not pursued and, paradoxically, the most important (Bartels, Turnbull, 2020). Therefore, it becomes necessary to use methods of supporting customer service employees in situations that pose the greatest challenges by looking for answers to several questions:

- Why there are misunderstandings, difficult, often conflicting situations in dealing with clients?
- Why is the client still dissatisfied with the service despite meeting his substantive needs?
- Why the adopted argumentation does not bring the desired effect, and what are the clients' motives?

Based on our observations and the obtained answers to the questions mentioned above, a standard implementation model. The activities described above constituted preparatory activities for conducting a pilot survey in 2020, which resulted from the implementation of international research and a scientific project entitled An innovative model of assistance, an avatar of an elderly caregiver, co-financed by the EU.

The survey questionnaire consisted of a main part consisting of 23 questions and a measure with four questions. The main issues included in the survey concerned two main research areas:

- the first is devoted to the assessment of respondents in the field of functioning and service of petitioners (clients) in public administration offices,
- the second, which focused on the expectations and requirements of applicants (clients) in the field of service in public administration offices.

The research aimed to verify the correctness (elimination of defects) of the adopted research procedure, the correct selection of people and the use of the research tool (questionnaire). This study was not used to verify hypotheses; its purpose was to provide information enabling the construction of a prototype of the avatar tool with the broadest possible functionalities, which were determined after analyzing the obtained data as a result of an empirical study.

The study was qualitative (questionnaire test) and was conducted as a meeting of people from a deliberately selected sample with the number $N = 40$. it is understandable whether the questionnaire finally contains a complete set of answers), supplemented with a cognitive interview (suggestions for changes/supplementing the scope and type of questions, analysis of the target group of respondents).

Statistical analysis showed that all participants of the study used the services of public administration offices, but most (85%) used the services of the city or commune, while the rest - used the services of the County Office. During the research, it turned out that the respondents, in most cases, deal with official matters once a year (50%) or once every few years (25%), and 10% of the respondents could not precisely define the frequency of visits to the office, and 5% of the respondents did not provide any responses (the above data is presented in Figure 1).

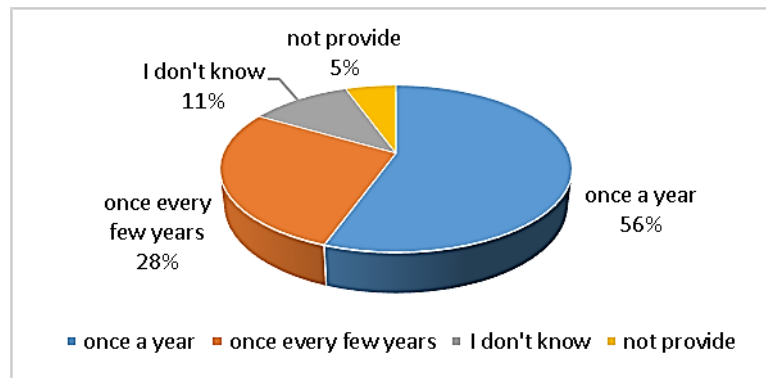


Figure 1. Structure of answers to the question: *How often do you deal with official matters in local government units?*

Source: Own elaboration based on empirical research.

In the next part of the survey, participants were asked about the most frequent contact method with local government units - two responses could be selected in the survey. The respondents indicated that they most frequently contacted themselves in person 80%, by phone 15%, by e-puap 4 % and by letter 1%. There was no indication of electronic contact via the e-PUAP platform. The structure of the answer to this question is presented in Figure 2.

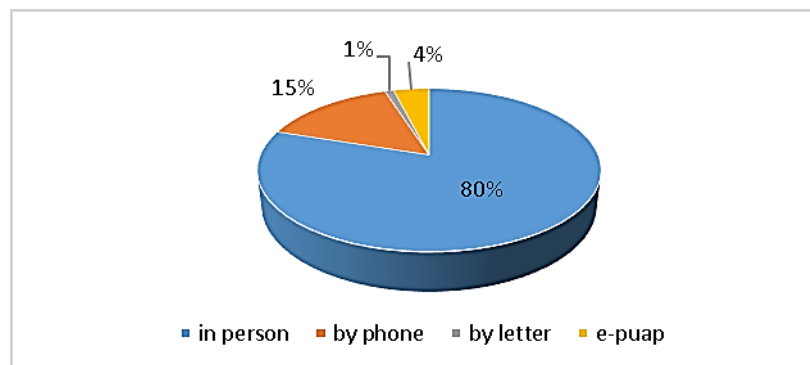


Figure 2. Structure of responses to the question about *how to handle matters in local government unit?*

Source: Own elaboration based on empirical research.

It should be emphasized that this publication presents only a general introduction to the research subject and indicates the structure of responses to the two most important questions from the article's point of view included in the survey. Concept avatar devices were installed for testing in November 2020 in Przysucha and Sulejów. The purpose of the testing program, which lasted for six months, was to identify significant changes in the software and the scope of matters handled by the Avatar in relation to its original version.

Based on the analysis of matters handled by the applicants and based on continuous interviews with avatar users, the most important advantages of the avatar device should be indicated:

- improving the quality of customer service (applicants),
- analysis of the number and types of cases handled by obtaining electronic feedback,
- increasing the safety of residents through the possibility of electronic settlement of an increasing number of matters,
- efficient and quick information transfer to applicants,
- verification and control of the state of implementation of official matters,
- availability, without time limits.

Following the assumptions of the project, it was assumed that the updating changes would be introduced once a week - a team monitoring the actual needs of applicants in this regard has been appointed in each local government unit. Research in this area has shown that the device's possibilities are almost unlimited. Therefore the focus was on observing the number of people using the Avatar as a device through which official matters are dealt with and information on the current problems of local government units. This indicator is the basis for the research team to determine the possibility of using an avatar as a modern marketing tool, facilitating an easy, fast and, above all, always accessible way of contacting an institution, local government unit or enterprise.

Criticism of traditional forms of marketing communication

Traditionally, as mentioned in the literature, forms of marketing communication in the realities of the 21st century do not fulfil their original functions - the influence of the Internet and social media on consumer decisions can be seen more and more often. This is where most of the most up-to-date and opinion-forming information comes from, which helps to make the right consumer (and other) decisions. In order to assess the importance of individual forms of information exchange, a survey was carried out among the group of respondents aged 21-29 from January to June 2022. The research was carried out based on an electronic questionnaire, which was available through the avatar devices, tested in local government units, i.e. in the Sulejówek City Hall and the Przysuski County Council. The voluntary study involved subjects from the above offices that met the age criteria. The subjects were verified by asking Avatar to provide their date of birth - these data were verified in the databases of the relevant office. After positive verification, Avatar invited people to fill in a special questionnaire (in electronic format), which was then subjected to appropriate system analysis. As a result of the research procedure, responses were obtained from 424 people who were asked to indicate the forms of marketing communication that they used most often (and why). Therefore, the respondents had the opportunity to evaluate the most frequently used forms of marketing communication from among the following (Kotler, 2022):

- TV,
- radio,
- press,
- advertising banners - wall advertisements,
- leaflets,
- e-mailing campaigns,
- telephone marketing,
- word of mouth marketing,
- fairs, exhibitions,
- sponsorship,
- mobile visual advertising.

Based on the analysis of the answers provided, it should be stated that the traditional (classical) media are losing their importance. The above statement is reflected in the data presented in Figure 3, which illustrates the structure of the answer to the question about the use of television to transmit information.

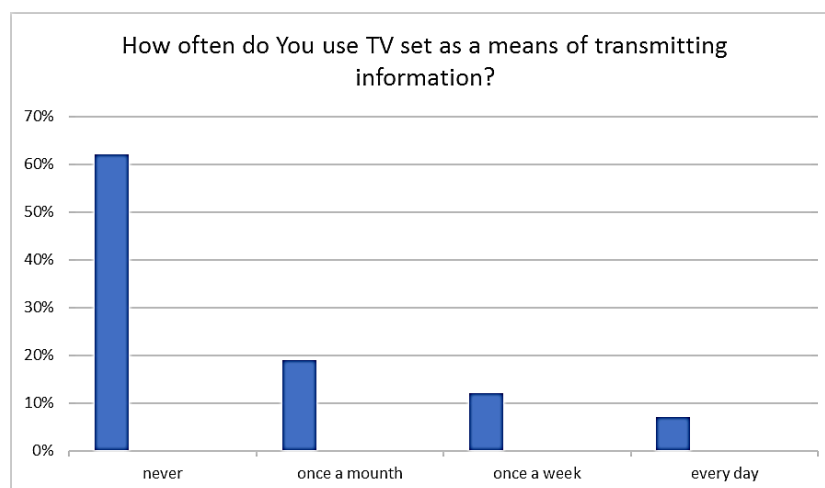


Figure 3. Structure of the answer to the question: *How often do you use television as a means of transmitting information?*

Source: own study based on survey research.

According to the data presented, 62% of respondents declare that they do not watch TV at all, watch it occasionally (once a month - 19%) or watch it once a week (12%). The above results suggest that the role of television in providing information and marketing communication is becoming marginal among the surveyed people. Moreover, as the research shows, most respondents do not even declare the will to have a TV set and traditional television.

The situation is very similar concerning the press. Contradictory information on the same event in different newspapers is widespread. Catchy and, unfortunately, manipulated article titles are used to attract as many readers as possible. The respondents' responses to the importance of the press in the marketing message are shown in Figure 4.

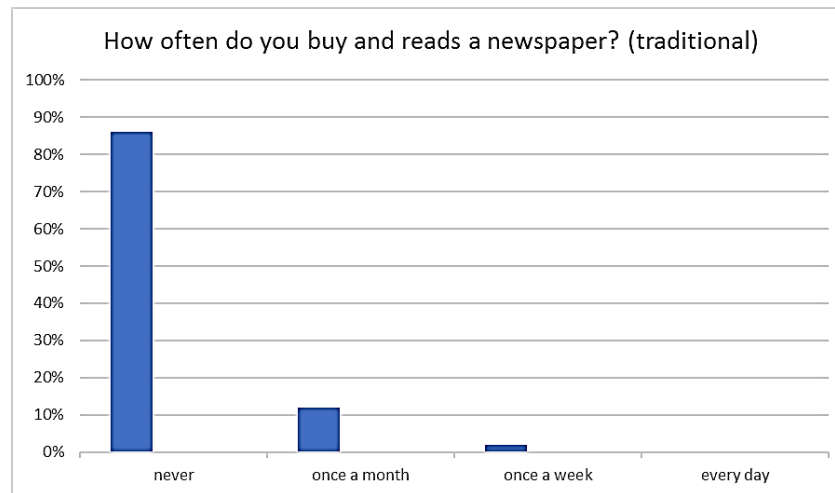


Figure 4. The importance of the traditional press in the marketing message - answers to the question: *How often do you buy and read a paper-based newspaper?*

Source: own study based on survey research.

As a result of the structure of answers to such a question, as many as 86% of the respondents indicated no interest in this form of communication. Another 12% declared using the press once a month, which practically confirms the decline of this form of communication. It should be noted that at the turn of the last few years, an increase in demand for newspapers published in electronic form has been observed. According to M. Thompson, boss of The New York Times, this newspaper will cease to be published in paper form within the next 20 years (Sherman,2020).

In turn, the data presented by Empik and the TaniaKsiążka.pl portal in 2020 saw an increase in e-book sales by as much as 20%. This report confirms the results of our empirical research, based on which it can be clearly stated that traditional editions of the paper press are a marginal way of communicating marketing messages with a downward trend in demand for the press, which is confirmed by the statistics on changes in the sales volumes of newspapers traditional, issued in paper form.

Another, so far popular medium that has been noticed in marketing activities is radio. In the survey, the question was not about listening to a radio message but about the degree of interest, understanding and remembering marketing and advertising messages. The answers to the question concerning the indicated problems are presented in Figure 5.

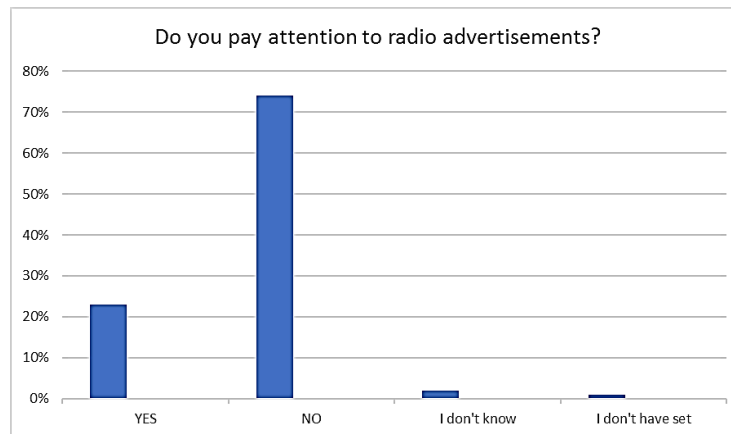


Figure 5. Structure of the answer to the question: *Do you pay attention to radio advertisements?*

Source: own study based on survey research.

It is worth emphasizing that in this case, not only the structure of the responses obtained is important (74% of the respondents practically do not pay attention to the content transmitted via the radio receiver), but also the commentary on them. Complementing their responses, the respondents claimed that the radio receiver was turned on (e.g. while driving a car), but focusing on other activities allowed for the perception of advertising messages conveyed through the medium in question only to a limited extent. The respondents also pay attention to the fact that even if they listen to a selected radio station, e.g. while performing other activities, the frequency of broadcasting advertising messages is so high that it has the opposite effect of discouraging the company or product.

Another traditional form of information transfer is mailing campaigns and newsletters. Figure 6 shows the answers to the question regarding the respondents' interest in mailing campaigns and newsletters.

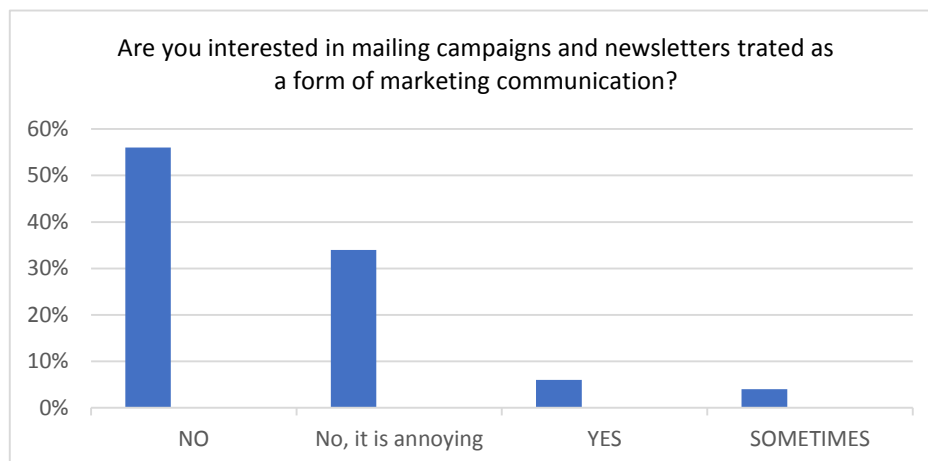


Figure 6. Structure of answers to the question: *Are you interested in mailing campaigns and newsletters as a marketing communication form?*

Source: own study based on survey research.

According to the conducted analyses, mailing campaigns or newsletters, until recently indicated as an exciting and effective marketing tool, do not fulfil any previously assigned functions.

Similar conclusions were drawn by the research team of First Orion Corporation, which proved that in 2020 as many as 90% of e-mail users would most likely block spam messages permanently (FirstOrion,2020). The results obtained by First Orion Corporation confirm the answers obtained in the presented results of its empirical research. It is also worth noting that this form of marketing communication has lost its importance due to the excessive number of messages received from various sources and the fear of cyberattacks.

Another issue of interest to the authors was the receipt of marketing and advertising messages placed on banners, posters and leaflets. The distribution of responses to the indicated issues is presented in Figure 7.

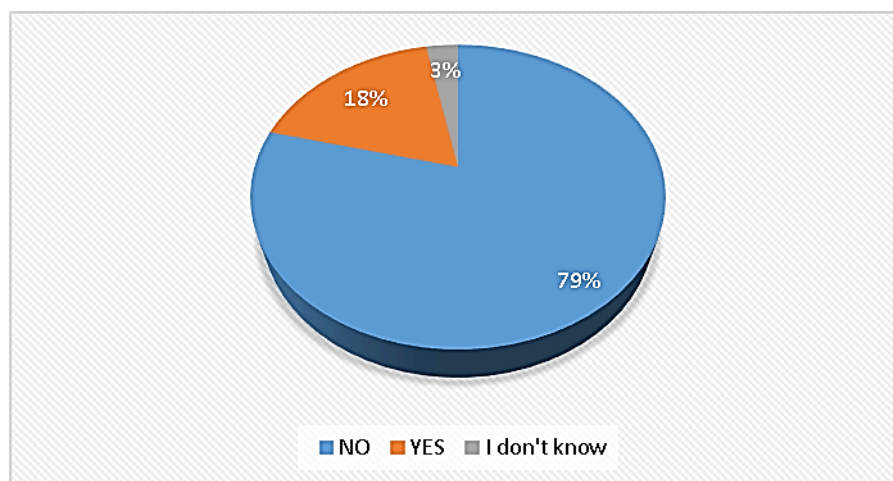


Figure 7. Structure of answers to the question: *Do you pay attention to marketing messages (advertisements) on banners, posters, and leaflets?*

Source: own study based on survey research.

When analyzing this thread of answers included in the questionnaire, one should refer to the limited possibilities of human perception. Furthermore, precisely this limitation makes potential customers unable to remember and even pay attention to the marketing message. This is due to the lack of regulations in this respect, i.e. regulations concerning the rules for placing advertisements along the main routes of cities. Unfortunately, too many advertisements have the effects described above, disqualifying that marketing message

Other popular forms of marketing communication were fairs and exhibitions - unfortunately, in the face of the pandemic, this form of communication practically ceased to exist. Moreover, according to the authors, one should not think that fairs and exhibitions will again become part of the canon of effective marketing activities after the pandemic.

The situation is slightly different in the case of the so-called word-of-mouth marketing. This form of communication is still important in services which, due to their immateriality, are subject to specific marketing activities. According to the analysis of the results of the conducted

research, the role of word of mouth marketing, understood as a traditional form of information transmission, is also decreasing, but it is being replaced by such tools as the Internet and social media. As confirmed by the respondents, they more often reach for advice on the forum of social networking sites - it is easy to notice how significant the opinion of Internet users is when it comes to assessing products or services and how this influences the consumer decisions made.

The analysis of the survey results shows that the traditional forms of communication proposed by marketing are not very attractive to people under 29. Moreover, the respondents practically do not use them in everyday communication and ignore them, e.g. advertising campaigns posted there. Of the proposed forms of information transmission, virtually all, except for social media and the Internet, have been rejected. In connection with the above, other, even more, innovative solutions for mutual communication and supporting customer service should be proposed. This tool is an avatar with elements of artificial intelligence.

Summary



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The empirical research and avatar concept presented in the publication, the implementation of further research and development works, the preparation and testing of prototypes and the development of the final version of the tool were carried out as part of a project financed by the European Union entitled *An innovative model of assistance, an avatar of an elderly caregiver*, contract number: POWR.04.03.00-IP.07-00-006 / 18, coordinated by the Academy of War Art, in partnership with the Częstochowa University of Technology, Przysuski County Council, Sulejówek City Hall and a foreign partner, an Education & Information Technology company from Cyprus.

As a result of the analysis presented in the first part of the publication, traditional forms of marketing communication are not and will certainly not fulfil the role assigned to them in the literature. As previously mentioned, social media and the Internet dominate among young people. Due to the lack of possibility to develop traditional forms of communication, an avatar tool was designed, which is a combination of a digital form of communication with elements of interaction with the client (applicant), interactions in the form of, among others, opportunities to chat with a virtual person. It should also be emphasized that the avatar device has been subjected to a series of tests to analyze its possibilities, introducing modifications in the scope of the cases carried out and assessing applicants' interest in the device. What is more, the Avatar has unintentionally become an excellent communication tool in the time of the COVID-19

pandemic; regarding how it helped with several matters of local government and dealt with them without contacting an office employee.

As mentioned earlier, based on the research and analyses, the avatar device works well in communication between the applicant and the office. Therefore, after the completion of the project and the introduction of modifications resulting from adapting the device software to the needs of specific institutions, it should be assumed that it will be a solution recommended as a completely new, innovative form of marketing communication.

In connection with the research procedure and the results obtained, it should be stated that the hypothesis concerning the departure of young people from classic forms of marketing communication has been verified positively. It is similar in the case of the second hypothesis - here, the respondents opted for modern means of marketing communication.

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THE ANALYSIS OF SELECTED INCENTIVES IN THE POLISH MINING FROM THE PERSPECTIVE OF DIFFERENT EMPLOYEE GROUPS

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Purpose: This article is aimed at reviewing selected incentives in the mining sector and checking how they are perceived by blue-collar and white-collar underground workers.

Design/methodology/approach: The article is cognitive in nature and the basic research method is the analysis of reference works and surveys. The reference work studies cover the analysis of national and foreign works. Surveys are carried out for the sample of 4000 employees, with the survey return rate of 8.75%. This article also uses a case study based on analyzing the internal documents of a selected enterprise.

Findings: The analysis revealed that more than one half of surveyed blue-collar employees are satisfied with the intangible incentives used by the organization, including the conditions of qualification development, as well as further education and development opportunities, while their managers entirely agree with those statements. The majority of the surveyed blue-collar workers are well aware how their work contributes to the company efficiency and finance, and a bit more than one half of the surveyed employees in this group knows the company situation when compared to the market.

Research limitations/implications: The studies presented in this article may contribute to further empirical studies and may provide guidelines for the mining enterprise managers relating to the incentive system improvement.

Practical implications: The practical implications of the completed studies are connected with their applicability for the selection of incentives in the created and improved incentive systems in mining companies.

Originality/value: The reference work review and surveys point to the need for continuous improvement of incentive systems in mining companies.

Keywords: incentives, motivation, mining.

Category of the paper: General review, Research paper.

1. Introduction

In the traditional theory of management, motivating is one of four basic functions, besides planning, organizing, and control. The motivation is also broadly developed in the human resource management concept derived from the Michigan School group. An objective of the human resource management is to improve motivation, accountability, and commitment to work by implementing rules and processes which guarantee that the employees are recognized and rewarded for their achievements based on their competences and skills (Armstrong, 2012). The reference works define motivation in many ways as it is a term with many different meanings. In the first meaning, motivation comprises factors which provide energy for human behavior and conditions for it, or ensure human readiness to start the activity. In the second meaning, motivation refers to mental experiences of a human which shape the ability and direction of their activity and is a process controlling the activities so that they lead to achieving a specific goal (Kozłowski, 2009). According to other definitions, motivation is all driving forces stimulating an individual to choose, to initiate any activity or to keep ready to act, all the forces and factors stimulating and maintaining a human being in their behavior intending to achieve specific goals; the factors which affect the direction, power, and durability of the action (Jasiński, 2001). Generally speaking, it is the intention to do something to achieve something. If the intentions and actions of organization managers are reasonable, the major objective of motivating is the increased value and efficiency of the organization operations. The aim of motivating employees is to create higher work efficiency and to shape any attitudes and behaviors desired by the employer.

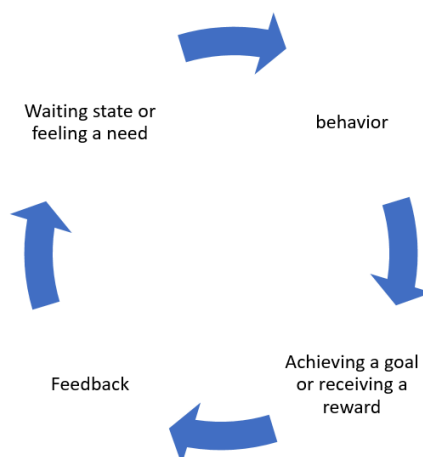


Figure 1. Basic motivation model.

Source: Kozioł, 2002, p. 28.

The model presented in Figure 1 depicts the motivation process:

- need — employees' activities to satisfy their needs,
- task acceptance — achieving better results by giving specific, challenging tasks which are feasible and give a sense of success,
- reinforcement — repeating specific behavior by earlier success,
- expected result — changing one's behavior when they think it will bring appropriate reward,
- anticipated efficiency — an employee who appreciates their abilities will be more persistent in their activities or will try any alternative activities,
- causal relationship — an employee is likely to repeat their behavior which brought success or to improve it if they understand the tie of this behavior with some previous failure or success.

According to the above mentioned motivation model, once the goal is achieved by an individual, the stimulus no longer acts (the stimulus is any change near or inside a living body which may bring about or change its state of agitation). Once the stimulus disappears, it eliminates the incentive for action and, consequently, also the behavior itself. The assumptions behind the presented concept, i.e. the causality, motivation, and goal orientation enable to analyze behavior of different people any time (Kozioł, 2002).

The problems of employee motivation become particularly important for the mining sector. The reason is the multitude of relatively complex documents governing miners' pay, including but not limited to collective labor agreements. Based on them, many pay components are created which may lose its motivating nature due to their fragmentation. The problems of motivation in the mining sector are not widely discussed in reference works. They usually deal with pay (Bator, Ślósarz, 2009, pp. 52-54; Gruca, Lacheta, 1984, pp. 266-273; Lisowski, 1992, pp. 275-278, Kutkowski, Zaniewski, 2010, pp. 100-103; Tchórzewski, 2011, pp. 77-81). Motivation systems in the mining sector become more and more expanded and contain a number of other tools beside pay incentives.

To analyze selected incentives in the mining sector, one of the largest mining companies in Poland, listed on the Stock Exchange, was selected as a study entity. Its choice was based on the availability of data and a large range of public information concerning the incentive system in the company. It stems from the need to publish data for the reporting process required by the Stock Exchange. The selected mining company has several mining plants (mines) using the same incentive system. For the survey, one mine in this company structure was selected. The survey was administered to 350 blue-collar and white-collar workers in the underground part of the mining plant. The article presents the analysis of selected incentive system aspects.

2. Classification of motivation theory

Every incentive system is based on motivating factors (stimuli, incentives) constituting tools and instruments. The motivating factors in the following groups are listed most often: coercion, encouragement, and persuasion. There are no perfect stimuli and their appeal to a given employee is conditional on many economic and psychological factors. The non-payroll incentives discussed in this category are the means of encouragement, as opposed to the means of coercion. They have high motivating load based mostly on rewards (Kozłowski, 2022).

The motivating factors making up the incentive system are characterized in Figure 2.

Coercive measures	Incentives	Means of persuasion
<ul style="list-style-type: none"> • company status, regulations, instructions • Resolutions and regulations • Responsibilities • Punishments, threats, discipline system 	<ul style="list-style-type: none"> • Wages, awards, bonuses, shares, shares, housing, trips abroad • Recognition, praise, distinctions • Career paths, training, evaluation system, job evaluation • Content and working conditions, standards, work restrictions 	<ul style="list-style-type: none"> • Coaching, support • Advice, requests, agitation, negotiations • Quality circles, group forms of work organization • Employee opinion research, IT systems • Management style, management methods, quality systems

Figure 2. Incentive system in a company.

Source: Kozłowski, 2022, p. 24.

Non-payroll incentives have a double motivating function. On the one hand, they reinforce the motivating activity of payroll stimuli, being recognition for the employee. On the other, those stimuli act on their own and are particularly effective for employees with highly developed social needs and the self-fulfillment needs.

Non-payroll incentives can be divided into tangible and intangible ones. Tangible non-payroll incentives are granted to employees as an extra pay for work. They are often a basis of cafeteria pay which creates the opportunities to adapt the benefits and privileges to the employee's current needs and individual expectations. Tangible incentives which often have high motivating power and are frequently employed by organizations include education paid by the employer, including covering the costs of training and workshops, participation in conferences, seminars and symposiums, accommodation, company car, extra paid leaves, extra old-age pension and health insurance, company loans, vouchers or healthcare at the company's expense. These incentives are offered primarily in international companies, banks, and listed companies. The systems including expanded tangible non-payroll incentives are becoming

an important component of motivating in high market competition, allowing to retain the “intellectual capital” (Kopertyńska, 2009).

Intangible incentives have won increased interest of managers and employees recently. They have advantages and are popularly employed in all countries with developed market economy. Intangible incentives in the overall incentive system constitute an organizational area of the company. From the perspective of encouraging factor classification, intangible incentives are activated by external stimuli (Kamińska, Warzyński, 2011). The most frequently used of them with high motivating power include:

- professional development opportunity,
- employer’s trust,
- freedom of action, independence, autonomy and delegation of rights,
- appreciation from managers, celebrating employees’ achievements,
- honorary titles and functions,
- flexible working time,
- right to work from home,
- signing the work or product with one’s own name (Gick, Tarczyńska, 1990).

Medium-sized and small companies usually employ a small range of tangible and intangible non-payroll incentives. Sometimes none of them are used apart from appreciation.

Non-payroll incentives can be external, i.e. they improve working conditions and the standard of employee’s life (e.g. company car, mobile phone, advantageous insurance, catering) and internal, i.e. contributing to the fulfillment of the employee’s personal goals and ambitions (e.g. promotion opportunities, recognition, personal development). The internal factors influence primarily well-educated young people where they bring about an immediate result (Kopertyńska, 2009).

Another classification which gives rise to fewer doubts is the division into positive and negative incentives. Positive incentives bring about positive emotions in the motivated person and encourage them to more effective work, to make an effort because of the anticipated tangible and intangible goods. They create perspectives for the employee and ensure improved realization of their goals when then meet the employer’s expectations. Negative incentives cause negative emotions in the employee, are based on fear and anxiety, communicate improper attitude and behavior unwelcome by the employer to the motivated person. They are usually disapproved by them. Based on this classification, the incentive groups are not clear (Kozłowski, 2009). For example, the base pay or bonus is, as a rule, a positive incentive, but if the motivated person perceives its value as too low, it may cause the sense of humiliation or frustration, or even make them resign from work. Another example is the value of the bonus received by the employee. It may be satisfactory as long as the employee does not learn that another employee on an equivalent position received a higher bonus for similar work. This situation may discourage the motivated person in the future from effective work even

though the bonus is a positive incentive. This means that it can be difficult to say whether a given incentive is positive or negative, as one incentive can be deemed positive in some circumstances and negative in other. Motivating tools should not be identical for all social and professional groups, but they should be differentiated based on the expectations of employees and organizations. Motivating by remuneration should be positive, consisting in paying for the achieved result and not in punishing for its absence or improper level (this is connected mainly with the changing pay part, i.e. bonuses) (Borkowska, 2006). At present, it is popularly believed that it is necessary to use positive incentives, considering the negative ones to be the last resort. However, when it is necessary to employ a negative incentive, it is advisable to follow the principles presented below and proven in practice:

- the punishment should be just and adapted to the punished act. It should be more lenient rather than excessively harsh,
- no punishment should be administered before the wrongdoer is allowed to speak for them,
- do not punish under the influence of emotions, hastily, but it is also not permissible to delay punishment for too long,
- punishment gradation,
- avoid humiliating punishment in public.

At present, there is no social acceptance of severe treatment of employees; punishment often becomes a relic of the past in organizations. Companies which use excessive punishment shape passive and anxious peoples who want primarily to ensure safety and avoid errors and are reluctant to make any decisions. The ratio of the positive and negative incentives used is largely conditional on the company sector, its culture, managers' personality, and leadership style. Harsh treatment of employees by employing punishment and reprimands causing fear and general sense of anxiety reduces satisfaction from the work done significantly. It is impossible to expect that people who are not satisfied with their work will be innovative, creative, proactive or willing to make any extra work effort. This is why the reasonable direction of improving the incentive systems in contemporary companies is the strive to implement solutions based on the new paradigm, i.e. taking care of the employee satisfaction level (Juchnowicz, 2014).

Motivating can also be divided into short-term and delayed. Intangible stimuli can entirely replace tangible encouragement solely for a short time and in the times of required sacrifice (Borkowska, 1985). For employees who sustain themselves on the salaries paid once a month and bonuses paid monthly or quarterly, the short-term incentives are most important. Short-term stimuli are more important for doing tasks on the operating level, including the acquisition, stabilization, and motivation of employees to achieve ongoing goals. Delayed income enables organizations to invest more here and now as the current payroll expenditure is relatively lower. Employing delayed incentives, e.g. organization securities which may usually be sold only after many years, is a good incentive solution. They make both the managers and the specialists cooperating with them interested not only in high assessment of their work but

also in the company operations in more remote future. Delayed income, including but not limited to company shares, is criticized due to the high income it gives to the managers. By means of long-term incentives, it is possible to foster global work standards, popularize values and patterns considered the most valuable by employees and desired by the organization. Short- and long-term stimuli should make a coherent whole and strengthen one another's impact. It is not easy to find a suitable composition of tangible and intangible motivating tools, both short- and long-term. This is a significant challenge for the incentive system designers, in particular if those systems are created for managers and specialists who are the driving force for the company development attitude (Borkowska, 2004).

3. Surveys — study assumptions

A survey was aimed at learning the selected components of the incentive system. It was carried out in one of the largest mining companies in Poland. The mining sector was selected due to its extended incentive system governed by the Collective Bargaining Agreement. The incentive systems of mining companies, apart from payroll incentives, include many different non-payroll ones. They may take the form of informal, customary procedures and may be difficult to identify. To learn non-payroll incentives, usually not governed in internal documents but employed in mining companies, better, it was necessary to administer a survey. The survey was carried out in a mining company employing more than 20 thousand workers, including more than 17 thousand underground ones. The analyzed mining company excavates in four mines. All the mines in the company structure follow a uniform motivating policy. The analysis of selected incentives was carried out in a mine in the company structure. The study tool was an anonymous survey addressed to blue- and white-collar (managerial) employees working underground in the selected mine. The survey addressed to blue-collar workers had slightly different questions than the one addressed to the white-collar (managerial) ones. Thanks to it, it was possible to look at the same problems from two different perspectives (of an ordinary worker and a manager), and to compare the perception of the relationship between them.

The analyzed mine employs more than 4 thousand underground workers, the survey was administered to all of them, 350 surveys were returned.

First, questions requiring one selected answer, as listed below, were asked:

1 – I definitely disagree; 2 – I rather disagree; 3 – I rather agree; 4 – I definitely agree.

However, the last question in this part required a yes or no response.

The survey questions addressed to blue-collar workers are listed in Table 1, while the ones to the white-collar ones (managers) in Table 2.

Table 1.*Study questions in the survey addressed to blue-collar mine workers*

Please answer by putting X in the relevant box	1	2	3	4
In the previous year, I was given an opportunity to develop and learn new things in my work.				
What the Management Board of our company says conforms to what they actually do.				
My workplace is equipped sufficiently (tools, machines, and equipment) for me to perform my duties well.				
I am able to do what I can do best every day at work.				
At work, I have the opportunity to learn and develop.				
I often express my opinion and show initiative.				
The work I do gives me pleasure.				
Work organization is good at my workstation.				
I believe that I have too many duties at work.				
My work contributes to the company efficiency and finance.				
I know the company standing against the market, I know its development plans.				
I have high opportunities for promotion.				
I have conditions to improve my qualifications.				
I have complete information on what happens in the company.				
		Yes	No	
Has your work satisfaction level been analyzed for one year?				

Source: own work.

Table 2.*Study questions in the survey addressed to white-collar (managerial) mine workers*

Please answer by putting X in the relevant box	1	2	3	4
What the Management Board of our company says conforms to what they actually do.				
I believe that the flow of information in the organization is correct.				
The workplace of the people answering to me is equipped sufficiently (tools, machines, and equipment) for them to perform their duties well.				
The people answering to me are given the opportunities to learn and develop.				
I believe that the analysis of the sources of individual employee's motivation should identify the stage of their personal life.				
Work organization at the work stations of the people answering to me is good.				
The employee should be motivated with a reward connected with a financial promotion at early stages of professional activity.				
My work is stressful.				
I am provided with training dealing with stress management.				
I motivate every employee equally.				
I have a lot of tools which I can use to motivate employees efficiently.				
I strive to improve my motivating skills.				
I have complete information on what happens in the company.				
I notify the workers of problems, intentions, and achievements of the company.				
The work performed by the people answering to me is pleasant for them.				
I know how to motivate the employees to work.				

Source: own work.

Subsequent tables (Table 3 and 4) include questions asked in the survey addressed to the workers and to their managers respectively, together with suggested answers. It was required to tick one answer.

Table 3.*Single-choice questions for blue-collar mine workers*

Question	My line manager:	To what degree I devote myself to work:
Responses	<input type="checkbox"/> Is always committed to work. <input type="checkbox"/> Is often committed to work. <input type="checkbox"/> Is sometimes committed to work. <input type="checkbox"/> Is rarely committed to work. <input type="checkbox"/> Is never committed to work.	<input type="checkbox"/> I am always committed to work. <input type="checkbox"/> I am often committed to work. <input type="checkbox"/> I am sometimes committed to work. <input type="checkbox"/> I am rarely committed to work. <input type="checkbox"/> I am never committed to work.

Source: own work.

Table 4.*Single-choice questions for white-collar mine workers*

Question	The people answering to me:	Remuneration system in our organization:
Responses	<input type="checkbox"/> Are always committed to work. <input type="checkbox"/> Are often committed to work. <input type="checkbox"/> Are sometimes committed to work. <input type="checkbox"/> Are rarely committed to work. <input type="checkbox"/> Are never committed to work.	a) <input type="checkbox"/> Has many tools which allow motivating employees efficiently. <input type="checkbox"/> Has few tools which allow motivating employees efficiently. <input type="checkbox"/> Is not good in their role of motivating employee. b) <input type="checkbox"/> Is perfect, there is no need to introduce any changes. <input type="checkbox"/> Is good, but requires some correction. <input type="checkbox"/> Is hardly effective, many changes are required. <input type="checkbox"/> Is absolutely ineffective, a new remuneration system needs to be introduced.

Source: own work.

The subsequent part of the survey contains closed questions which had to be answered as follows:

- 1 – Never.
- 2 – Seldom (once every few months).
- 3 – Sometimes (several times a month).
- 4 – Often (several times a week).
- 5 – Always (everyday).

The questions are presented in Table 5 (for blue-collar workers) and in Table 6 (for managers) respectively.

Table 5.*Closed questions for blue-collar mine workers*

Please answer by putting X in the relevant box	1	2	3	4	5
How often can I implement my own ideas?					
The manager rewards, appreciates, promotes the best workers.					
I work under pressure or in the atmosphere of uncertainty.					
My work is stressful.					
How often do you ask yourself a question of why you should do your best at work if it does not change anything anyway?					
How often am I motivated at work?					

Source: own work.

Table 6.*Closed questions for white-collar (managerial) mine workers*

Please answer by putting X in the relevant box	1	2	3	4	5
How often do I allow the workers to implement their own ideas?					
I reward, appreciate, promote the best workers.					
The people answering to me work under pressure or in the atmosphere of uncertainty.					
My work is stressful.					
I make the people answering to me aware that their work is important and it is worth doing their best.					
How often do I motivate employees?					

Source: own work.

A direct open-ended question was asked in a separate part of the survey. The following question was addressed to blue-collar workers: What other word would you use for “motivation”?

The following question was addressed to white-collar workers: Order the employees’ needs in the descending order from the most important ones (1 – social, 2 – safety-related, 3 – respect-related, 4 – self-fulfillment, 5 – physiological).

4. Needs Findings

The survey enabled to identify non-payroll factors of the incentive system in the mining company. The studied components included primarily the workers’ opportunities relating to development and learning new things, employees’ access to information on the company standing and decisions made by it, the employees’ awareness of the company standing when compared to the market and its development plans, the ability to express their opinions and show initiative, the awareness of work efficiency and its impact on the company finance. An important group of incentives includes conditions connected with the workplace. In the survey, it was asked if the workstation is equipped sufficiently and if it enables the worker to perform their duties well, if the work organization at the workstation is good and if the worker finds their work pleasant, and also if they feel that they have too much duties. The workers were also asked if their work satisfaction level is analyzed. The managers were asked to assess the information flow in the company, to specify the ways of employee motivation and any aspects which were covered by the questions asked to those answering to them. Thanks to it, the same aspects could be seen from two perspectives.

More than one half of surveyed blue-collar employees claim that they are provided with the conditions of qualification development, as well as further education and development opportunities, while their managers almost entirely agree with those statements. The vast majority of responding white-collar employees (managers) claim that their work is stressful and only 35% of them have access to training relating to dealing with such conditions.

Good news is that most managers motivate using reward rather than punishment and that they strive to improve their motivating skills. However, it is worrying that only 19% of those employees claim that they have a wide choice of tools allowing to motivate the people answering to them efficiently.

The majority of the surveyed blue-collar workers (81%) are aware that their work contributes to the company efficiency and finance, and 58% of employees in this group know the company situation when compared to the market. The statistics for employees asked what happens in the company and if the company Management Board is reliable are less optimistic.

Another important factor is the workplace. Both blue-collar and white-collar workers claim that their workplaces are not equipped as appropriate. Selected answers are presented in Figure 3.

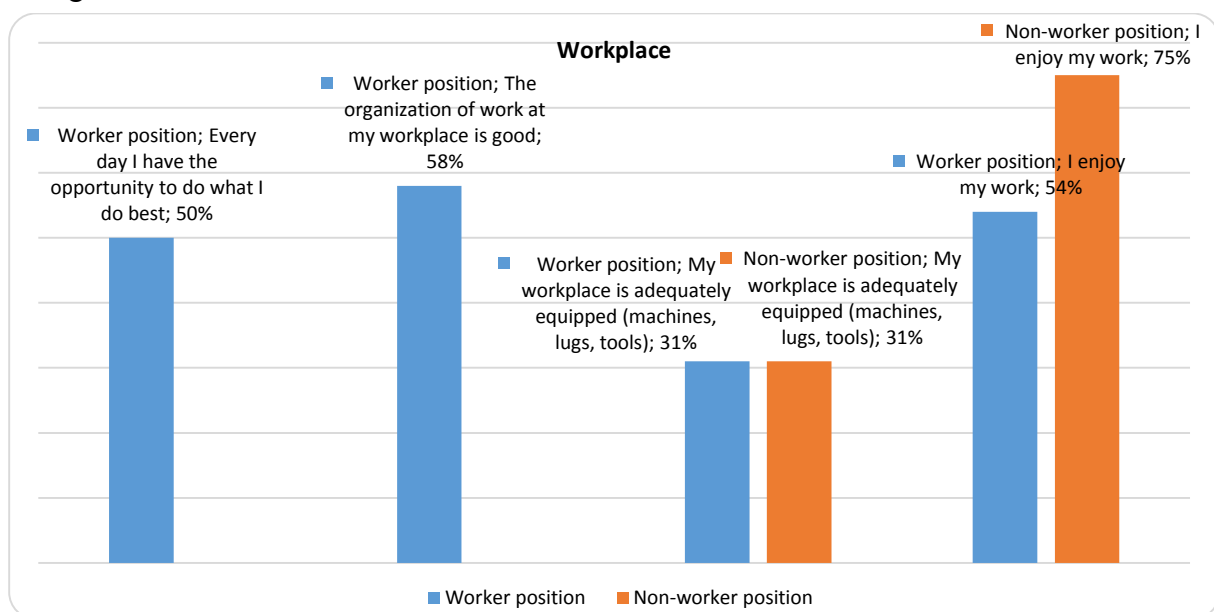


Figure 3. Workplace assessment by employees.

Source: own work.

More than one half of responding workers find their work pleasant, while three fourth of managers claim that the people answering to them derive pleasure from their work. One half of workers believe they are able to do what they can do best every day and that the work organization at their workstations is good. The workplace here does not mean prestige, as every worker works in similar conditions, usually harmful, onerous, and dangerous ones, and the insufficient equipment reduces the efficiency of their work significantly. It is worth paying attention to the "temperature" mentioned in the survey. Employees are eager to work in uncomfortable conditions in return for reduced working time. It proves that blue-collar workers do not feel any strong ties with their work establishment, but they want to do their work fast and leave it. In such a case, a solution could be to provide relevant equipment to the workplace. It could bring good results to spend funds which have been used as extra payment for work in specific conditions for improving the comfort, safety, and ergonomics in the place where work is done.

Another important incentive is promotion. Promotion, meaning raising to the higher position in hierarchy, is one of the major motivating mechanism. It satisfies the need for recognition and favorable self-esteem, and enables to access higher values and improved life quality. The promotion should be based primarily on the results achieved by the employee, including but not limited the quality and improvement of qualifications, skills, and capabilities. In the discussed company, just 12% of responding workers claim that they stand an actual chance of promotion and even their managers confirmed that the people answering to them stand hardly any chance to get it. In the company, there are no detailed rules of promotion (excluding the legal requirements). The promotion is frequently conditional on the relationship with the company top managers, trade union membership, interpersonal relationships, and nepotism. Such a policy results in reduced morale of workers, aversion to work, weakened ties with the work establishment and group ties. Such activities cause depression and frustration. For the promotion to play an efficient motivating role, the actual promotion policy is to be followed based on sound, fair and, first and foremost, proven rules which will help to open up the path to promotion to creative, talented workers who achieve extraordinary work performance. The criteria for promotion should be specified in the work rules and notified to all the workers. They need to be followed consistently and transparently. The criteria should be subject to social check.

Another important finding is that both groups of employees declared that they are often stressed while the managers admitted that they have no training relating to coping in such situations.

5. Summary

To sum up, it should be claimed that intangible incentives employed in the mining company are well received by workers. More than one half of surveyed blue-collar employees are satisfied with the intangible incentives used by the organization, including the conditions of qualification development, as well as further education and development opportunities, while their managers almost entirely agree with those statements. The majority of the surveyed blue-collar workers are well aware how their work contributes to the company efficiency and finance, and a bit more than one half of the surveyed employees in this group knows the company situation when compared to the market. Unfortunately, the scope of non-payroll incentives employed is relatively narrow when compared to their scope of applicability. For this reason, the motivating policy adopted in the analyzed mining company should be deemed to require expansion, in particular by means of non-payroll factors. The payroll policy is one of the most effective motivating tools, but it is hardly efficient if not supported with complementary incentives. In the face of the economic crisis, the company Management Board

could consider introducing training for managers devoted especially to the non-payroll means of stimulating motivation and coping in stressful situations.

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THE RELATIONSHIPS BETWEEN MANAGERS AND THE PEOPLE ANSWERING TO THEM AS AN INCENTIVE SYSTEM COMPONENT BASED ON THE EXAMPLE OF A MINING COMPANY

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Purpose: This article is aimed at analyzing and evaluating the relationships between managers and the people answering to them in a mining company in the context of the incentive system employed from the perspective of blue-collar and managerial underground workers.

Design/methodology/approach: The article is cognitive in nature and the basic research methods are the analysis of reference works and surveys. The reference work studies cover the analysis of national and foreign works. Surveys are carried out for the sample of 4000 employees, with the survey return rate of 8.75%.

Findings: The studies bring about a conclusion important for managers. Namely, the relationships between an employee and their manager are an important component of the incentive system. The workers do not think high of these relationships, while their managers have a much better opinion on them.

Research limitations/implications: The surveys discussed in this article may contribute to further empirical studies, including but not limited to initiating works to improve the incentive system in mining companies.

Practical implications: The practical implications of studies entail the possibility to use them to improve the relationships between managers and the people answering to them in the context of improving incentive systems in companies.

Originality/value: The findings indicate the need to consider the relationships between managers and the people answering to them in company incentive systems.

Keywords: employee relationships, incentive tools, non-payroll incentives.

Category of the paper: General review, Research paper

1. Incentive system concept

Motivation is the state of readiness to start a specific action caused by the process of conscious and purposeful impact on employees. Motivation is the driving force behind human activity. It is a necessary factor, one of the most important ones for increasing the work efficiency. It shapes attitudes and behavior patterns appreciated by the employer. In the traditional theory of management, motivating is one of four basic functions, besides planning, organizing, and control. Motivating is a two-way process. It takes place between a subordinate and a manager in a mutual interaction. Those motivated may influence the motivating one by feedback (Sikorski, 2004). Motivation mainly contributes to the intensity and durability of efforts made to achieve the goal which further offers the everyday readiness to work. In economics, there are 3 main approaches to employee motivation:

- behavioral – based on the belief that any behavior which resulted in pay increase or promotion is likely to be repeated,
- sequential – stresses the method and cause of starting, changing or stopping any activities leading to the achievement of personal human goals,
- satisfaction-related – explains what inspires and stimulates human behavior, what factors motivate people, and what needs they want to fulfill in their workplace (Kozłowski, 2022).

A collection of carefully selected, interrelated components with logical links between them, used to achieve the organization goals, implement the mission and strategies, considering the purposeful and feasible needs and expectations of managers and workers is called an incentive system. The incentive system may be mistakenly perceived as a set of recorded, agreed, and approved documents being grounds for motivating in the organization. However, this system is a non-homogeneous, constantly changing set of documents, procedures, customs, which are usually not described, and a mixture of instruments to stimulate workers. It comprises both prescriptive and other components, either described or not. It is organically connected with the organization culture or a set of cultures in different areas. It constitutes a configuration of stimuli, measures, and conditions which are to encourage employees to commit to their work and business duties in the way most beneficial for the company and ensuring personal satisfaction to them. For this reason, it is impossible to establish formally and describe a complete incentive system in a set of documents. However, we can influence numerous incentive system components and we should try to harmonize them. The collected incentives make up an employee incentive system (Nieżurawska-Zajac, 2022)

In the incentive system, it is assumed that in the beginning the employee expects something, has some need and believes that starting a specific task will enable them to achieve the desired result or avoid something undesirable. Thus the motivation level is conditional on the urgency of the employee's need, on how much they want to get the prize, achieve their goal, and on their

assessment of the goal achievement probability. In this process, the subordinates act according to the will of their manager who creates conditions and opportunities for them to implement their value systems and fulfill expectations in the course of work. To fulfill their motivating function well, the manager must know the factors inducing them to do the specific thing as well as their objectives and expectations, their experience, and also must have a broad range of motivating tools and know how to use them efficiently.

The incentive system and the remuneration system are strongly correlated. The broad interpretation of employee remuneration justifies treating the remuneration system in the organization and the employee incentive system as equivalent (Fig. 1). This stems from the fact that the contemporary management context substantiates using the term “remuneration” as an arbitrary equivalent for providing work and comprises all the financial and other benefits received by the employee. They are a carefully designed package supporting implementation of strategic goals of the organization which considers the objectives, needs, and value system of employees. The motivating efficiency of that package is conditional largely on its internal cohesion. All the remuneration components exert specific impact on the employee commitment, differing, however, in its direction (internal and external motivation) and the motivating power (Juchnowicz, 2012).

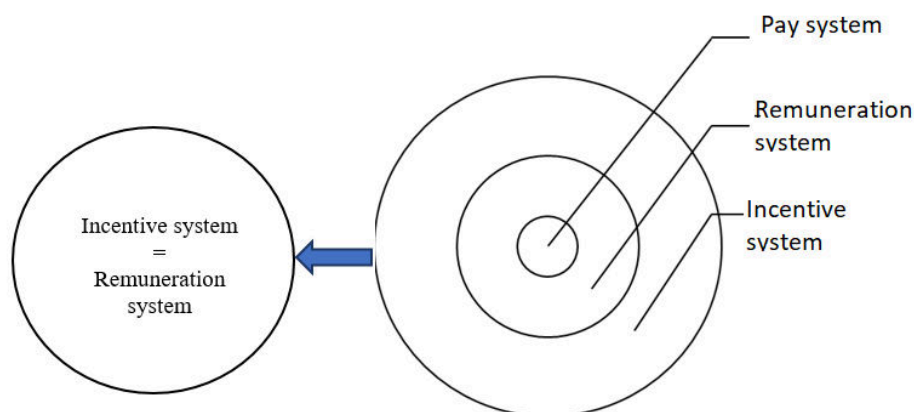


Figure 1. Relations between the remuneration system and the incentive system.

Source: Juchnowicz, 2012, p. 135.

The employee motivation is composed of numerous factors which include not just financial motives or the willingness to please, but also the need for achievements and the significance of work. This is why incentive systems should offer a broad range of solutions adapted to different employee needs. Today’s personal managers emphasize that motivating is no longer subject to the old rule of “stimulus = response”. Today, motivation is more about creating the right conditions for the employee to be eager to do what they are expected to do not out of fear and necessity, but with pleasure, out of the sense of belonging to the organization, identification with its ambitions and without continuous supervision. This is why tangible stimuli must be complemented by such factors as building the company atmosphere and culture which will make people work in it with satisfaction so that they are able to experience the joy of creation. The incentive systems oriented towards individuals, cooperation, and corporate culture may

guarantee authentic ties of the employee with their company in the long run. Zdzisław Niekciarz in his work entitled *Psychologia motywacji w organizacji* included a diagram of an efficient incentive system (Fig. 2).

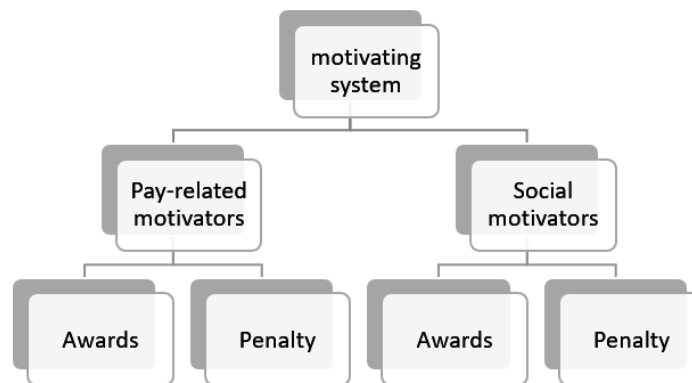


Figure 2. Diagram of an efficient incentive system.

Source: Niekciarz, 2011, p. 28.

Motivation is an unsatisfied desire. Desire is inseparable from motivation. They are always equally strong. Three motivation levels can be distinguished:

- subordination – which means doing what the manager says, as if the worker was unable to think or reason and as if they did not have any capabilities and were not committed to doing their work,
- goal identification – this is a sort of investment and gives rise to a desire to achieve it, thus increasing motivation. To help people to achieve the second tier, it is necessary to communicate the benefits of the result clearly and explicitly,
- commitment – motivation is never higher than when the employee considers the goal to be their own. To achieve the third tier, the employee must understand that they are the only person who was entrusted the task (Kopertyńska, 2009).

2. Relationships between managers and those answering to them

The relationships between managers and those answering to them are an important component of the company incentive system. The importance of that factor was emphasized in historical theories of motivation. One of them is the X and Y theory by D. McGregor. We perceive it as an attempt at specifying the relations between employees and their managers in the conditions of intensive industrialization. McGregor's theory rests on two opposing ideas concerning human nature (Sekula, 2008). According to the first of them, the so-called X theory, employees are unwilling to work and accept accountability for the task performance, they do not want to solve problems alone, they prefer to be guided and instructed on what to do. Such workers usually need to be forced to work or encouraged to do their task in some specific

way. This theory supported the traditional approach to HR management where human activities were stimulated by the willingness to avoid punishment. In that case, the manager takes the role of a dictator or a tyrant abusing their workers and manipulating them. In this approach, there is no room for employee development. Motivating employees is reduced to satisfying their physiological needs and ensuring safety. It usually takes the form of a threat to deprive of the ability to satisfy those needs.

The second view, termed Y theory, was created in opposition to the X theory. The supporters of the former believed that people are more creative, active, and interested in their work when they are not subject to an authoritarian regime. Work becomes an indispensable development component for them. According to the Y theory, employees set ambitious goals and want to satisfy their higher needs. Managers put lesser stress on supervising their employees, empower them more, and strive to ensure the opportunity to use their development potential to them. On the other hand, they have high expectations with respect to them. The assumptions of the X theory are similar to the ones of parents to their unruly children. The reference works suggest that the X theory is rather ineffective and obsolete. The Y theory, however, is more effective in the educated society though it needs to be employed consciously by the contemporary industry managers. Nonetheless, it is sometimes heard that practice and awareness (theory) are two banks of the same river (Kozłowski, 2009).

The X and Y theory provides grounds for identifying different relationships which may take place between the worker and their manager. Those relations may entail the means of coercion or of encouragement (Borkowska, 1985). The means of coercion are based on fear and punishment, entailing subordination of employee behavior to the manager's interests and will. They take the form of an order, command, direction, recommendation or prohibition. They are successful in emergency where prompt action is required. They constitute an administrative foundation of the organization operations, but their effects give rise to employee dissatisfaction as they are not adapted to the reality, unjust or are perceived as a way to take autonomy from workers. For this reason the means of coercion are devoid of a positive motivating load and their excessive share in the incentive system may disintegrate the motivation process.

On the other hand, the means of encouragement are most frequently used and offer a certain margin of freedom to the worker, enabling to decide whether to accept rewards and related behaviors. Thanks to using tangible and intangible rewards and a symptomatic system of punishing for specific behavior, they stimulate employee's interest in their work and encourage their activity. The means of encouragement have the highest impact on employee behavior due to the measurable sense of their effort efficiency. However, they are the area of the incentive system which is most difficult to shape (Kozłowski, 2009).

Between the means of coercion and means of encouragement, there is also persuasion, a tool enabling to affect the employee's mentality to change attitudes, habits or feelings. Persuasion does not include prohibition, but assumes partnership of the motivating and the motivated person, is rational or emotional. It usually complements other motivating tools and

often takes the form of persuading, propaganda, negotiation, understanding, counseling or suggestion. The role of persuasion increases together with the increase in employee qualifications and educational background. The role of persuasion based on convincing, counseling, and informing increases together with the increase in employee qualifications and awareness, with the increase in the needs to participate in the decision-making process and having independent power (Kozioł, 2002).

Certain standard motivating factors can be distinguished in the relationships between the manager and the employee. Those are usually intangible incentives, including:

- employer's trust,
- freedom of action, independence, autonomy and delegation of rights,
- appreciation of managers, celebrating employees' achievements.

Other incentive classifications divide the incentives into positive and negative. Positive incentives bring about positive emotions in the motivated person and encourage them to more effective work, to make an effort because of the anticipated tangible and intangible goods. Negative incentives cause negative emotions in the employee and communicate improper attitude and behavior unwelcome by the employer to the motivated person. They are usually disapproved by them. In this classification the incentive groups are not specified precisely. For example, the base pay or bonus is, as a rule, a positive incentive, but if the motivated person perceives its value as too low, it may cause the sense of humiliation or frustration, or even make them resign from work. Another example is the value of the bonus received by the employee. It may be satisfactory as long as the employee does not learn that another employee on an equivalent position received a higher bonus for similar work. This situation may discourage the motivated person in the future from effective work even though the bonus is a positive incentive. This means that it can be difficult to say whether a given incentive is positive or negative, as one incentive can be deemed positive in some circumstances and negative in other. At present, it is popularly believed that it is necessary to use positive incentives, considering the negative ones to be the last resort. However, when it is necessary to employ a negative incentive, it is advisable to follow the principles presented below and proven in practice:

- the punishment should be just and adapted to the punished act. It should be more lenient rather than excessively harsh,
- no punishment should be administered before the wrongdoer is allowed to speak for them,
- do not punish under the influence of emotions, hastily, but it is also not permissible to delay punishment for too long,
- punishment gradation,
- avoid humiliating punishment in public.

At present, there is no social acceptance of severe treatment of employees; punishment often becomes a relic of the past in organizations. Companies which use excessive punishment shape passive and anxious peoples who want primarily to ensure safety and avoid errors and are reluctant to make any decisions. The ratio of the positive and negative incentives used is largely conditional on the company sector, its culture, managers' personality and leadership style (Forsyth, 2004).

In the motivation process, it is necessary to remember the important role of interactions between the manager and the people answering to them who behave according to their will provided that the conditions to satisfy their values and expectations are met. To perform the motivating function efficiently, the manager should know the factors exerting impact on the employees answering to them. The supreme efficiency of the motivating process can be obtained solely by means of absolute professionalism of human resource managers. The manager able to identify expectations of their workers, their personal motives and to use this knowledge aptly, will have immense potential for the organization (Kozłowski, 2022).

What is more, it should be stated that for the manager to be able to exert influence on the workers answering to them, they should be familiar with the way in which employee groups operate in the organization and should know the impact of the corporate culture on the behavior of employees and groups. They should possess relevant knowledge of the social structure in the organization. This structure refers to all the interpersonal relationships in the organization and informal ties between its participants. The reference works indicate that employee manager should be able to specify personality traits of the person at a given position. Such ability will allow employing the worker at the position suitable for them and will also contribute to their improved efficiency and satisfaction with the work done remune (Wachowiak, 2002).

3. Surveys — study assumptions

The survey was aimed at studying one of the most important components of the incentive system, namely the relationships between managers and people answering to them. The survey was carried out in a mining company, one of the largest representatives of the mining sector in Poland. The mining sector was selected due to its strategic importance for the economy, subject to a significant influence of the state and characterized by an extended system of payroll incentives governed by the Collective Bargaining Agreement characteristic of the sector. Apart from payroll incentives, there are many different non-payroll ones. However, they are usually employed in informal, customary procedures in companies which is why they cannot be derived in a straightforward fashion from company reports or other internal documents. To learn one of such non-payroll incentives better, namely the relationship between the manager and the person answering to them, it was necessary to carry out a survey. The survey was carried

out in a mining company employing more than 20 thousand workers, including more than 17 thousand underground ones. The analyzed mining company excavates in four mines. All the mines in the company structure follow a uniform motivating policy. The analysis of the relationship between managers and the people answering to them was carried out in a mine in the company structure. The study tool was an anonymous survey addressed to blue- and white-collar (managerial) employees working underground in the selected mine. The survey addressed to blue-collar workers had slightly different questions than the one addressed to the white-collar (managerial) ones. Thanks to it, it was possible to look at the same problems from two different perspectives (of an ordinary worker and a manager), and to compare the perception of the relationship between them.

The analyzed mine employs more than 4 thousand underground workers, the survey was administered to all of them, 350 surveys were returned. In the first part of the survey, the questions requiring one selected answer, as listed below, were asked:

- 1 – I definitely disagree.
- 2 – I rather disagree.
- 3 – I rather agree.
- 4 – I definitely agree.

The study questions included in this part of the survey addressed to blue-collar workers are listed in Table 1, while the ones to the white-collar workers (managers) in Table 2.

Table 1.

Study questions in the first part of the survey addressed to blue-collar mine workers

Please answer by putting X in the relevant box	1	2	3	4
I am fully aware what is expected of me at work.				
My line manager takes care of me and my comfort at work.				
The way in which my work is assessed helps me to do it more efficiently.				
I feel appreciated for the work done at least several times a week.				
The manager is able to motivate me to work well.				
The manager prevents any conflicts at work efficiently.				
I receive fair treatment at work.				
The manager specifies the tasks to do precisely.				
The manager motivates every employee equally.				
My manager is a competent person.				
The tasks requested by the manager are feasible.				
The manager is an authority for me.				
I have complete information on what happens in the company.				
I know the manager's requirements relating to me.				
I discuss not only business, but also my private life with the manager.				
My manager knows how to motivate me to work.				

Source: own work.

Table 2.

Study questions in the first part of the survey addressed to white-collar (managerial) mine workers

Please answer by putting X in the relevant box	1	2	3	4
The people answering to me are aware what I expect of them at work.				
I recognize my workers' needs.				
I take care of those answering to me and the comfort of their work.				
I believe that I am an authority for those answering to me.				
Every day, I enable workers to do what they can do best.				
I recognize workers for their work every day.				
Employees often express their opinion and show initiative.				
I know how to motivate to work well.				
I prevent any conflicts at work efficiently.				
I treat workers justly.				
I specify the tasks to do precisely.				
I request the workers to do feasible tasks.				
The workers always notify me of any work-related issues.				
The workers have conditions to improve their qualifications.				
I more often use reward than punishment when motivating the worker.				
I discuss not only business, but also my private life with the workers.				

Source: own work.

The second part of the survey contains questions and suggested answers; one of them was to be selected. The questions addressed to blue-collar workers are listed in Table 3, while the ones to the white-collar workers in Table 4.

Table 3.

Single-choice questions in the second part of the survey for blue-collar mine workers

Question	If the manager criticizes me, they do it:	I receive the manager's criticism:
Responses	<input type="checkbox"/> In the presence of all employees <input type="checkbox"/> During a face-to-face dialog <input type="checkbox"/> I am not criticized at all	<input type="checkbox"/> Always positively <input type="checkbox"/> Usually positively <input type="checkbox"/> Indifferently <input type="checkbox"/> Usually negatively <input type="checkbox"/> Always negatively

Source: own work.

Table 4.

Single-choice questions in the second part of the survey for white-collar mine workers

Question	How do you express your criticism of your employee relating to their misconduct?	How do employees receive the criticism:
Responses	<input type="checkbox"/> In the presence of all employees <input type="checkbox"/> During a face-to-face dialog <input type="checkbox"/> I do not criticize workers at all	<input type="checkbox"/> Always positively <input type="checkbox"/> Usually positively <input type="checkbox"/> Indifferently <input type="checkbox"/> Usually negatively <input type="checkbox"/> Always negatively

Source: own work.

The third part of the survey is closed questions which had to be answered as follows:

- 1 – Never.
- 2 – Seldom (once every few months).
- 3 – Sometimes (several times a month).
- 4 – Often (several times a week).
- 5 – Always (everyday).

The questions are presented in Table 5 (for blue-collar workers) and in Table 6 (for managers) respectively.

Table 5.

Closed questions in the third part of the survey for the blue-collar mine workers

Please answer by putting X in the relevant box	1	2	3	4	5
How often am I praised for well-done work?					
How often does the manager favor one person or two people from the group?					
The manager provides the reasons for their decision and gives factual arguments if they have a different opinion					
The manager thanks for well-done work personally					
My work is stressful					
The manager changes the requested task when the work is being performed					
The manager treats myself/my team with due respect					

Source: own work.

Table 6.

Closed questions in the third part of the survey for the white-collar (managerial) mine workers

Please answer by putting X in the relevant box	1	2	3	4	5
How often do I praise workers for well-done work?					
I sometimes favor one member of workers' group.					
I provide the reason for my decision and present factual arguments if I have a different opinion.					
I thank for well-done work personally.					
I sometimes change the task requested from the worker during the work performance.					
I treat those answering to me with due respect.					

Source: own work.

4. Findings

The survey enabled to identify the immediate relationships between the manager and the person answering to them in the analyzed company. This is an important factor in the motivating process. The direct relationships are connected inseparably with communication between the manager and the person answering to them and the conflict resolution skill. Internal communication improves employee motivation and their satisfaction with their work, their commitment and energy put to work. Good communication means that the company appreciates workers not only for their roles, but also for their personality, resourcefulness, and initiative.

The questions in the first part of the survey are divided into three groups concerning:

- the quality of the direct relationships between the manager and the person answering to them,
- the communication in the organization,
- conflict resolution.

The first group of incentive includes direct relationships of managers with those answering to them. The distribution of responses for this group of questions is presented in Figure 3.

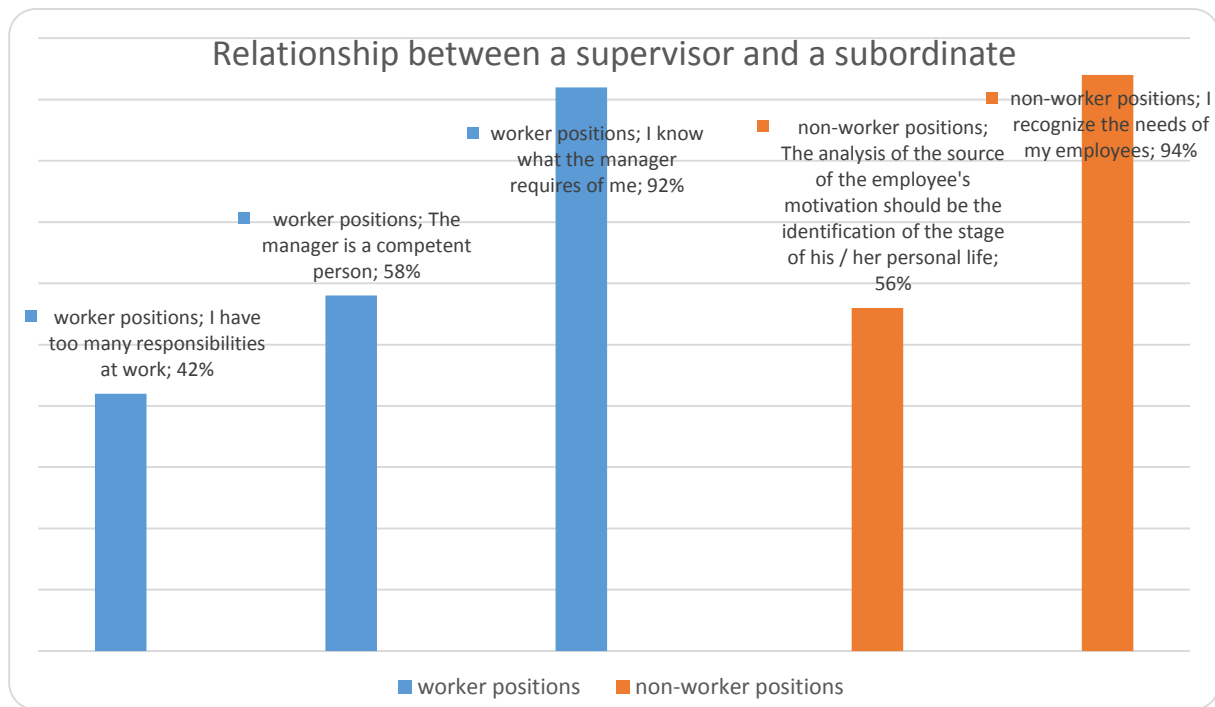


Figure 3. Perception of selected incentives relating to the direct relationship with managers.

Source: own work.

Fewer than one half of workers claim that they have too many duties at work. 58% of responding blue-collar workers believe that the manager is competent and almost everyone knows what is expected of them. Most responding white-collar workers claim that they recognize employees' needs but only 56% of people in this group are aware that the employee's motivation sources should be identified with their personal life stage.

The assessment of the relationship between the manager and the person answering to them is disadvantageous in the areas depicted in Figure 2. In those areas the managers and those answering of them have differing opinions and the differences are significant.

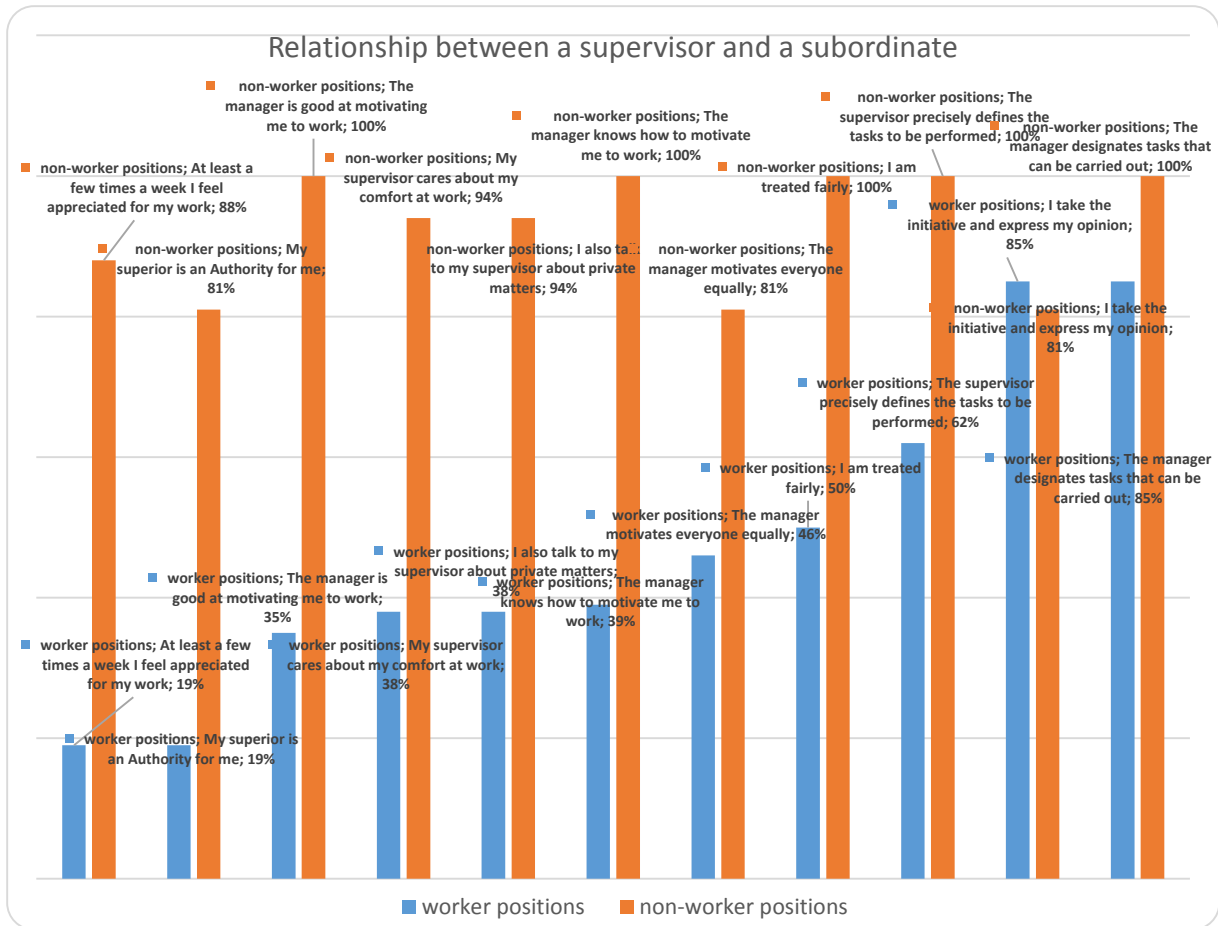


Figure 4. Perception of selected incentives relating to the relationship of a manager and a person answering to them.

Source: own work.

The managers and the persons answering to them have highly discrepant opinions relating to the relationship assessment. Most workers feel unappreciated for their work, while close to 90% of managers claim that they appreciate their workers every day. Just 19% of responding blue-collar workers believe that their manager is an authority, while as much as 81% of managers claim they are an authority for those answering to them. The majority of blue-collar workers indicate that their manager does not know how to motivate them to work, that they do not take care of employees’ comfort at work and do not discuss any personal issues with them. On the other hand, all or close to all responding managers agree with most statements. The opinions are concordant with respect to the statement that the workers show initiative and express their opinion and that the managers request them to do feasible tasks.

Another incentive detailed in the survey questions is the communication in the organization. Responses to those questions are depicted in Figure 5.

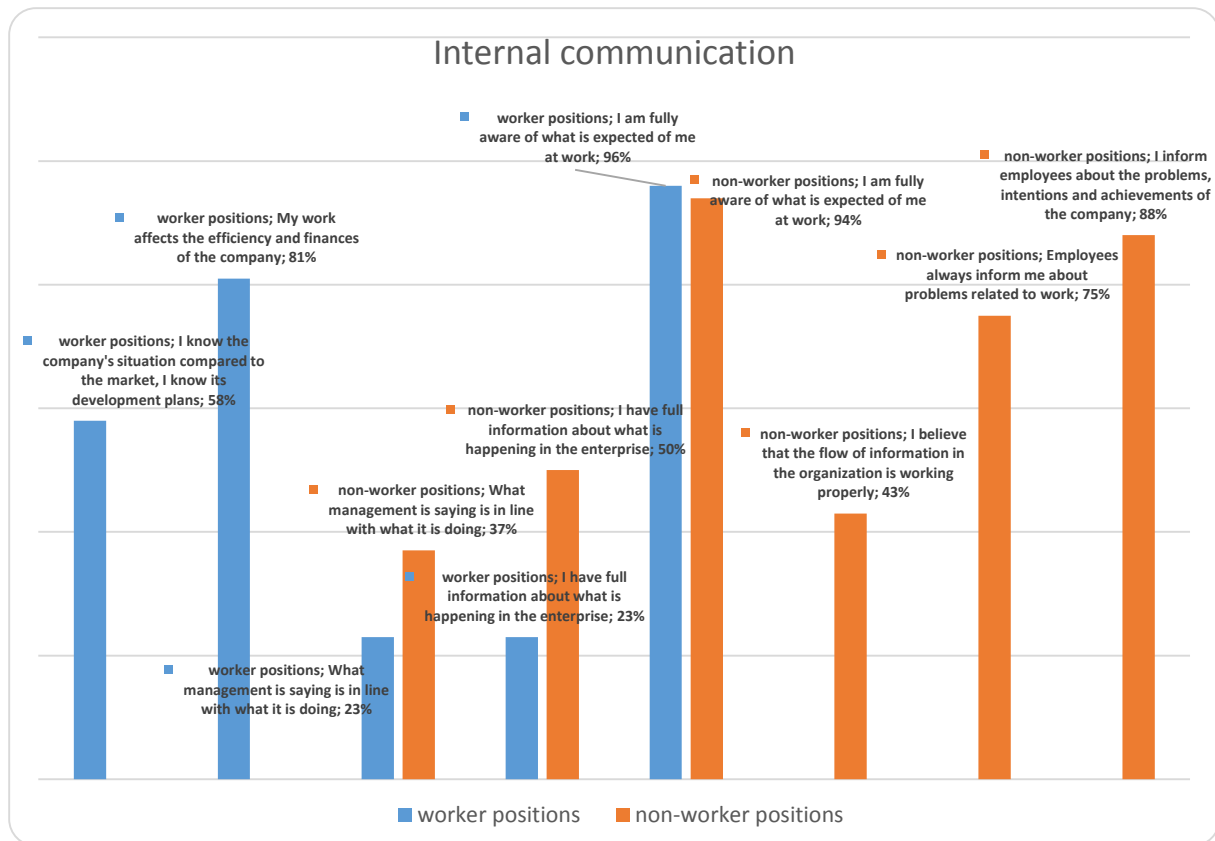


Figure 5. Perception of selected incentives relating to the communication in the organization.

Source: own work.

Most surveyed blue-collar workers (81%) are aware that their work contributes to the company efficiency and finance, while 58% of employees in this group know the market situation of the company. It is different when it comes to the knowledge of what takes place in the company and to the Management Board credibility. The survey results prove that the communication between the worker and their line manager is good, which is most conspicuous in the question concerning the awareness of expectations towards those answering to them and also feedback from employees relating to the work-related issues.

This part of the survey ends with the conflicts at work and other issues. They are presented in Figure 6.



Figure 6. Perception of selected incentives relating to the communication in the organization.

Source: own work.

38% of employees believe that their manager prevents any conflicts at work efficiently, while as much as 94% of managers claim they do it efficiently. The vast majority of responding managers claim that their work is stressful and only 35% of them have access to training relating to dealing with such conditions.

It is good news that most managers motivate using reward rather than punishment and that they strive to improve their motivating skills. However, it is worrying that only 19% of managers claim that they have a wide choice of tools allowing to motivate the people answering to them efficiently.

In the second part of the survey blue-collar workers were asked about the way in which they are criticized by managers. 42% of respondents claim that the manager does it in the presence of all workers, 27% that they do it during a face-to-face dialog, the others said that they are not criticized. A half of the surveyed workers accepts the criticism indifferently, a bit more than 30% of respondents accepts it always positively or rather positively, and just a low percentage of workers negatively.

Managers responded to the same questions as the blue-collar workers in this part. 57% of respondents claimed that they criticize workers during a face-to-face dialog, the remaining declared that they did it in public. This opinion differs from the one of the first group. 57% of managers state that those answering to them accept the criticism positively, only one person believes that they are indifferent to criticism, while the others declare that they respond negatively to criticism.

The fourth part of the survey contains questions asked both to blue-collar workers and to managers. The responses are presented in Table 7.

Table 7.

Responses to closed questions in the fourth part of the survey for the blue-collar and managerial mine workers

Responses selected most often (%)		
Blue-collar workers	Questions	White-collar workers
Rarely 46%, sometimes 39%	How often am I praised/do I praise for well-done work?	Often 60%, sometimes 30%
Often 50%, sometimes 23%	How often does the manager favor one person or two people from the group?	Rarely 65%, sometimes 30%
Rarely 42%, sometimes 35%	The manager provides the reasons for their decision and gives factual arguments if they have a different opinion	Often 50%
Rarely 46%, never 25%	The manager thanks for well-done work personally	Often 69%
Rarely 35%, sometimes 35%, never 30%	The manager rewards, appreciates, promotes the best workers	Often 75%
Often 46 %, sometimes 42 %	The manager changes/I change the requested task when the work is being performed	Rarely 44%, sometimes 44%
Sometimes 35%, often 30%, rarely 30%	The manager treats myself/my team with due respect	Always 57%, often 43%

Source: own work.

The employee groups selected opposite responses to the questions. Blue-collar workers believe that they are rarely praised for work done, while the managers claim that they often praise those answering to them. The managers claim that they do not favor individual workers, while those answering to them believe that favoritism takes place frequently. Ca. 70% of managers declared that they thank for well-done work personally, reward, and promote the best workers. Blue-collar workers have an opposite opinion and stated that their managers do it rarely, and sometimes even do not do it at all. As indicated in the table, the different perceptions of certain aspects by two employee groups may prove the existence of problems in their relationships.

5. Summary

The findings of a survey in a mine belonging to the selected mining company enabled to outline relationships between managers and the people answering to them as a basic component of the employed incentive policy.

Today, workers demand respect, mutual trust, and cooperation. Ordering is no longer as effective as it used to be and partnership is important. According to blue-collar workers, the manager rarely recognizes them for their work, rarely takes care of their comfort at work, usually discusses solely business with those answering to them and does not know how to

motivate to work. The positive thing is that the managers know how to set achievable objectives and specify the tasks to do precisely. Blue-collar workers often express their opinions and show initiative which is confirmed by the findings for managers. The responding managers should be in touch with those answering to them, talk to them, get to know them as individuals and not solely performers of specific roles as this will allow them to learn their workers' needs better. To maintain mutual trust, the manager should not only encourage others to look for solutions, but also restrain imposing their own decisions and treat those answering to them fairly. The vast majority of managers are competent professionals. However, they should take care of their image to become an authority for blue-collar workers.

The organization's strength is communication, including but not limited to the two-way communication between the worker and their manager. Blue-collar workers know what is expected of them at work and inform their managers of problems. Most workers know the company situation on the market and its development plans. This is thanks to the fact that the company uses numerous methods to inform workers of anything important in the company which include:

- a company website with a dedicated employee zone,
- informative monthlies,
- LED displays before entry to the workplace.

However, the information provided by those media is general and refer to the whole company. The flow of information in the specific work establishment is not developed so well and it often takes the form of informal information, the so-called "whisper propaganda" and the news is sometimes inaccurate or distorted. Good communication entails providing accurate information and mutual trust. Information is accurate when it is up-to-date, precise, sufficient, available, and relevant. Mutual trust facilitates information flow without selecting and distorting it.

Another important aspect covered by the survey is conflicts. The company managers must prevent conflicts, find and remove their sources, know how to behave when any conflict emerges and, first and foremost, refrain from generating them. The managers often cause conflicts, not knowing how to respond correctly to critical social situations. The following managers' traits promote conflict emergence:

- authoritative inclinations,
- dogmatism,
- lack of empathy,
- low tolerance of stress.

As much as 96% of responding managers believe that they prevent any conflicts at work efficiently, but this opinion is shared by just 38% of workers. Moreover, if the managers apply an autocratic management style and believe that they are better than others, they will tend to consider their needs, goals and preferences more important than those of people answering to

them. The conflict resolution should consider both current and future interests of all the parties. The manager should strive to reach an agreement, stressing that they do not want to use force but rather harmonious cooperation. They should not blame any party for the conflict.

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THE IMPACT OF THE COVID-19 PANDEMIC ON THE FINANCIAL CONDITION OF LARGE ENTERPRISES IN POLAND

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Purpose: The aim of the research is to assess the financial condition of large enterprises in Polish voivodeships, taking into account the division into the private sector and the public sector in the years 2007-2021, and to try to classify the analyzed voivodeships into separate classes according to the level of the studied phenomenon.

Design/methodology/approach: To achieve the goal, the TOPSIS method was used, which allows for the assessment of the examined objects and their comparison in terms of the analyzed phenomenon.

Findings: The conducted analysis made it possible to rank and group voivodeships in terms of the financial condition of large enterprises, both for the public and private sectors. When researching the impact of the Covid-19 pandemic on the financial condition of large non-financial enterprises, it can be noticed that enterprises started to reduce the costs of their economic activities, the total number of enterprises decreased, but the percentage of enterprises reporting a net profit on their economic activity increased. Despite the difficult condition caused by the pandemic, companies were able to pay off their obligations.

Research limitations/implications: The financial condition of enterprises, estimated with the TOPSIS synthetic measure, is a variable which is not directly measurable. Its value is generated by observations of diagnostic variables that are directly measurable. The choice of diagnostic variables is a subjective choice of the researcher and should be carried out reliably, preceded by studies of the relevant literature.

Practical implications: It shows changes and highlights the differences between the financial condition of enterprises in different voivodeships. Indicates objects that behave similarly.

Social implications: (if applicable) What will be the impact on society of this research? How will it influence public attitudes? How will it influence (corporate) social responsibility or environmental issues? How could it inform public or industry policy? How might it affect quality of life? Not all papers will have social implications.

Originality/value: Showing that the use of the TOPSIS method to analyze the financial condition of public and private sector enterprises in Poland is possible and allows for the classification of voivodeships in terms of the studied phenomenon. The article, the use of the method is useful for traders and investors.

Keywords: TOPSIS measure, linear ordering, financial condition of enterprises.

Category of the paper: research paper.

1. Introduction

The financial condition of the enterprise is an important determinant of the changes taking place in it. The conducted research shows that there is a strong positive correlation between the financial indicators and the investment decisions made (Kolegowicz, Krzemiński, 2019). Preparation of a reliable opinion on the state of the enterprise, reflecting the actual state of the enterprise, requires conducting appropriate studies, which may not be limited only to the financial statements (Hamrol, 2013). The assessment of the company's financial condition should be carried out in time and space, and therefore should take into account the internal and external conditions of the assessed enterprise. Internal factors include the selection of appropriate tools (e.g. financial analysis) enabling the analysis of changes taking place in the enterprise and drawing correct conclusions. External factors include the principles of the company's operation against the background of its environment, assessment of the strengths and weaknesses of the enterprise related to the resources held, as well as opportunities and threats in its environment (Gackowska-Cieściów). The subject of the analysis should also be relations at the level of the industry in which the company operates and the phenomena occurring in its closer and more distant environment (Hamrol, 2013). The structure of the company's capital is strongly influenced by both the environment and the factors generated by the sector in which it operates (Szymańska, Jegers, 2014).

The environment of the enterprise, both internal and external, is undoubtedly one of the main determinants of its operation and development. The environment of the enterprise includes not only other entities related to its functioning, but also phenomena and processes that are outside them and which are not influenced by (Kraska, 2022). One of such unpredictable phenomena called "black swan" (Szczepański, 2020) was the outbreak of the Covid-19 pandemic. Its consequences and impact on the economy had a huge impact on many areas of life, both social and economic. The introduced restrictions resulting from the lockdown limited the running, and even in many cases also closing, of economic activities.

The aim of the research is to assess and influence the Covid19 pandemic on the financial condition of large non-financial enterprises in Polish voivodeships, taking into account the division into the private and public sectors in 2007-2021. The TOPSIS measure was used to group voivodeships in terms of the financial condition of enterprises. The research used statistical data from the Local Data Bank of the Central Statistical Office in selected years.

2. TOPSIS measure

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is a linear ordering method in which two reference points of objects in a multidimensional space are determined - a pattern and an anti-pattern. The basis of linear ordering is a synthetic variable (also known as an aggregate variable, a synthetic measure, a synthetic measure of development, a taxonomic measure of development, an aggregate measure of development), the values of which are estimated on the basis of observations of diagnostic variables describing the examined objects. Estimated values of a synthetic variable allow for the ordering of objects in terms of the studied phenomenon.

The construction of the TOPSIS synthetic measure follows the following steps (Hwang, Yoon, 1981; Bał, 2016):

- normalization of variables according to the formula:

$$z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^n x_{ij}^2}} \quad (1)$$

where x_{ij} – observation of the j -th variable for the object i ,

- estimating the coordinates of the positive ideal:

$$z_{0j}^+ = \begin{cases} \max_i \{z_{ij}\} & \text{for stimulants} \\ \min_i \{z_{ij}\} & \text{for destimulants} \end{cases} \quad (2)$$

- estimating the coordinates of the negative ideal:

$$z_{0j}^- = \begin{cases} \min_i \{z_{ij}\} & \text{for stimulants} \\ \max_i \{z_{ij}\} & \text{for destimulants} \end{cases} \quad (3)$$

- calculating the distance of objects from the positive ideal:

$$d_{i0}^+ = \sqrt{\sum_{j=1}^m (z_{ij} - z_{0j}^+)^2} \quad (4)$$

- calculating the distance of objects from the negative ideal:

$$d_{i0}^- = \sqrt{\sum_{j=1}^m (z_{ij} - z_{0j}^-)^2} \quad (5)$$

- value of an aggregate variable according to the formula:

$$q_i = \frac{d_{i0}^-}{d_{i0}^- + d_{i0}^+} \quad (6)$$

The estimated variable takes values from the interval $q_i \in [0,1]$, where the best object is the one with the highest value of q_i , and the worst one with the lowest value of q_i .

3. Financial condition of large enterprises in Poland in the years 2007-2021

Figure 1-2 shows the average financial results of Polish non-financial enterprises, including net profit and net loss in 2007-2021 for the private and public sectors.

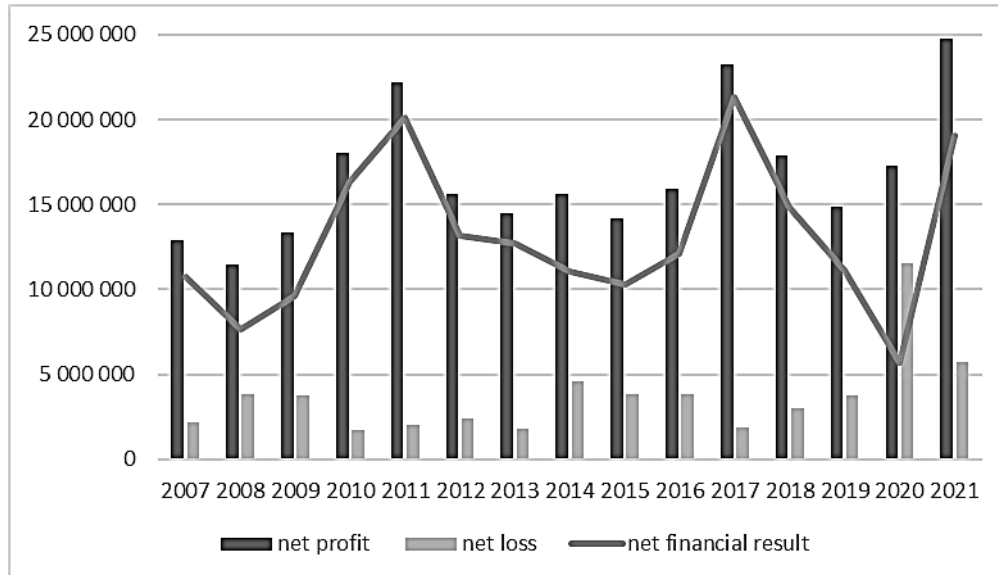


Figure 1. Net financial result, net profit and net loss of public sector non-financial enterprises in Poland in 2007-2021.

Based on the data in Figure 1, it can be noted that the highest values of the net financial result, and also the net profit for public sector enterprises, were recorded in 2011, 2017 and 2021. and the lowest net loss in 2011. The lowest financial result is observed in 2020, i.e. in the year the WHO announced the Covid-19 pandemic. The impact of the pandemic is also visible when analyzing the net loss value, which in 2020 is several times higher than in previous years, which results in a much lower financial result.

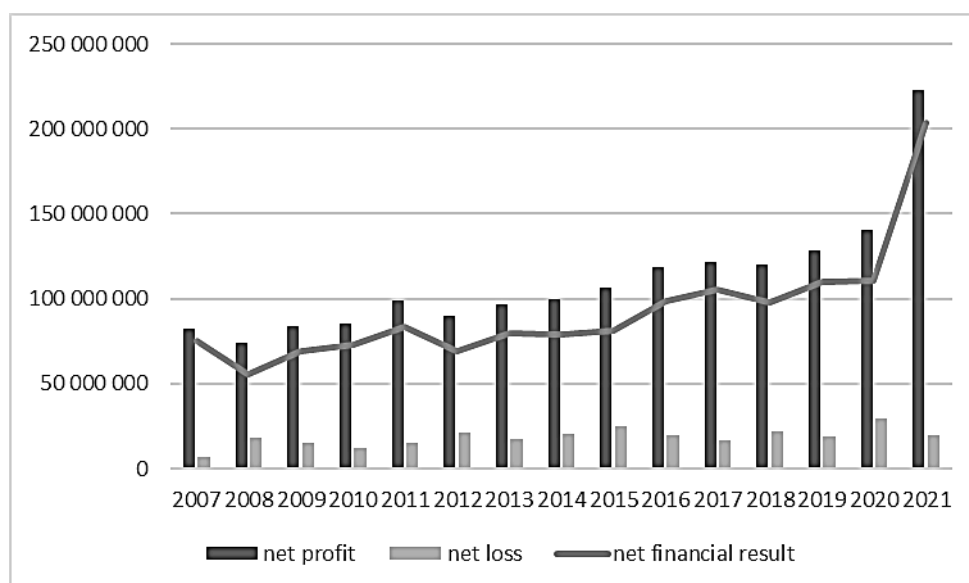


Figure 2. Net financial result, net profit and net loss of private sector non-financial enterprises in Poland in 2007-2021.

When analyzing private sector enterprises (Fig. 2), it can be observed that they are characterized by higher values of the analyzed indicators than public sector enterprises. In the case of private sector enterprises, the net profit as well as the financial result are systematically growing, and they reach the highest values in 2021. During the pandemic (2020-2021), the ratio of net loss to net profit in the analyzed years is much lower than in the public sector, similarly in 2007-2009, 2014-2017 and 2019.

4. Empirical analysis

The subject of the study were Polish voivodeships in the years 2007-2021. In order to organize the voivodeships according to the financial condition of large enterprises, the TOPSIS measure was used. Over 17,000 enterprises from both the public and private sectors, regardless of their subject of economic activity, were taken into account in the study. The data used in the analysis concerned the financial condition of large enterprises that employ more than 49 people and are required to submit financial reports. The considered indicators describe the financial condition of enterprises in voivodeships in a multilateral manner. The financial indicators used come from the Local Data Bank of the Central Statistical Office (GUS) and cover the years 2007-2021. In the selected years, the number of enterprises in the GUS data changed, but not more than 3%.

Tables 1-7 characterize the dynamics of the studied variables using single-base indexes for each voivodeship in 2019 compared to 2007 and in 2020 and 2021 compared to 2019. The largest and smallest values of the estimated indexes are marked in bold.

When analyzing the data in Table 1, it can be seen that in the public sector, the net profit of enterprises increased in 2019 compared to 2007 only in 5 voivodeships. The highest increase was recorded for the Świętokrzyskie Voivodeship, then Małopolskie Voivodeship. However, the largest decrease was in the Opolskie Voivodeship. During the Covid19 pandemic in 2020, there was a decrease in the net profit of enterprises in 8 voivodeships compared to 2019, while in 2021 only in two: in Lubuskie and Świętokrzyskie. The largest increase was recorded in 2021 in Podlaskie Voivodeship compared to 2019. In the private sector, the net profit of enterprises in 2019 compared to 2007 increased in almost all voivodeships, with the exception of Świętokrzyskie. The highest increase in the indicator was recorded for the Lubelskie Voivodeship. During the Covid19 pandemic in 2020, there was an increase in the net profit of private sector enterprises in all provinces compared to 2019. The highest increase was recorded in the Dolnośląskie Voivodeship, and the smallest in the Lubuskie Voivodeship. In 2021, compared to 2019, a significant drop in the net profit of enterprises in Mazowieckie voivodship has already been noted, as well as in Wielkopolskie, Śląskie and Podkarpackie voivodships. The highest increase of over 25 times was recorded for the Zachodniopomorskie Voivodeship.

Table 1.
Net profit index of public and private sector enterprises

	Public sector			Private sector		
	2019/2007	2020/2019	2021/2019	2019/1007	2020/2019	2021/2019
Dolnośląskie	0,43	0,75	1,68	1,52	1,84	1,84
Kujawsko-Pomorskie	0,65	1,71	2,57	2,28	1,55	1,55
Lubelskie	0,25	0,71	1,33	3,22	1,35	1,35
Lubuskie	1,64	0,62	0,67	2,45	1,21	1,21
Łódzkie	0,21	1,27	1,29	2,12	1,47	1,47
Małopolskie	2,23	0,92	1,49	2,40	1,53	1,53
Mazowieckie	1,63	1,57	1,62	1,66	1,70	0,08
Opolskie	0,03	1,07	1,23	1,58	1,63	3,14
Podkarpackie	0,55	1,45	1,95	2,56	1,28	0,55
Podlaskie	0,72	1,94	4,22	2,38	1,31	6,14
Pomorskie	1,69	0,51	2,18	2,00	1,65	2,99
Śląskie	0,84	0,39	2,61	1,40	1,97	0,24
Świętokrzyskie	5,46	0,71	0,88	0,94	1,26	1,28
Warmińsko-Mazurskie	0,82	2,31	2,34	2,21	1,54	14,25
Wielkopolskie	1,29	0,56	1,09	2,76	1,32	0,20
Zachodniopomorskie	0,73	1,19	1,08	2,32	1,49	25,78

Table 2 presents net loss indices of public and private sector enterprises. In the public sector, the highest increase in net loss for enterprises in 2019 compared to 2007 was recorded in the Warmińsko-Mazurskie voivodship. And the biggest decrease for the Pomorskie voivodship. In 2020, for most voivodships, there was a decrease in the value of net loss of enterprises or a slowdown in its growth. The exception is the enterprises of the Podkarpackie Voivodeship, for which the net loss in 2021 compared to 2019 increased more than 13 times. In the private sector, in 2019, compared to 2007, the net loss of enterprises increased for all voivodships. The highest increase in the indicator was recorded for the Pomorskie Voivodeship, and the smallest increase for the Warmińsko-Mazurskie Voivodeship. During the Covid-19 pandemic, there was a decrease in the net loss of private sector enterprises for 5 voivodeships in 2020 compared to 2019, while in 2021 for 9 voivodeships.

Table 2.
Index of net loss of public and private sector enterprises

	Public sector			Private sector		
	2019/2007	2020/2019	2021/2019	2019/1007	2020/2019	2021/2019
Dolnośląskie	4,11	1,62	1,40	3,80	2,00	1,14
Kujawsko-Pomorskie	1,30	0,72	1,00	4,11	0,45	0,42
Lubelskie	1,21	0,93	1,26	1,41	0,63	0,80
Lubuskie	1,91	0,42	0,45	1,25	1,33	1,13
Łódzkie	2,58	0,91	0,84	3,18	1,04	0,40
Małopolskie	0,77	2,93	1,58	5,28	1,29	0,52
Mazowieckie	1,17	3,98	2,43	1,76	2,02	1,13
Opolskie	1,13	0,97	2,16	4,57	1,44	1,21
Podkarpackie	0,40	1,40	13,46	3,96	0,87	0,80
Podlaskie	0,96	1,80	0,86	1,60	0,70	0,41
Pomorskie	0,26	11,69	0,41	5,35	1,06	1,06
Śląskie	7,30	2,53	1,21	3,77	2,06	0,94
Świętokrzyskie	2,62	1,33	0,74	4,05	1,09	0,52
Warmińsko-Mazurskie	15,36	2,56	1,00	1,03	1,36	0,86
Wielkopolskie	5,83	6,96	1,61	2,42	1,66	2,84
Zachodniopomorskie	0,53	0,83	0,83	1,42	0,71	1,55

In Poland, in the analyzed period, the percentage of enterprises reporting a net profit in the public sector systematically decreased from 74.5% in 2007 to 66.2% in 2019. In the private sector, the percentage of enterprises reporting a net profit in the analyzed period was very diversified and ranged from (77.3%; 83.5%), in 2007 it was 83.5% and in 2019 83.1%. During the pandemic in 2020, only 65% of public sector enterprises reported net profit and 81.7% of private sector enterprises. In 2021, the percentage of enterprises reporting a net profit increased to 68.6% in the public sector and 85.7% in the private sector. When analyzing the financial condition of enterprises in individual voivodeships (Table 3), it can be seen that in the public sector the percentage of enterprises reporting a net profit decreased in 2019 compared to 2007 for almost all voivodeships. For the remaining 3 voivodeships (Podkarpackie, Małopolskie, Lubuskie), this percentage slightly increased. On the other hand, in the private sector, the indices showing changes in the share of the number of enterprises reporting net profit in the total number of enterprises in 2019 compared to 2007 oscillate around 1. During the Covid-19 pandemic, the percentage of public sector enterprises reporting profit increased in 8 voivodeships. In 2020 and 2021, the highest increase was recorded in the Lubelskie Voivodeship. On the other hand, the largest decrease in the indicator was recorded in Małopolskie in 2020, and in 2021 in Opolskie. In the private sector, the outbreak of the pandemic in 2020 resulted in a decrease in the number of enterprises reporting a net profit in most provinces, and in 2021 an increase in this number for almost all provinces. The exception is Podkarpackie and Świętokrzyskie.

Table 3.

Index share of enterprises with net profit in the total number of enterprises

	Public sector			Private sector		
	2019/2007	2020/2019	2021/2019	2019/2007	2020/2019	2021/2019
Dolnośląskie	0,80	1,01	1,15	1,01	0,98	1,02
Kujawsko-Pomorskie	0,91	0,99	1,12	0,98	1,01	1,06
Lubelskie	0,79	1,19	1,32	1,00	1,01	1,03
Lubuskie	1,00	1,03	1,03	1,08	0,98	1,01
Łódzkie	0,80	1,13	1,03	0,97	1,00	1,06
Małopolskie	1,06	0,82	0,93	1,00	0,97	1,04
Mazowieckie	0,97	0,88	0,95	0,98	0,96	1,03
Opolskie	0,78	0,85	0,87	0,97	0,97	1,03
Podkarpackie	1,01	1,07	0,96	1,02	0,99	0,99
Podlaskie	0,98	1,17	1,04	1,01	0,99	1,04
Pomorskie	0,91	1,06	1,08	1,01	0,99	1,01
Śląskie	0,89	0,99	1,00	0,98	0,98	1,04
Świętokrzyskie	0,88	0,90	1,11	1,01	0,95	0,99
Warmińsko-Mazurskie	0,69	1,02	1,09	1,04	0,99	1,01
Wielkopolskie	0,86	0,97	1,07	1,00	1,01	1,05
Zachodniopomorskie	0,80	1,03	1,10	1,03	0,97	1,01

The cost level indicator for public sector enterprises in the analyzed years assumes values in the range [78.5; 116.2], while in 2019, compared to 2007, slight increases in the indicator can be noticed (Table 4) for most voivodeships. For private sector enterprises the values of the index are less diversified and belong to the range [87.9; 99.7]. Based on the data in Table 4,

it can be seen that in 2019, for almost all voivodeships, slightly higher values of the enterprise cost level indicator were recorded than in 2007. During the pandemic, this indicator for both public and private sector enterprises slightly decreases compared to 2019.

In Poland, in the analyzed years, the gross sales profitability indexes remained above 4.1 in the private sector and above 2.0 in the public sector, which means that enterprises showed efficiency in their basic business activities. In the public sector, the profitability ratio decreased from 3.0 in 2019 to 2.7 in 2020, and then increased to 4.1 in 2021. In the private sector, during the pandemic, the profitability ratio increased from 4.4 in 2019 to 5.0 in 2020 and 6.0 in 2021. When analyzing the data contained in Table 5 concerning the profitability ratio, it can be noticed that in the analyzed years, public sector enterprises in many voivodeships are unprofitable (indicators below 0). For the voivodships with negative profitability ratios in 2019 and the following years, the sign "-" was entered. The enterprises of Podlaskie voivodeship are characterized by the highest growth, for which the profitability index increased 13.5 times in 2021 compared to 2019. In the private sector in the analyzed years for all voivodships profitability indicators are positive. Comparing the profitability of enterprises in 2007 and 2019, it can be seen that these indicators have decreased for most voivodeships. The exception is Wielkopolskie, Zachodniopomorskie, Kujawsko-Pomorskie and Lubelskie, for which the profitability index of enterprises increased by 61% in 2019 compared to 2007. During the pandemic, the profitability ratio increased for almost all provinces. The exceptions are the Łódzkie, Podkarpackie and Śląskie voivodships in 2010, and in 2021 - Łódzkie. The highest increase in the profitability ratio was recorded for the Świętokrzyskie Voivodeship in 2020 and for the Śląskie Voivodeship in 2021.

Table 4.
Index of enterprise cost indexes

	Public sector			Private sector		
	2019/2007	2020/2019	2021/2019	2019/1007	2020/2019	2021/2019
Dolnośląskie	1,05	1,03	0,97	1,04	1,01	0,98
Kujawsko-Pomorskie	1,02	0,98	0,96	1,00	0,99	0,97
Lubelskie	1,01	1,02	1,02	0,99	0,99	0,98
Lubuskie	1,00	1,01	1,01	1,02	0,98	0,98
Łódzkie	1,06	0,99	0,99	1,02	1,00	0,97
Małopolskie	0,96	1,00	0,96	1,00	0,99	0,97
Mazowieckie	1,01	0,98	0,99	1,02	1,00	0,97
Opolskie	1,14	1,00	1,01	1,03	1,00	0,98
Podkarpackie	1,00	0,98	1,05	1,01	1,00	0,99
Podlaskie	1,00	0,98	0,94	1,01	0,99	0,98
Pomorskie	0,99	1,05	0,95	1,02	0,99	0,97
Śląskie	1,04	1,11	0,97	1,03	1,01	0,98
Świętokrzyskie	0,94	1,03	1,03	1,05	0,98	0,97
Warmińsko-Mazurskie	1,07	1,04	0,98	1,00	0,99	0,97
Wielkopolskie	0,96	1,07	1,01	1,01	1,00	0,99
Zachodniopomorskie	0,97	0,99	0,99	1,00	1,00	0,99

Table 5.
Index of enterprises' gross sales profitability index

	Public sector			Private sector		
	2019/2007	2020/2019	2021/2019	2019/2007	2020/2019	2021/2019
Dolnośląskie	-	-	-	0,51	1,07	1,28
Kujawsko-Pomorskie	0,36	3,08	3,62	1,06	1,16	1,47
Lubelskie	1,10	0,48	0,60	1,61	1,07	1,11
Lubuskie	0,24	-	-	0,64	1,27	1,36
Łódzkie	-	-	-	0,92	0,91	0,77
Małopolskie	1,56	0,85	1,19	0,96	1,16	1,43
Mazowieckie	0,81	2,09	1,06	0,80	1,07	1,22
Opolskie	-	-	-	0,67	1,04	1,29
Podkarpackie	3,30	0,97	0,76	0,73	0,81	1,33
Podlaskie	0,24	-	13,50	0,93	1,18	1,20
Pomorskie	1,52	-	2,08	0,89	1,13	1,38
Śląskie	-	-	-	0,58	0,87	1,61
Świętokrzyskie	3,05	0,95	1,07	0,57	1,30	1,43
Warmińsko-Mazurskie	-	-	-	0,81	1,21	1,55
Wielkopolskie	0,85	0,36	0,82	1,00	1,09	1,15
Zachodniopomorskie	1,77	1,35	0,35	1,09	1,00	1,12

1 and 2 degree financial liquidity ratios were used to assess the financial liquidity of enterprises. The 1st degree financial liquidity ratio is the ratio of short-term investments to short-term liabilities (excluding special funds) (GUS, stst.gov.pl). In the literature, values close to 0.2 are assumed as the optimal value of the 1st degree liquidity ratio. However, in the analyzed period, this condition is not met for public sector enterprises, and the values of the indicator for all voivodeships exceed the set level, which proves the existence of the phenomenon of overliquidity. For private sector enterprises, the liquidity ratios for all voivodeships are much lower than the corresponding values for the public sector. On average, the values hover around 0.3. In the private sector, corporate liquidity ratios tend to increase for almost all voivodships, which is clearly visible during the pandemic, also in the public sector (Table 6).

Table 6.
Index of the financial liquidity ratio of st. 1

	Public sector			Private sector		
	2019/2007	2020/2019	2021/2019	2019/1007	2020/2019	2021/2019
Dolnośląskie	1,46	1,04	1,29	0,81	1,07	0,93
Kujawsko-Pomorskie	2,26	1,00	0,77	1,35	1,28	1,06
Lubelskie	1,12	0,63	0,51	1,09	1,05	1,01
Lubuskie	2,57	0,56	0,56	1,05	1,48	1,07
Łódzkie	0,84	1,33	1,38	1,27	1,00	0,79
Małopolskie	0,73	0,83	1,06	1,50	1,12	1,04
Mazowieckie	1,56	1,51	1,31	1,13	1,06	1,07
Opolskie	0,57	1,05	1,09	1,04	1,30	1,27
Podkarpackie	2,03	1,08	1,01	1,12	1,24	1,00
Podlaskie	1,28	1,01	1,26	1,61	1,38	1,14
Pomorskie	1,18	1,42	1,23	1,02	1,28	1,37
Śląskie	1,61	0,96	0,85	0,88	1,24	1,09
Świętokrzyskie	4,79	1,12	1,47	0,94	1,23	0,85
Warmińsko-Mazurskie	0,69	1,18	1,27	1,32	1,44	1,25
Wielkopolskie	2,32	0,49	0,48	0,98	1,21	1,15
Zachodniopomorskie	3,95	0,76	0,84	1,91	1,45	0,94

Second degree financial liquidity ratio (accelerated liquidity ratio) is the ratio of short-term investments and short-term receivables to short-term liabilities (excluding special funds) (GUS, stst.gov.pl). The optimal value of the indicator is in the range [1 - 1.2]. In the analyzed years, for public sector enterprises, the values of the indicator were in the range (1.08; 1.43), while during the pandemic it was 136.3 in 2020 and 163.1 in 2021. This means that enterprises did not have problems with the repayment of short-term debts. However, the results higher than 1.2 (in 2015-2018, 2020-2021) suggest the phenomenon of excess liquidity, i.e. the use of current assets in an ineffective manner. In the private sector, the 2nd degree financial liquidity ratio, even during a pandemic, fluctuates around 1, which proves that enterprises did not have problems with financial liquidity or timely repayment of current liabilities. Taking into account the administrative division, it can be noticed that for most voivodships the financial liquidity ratios for public sector enterprises tend to increase and lead to overliquidity. The decreasing tendency is shown by enterprises from the Małopolskie, Podkarpackie and Śląskie voivodships. The lowest values of the liquidity ratio in the analyzed period were obtained for the Pomorskie and Śląskie voivodships, which in the case of the Śląskie voivodship (0.7 in 2021) indicates the possibility of a risk of loss of financial liquidity. In the case of private sector enterprises, the liquidity ratios oscillate around 1 for almost all voivodships, with the exception of Warmińsko-Mazurskie in 2011-2014 (table 7)

Table 7.

Index of the financial liquidity ratio of st. 2

	Public sector			Private sector		
	2019/2007	2020/2019	2021/2019	2019/1007	2020/2019	2021/2019
Dolnośląskie	1,32	0,94	1,11	0,84	1,00	0,96
Kujawsko-Pomorskie	1,79	0,97	0,81	1,00	1,14	1,08
Lubelskie	0,76	0,79	0,60	1,13	1,05	0,97
Lubuskie	1,41	0,70	0,67	0,83	1,20	1,02
Łódzkie	0,90	1,18	1,31	0,99	0,96	0,95
Małopolskie	0,68	0,94	1,06	1,13	1,05	1,05
Mazowieckie	1,08	1,40	1,56	1,09	1,00	1,01
Opolskie	0,74	1,00	0,99	0,94	1,13	1,09
Podkarpackie	0,96	1,08	1,10	1,11	1,03	0,93
Podlaskie	0,96	1,05	1,22	1,18	1,11	1,09
Pomorskie	1,25	0,95	0,94	0,89	1,12	1,15
Śląskie	1,01	0,90	0,89	0,88	1,07	1,01
Świętokrzyskie	3,22	1,10	1,56	0,93	1,08	0,92
Warmińsko-Mazurskie	0,57	1,27	1,27	0,92	1,14	1,09
Wielkopolskie	1,40	0,68	0,66	0,88	1,04	1,05
Zachodniopomorskie	2,76	0,69	0,81	1,13	1,21	0,96

In the next stage of the research, a set of diagnostic variables was defined, eliminating the variables that were too strongly correlated with each other. Table 8 presents the set of diagnostic features taken into account in the study, taking into account the division into stimulants (S) and destimulants (D). The selection of the following measures resulted from the analysis of the factors determining the changes taking place. From among the initially considered measures, due to the high degree of correlation with other variables, the following were abandoned: gross turnover profitability index, net turnover profitability index, short-term receivables, short-term investments, short-term liabilities, current assets, inventories.

Table 8.
Diagnostic variables

Symbol	Name	Stymulant/destimulant
X1	Net profit [thou. PLN/company]	S
X2	Net loss [thou. PLN/company]	D
X3	Share of the number of enterprises reporting a net profit in the total number of enterprises [%]	S
X4	Cost level indicator [%]	D
X5	Gross sales profitability indicator [%]	S
X6	1st degree financial liquidity [%]	S
X7	2st degree financial liquidity [%]	S

In order to organize Polish voivodeships according to the level of the studied phenomenon, the TOPSIS measure was used. Tables 9-10 show the values of the above-mentioned measure and the position of voivodeships in the ranking in 2007-2021, broken down into the public sector and the private sector of enterprises. The voivodeships occupying the highest and lowest positions in the ranking in the analyzed period are marked in bold.

Table 9.
Ranking of voivodeships according to the TOPSIS measure values for public sector enterprises in 2007-2021

Public sector	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Dolnośląskie	3	3	3	6	12	12	16	13	15	16	16	10	12	13	9
Kujawsko-Pomorskie	10	14	4	4	3	2	2	3	4	2	2	7	10	4	6
Lubelskie	2	7	6	7	4	4	3	6	3	3	4	8	3	7	7
Lubuskie	8	5	7	11	8	11	5	4	9	12	11	13	9	11	14
Łódzkie	7	4	2	1	1	1	9	9	12	13	14	14	14	12	12
Małopolskie	6	8	8	5	6	8	8	11	6	10	10	4	2	2	3
Mazowieckie	4	10	12	13	16	16	4	1	1	1	1	1	1	1	1
Opolskie	1	1	1	12	9	10	7	5	8	8	7	12	13	10	13
Podkarpackie	12	13	14	15	15	15	14	14	14	14	13	9	8	6	11
Podlaskie	11	12	11	14	14	14	12	8	10	9	8	11	11	9	5
Pomorskie	16	16	9	8	10	5	6	15	5	5	5	2	6	14	2
Śląskie	14	9	15	2	2	6	15	16	16	15	15	15	16	16	16
Świętokrzyskie	13	2	13	10	7	7	13	7	7	7	9	5	5	3	4
Warmińsko-Mazurskie	9	11	10	9	13	13	11	12	13	11	12	16	15	15	15
Wielkopolskie	5	6	5	3	5	3	1	2	2	4	3	3	4	8	8
Zachodniopomorskie	15	15	16	16	11	9	10	10	11	6	6	6	7	5	10

Table 10.
Ranking of voivodeships according to the TOPSIS measure values for private sector enterprises in 2007-2021

Private sector	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Dolnośląskie	2	8	2	1	1	1	4	4	4	3	9	15	15	15	15
Kujawsko-Pomorskie	13	16	14	16	6	12	7	8	9	8	15	6	13	5	3
Lubelskie	12	9	9	5	4	2	5	7	3	6	4	7	3	3	4
Lubuskie	9	11	11	13	14	9	10	9	10	10	11	10	6	7	9
Łódzkie	10	7	15	9	12	4	2	3	16	2	6	3	14	11	5
Małopolskie	6	6	3	2	7	3	8	5	2	5	5	2	9	2	1
Mazowieckie	16	12	4	8	16	6	16	16	5	16	16	11	2	14	2
Opolskie	7	5	5	10	10	13	13	15	13	14	13	9	10	12	10
Podkarpackie	8	10	7	7	8	7	6	11	11	4	3	14	8	9	11
Podlaskie	11	14	13	14	15	14	12	14	14	15	14	13	4	10	7
Pomorskie	5	2	8	3	5	5	3	6	6	7	2	4	12	4	6
Śląskie	1	3	16	15	2	15	14	1	15	12	8	16	16	16	14
Świętokrzyskie	3	1	6	6	3	8	15	12	7	11	7	5	7	6	8
Warmińsko-Mazurskie	15	15	12	11	13	11	9	13	12	13	12	12	11	13	12
Wielkopolskie	4	4	1	4	9	16	1	2	1	1	1	1	1	1	16
Zachodniopomorskie	14	13	10	12	11	10	11	10	8	9	10	8	5	8	13

The above results, obtained as a result of the linear ordering of objects, formed the basis for the classification of voivodeships into homogeneous groups, based on the level of the studied phenomenon. The total range of variability of measures was divided into four class ranges to which individual voivodeships were assigned, according to the following rules (Kuc, 2012; Zeliaś, 2000):

- group I (high level of development of the phenomenon): $m_i > \bar{m} + S_m$,
- group II (the average degree of development of the phenomenon): $\bar{m} + S_m < m_i < \bar{m}$,
- group III (low level of development of the phenomenon): $\bar{m} < m_i < \bar{m} - S_m$,
- group IV (very low level of development of the phenomenon): $m_i < \bar{m} - S_m$,

where:

$$\bar{m} = \frac{1}{n} \sum_{i=1}^n m_i,$$

$$S_m = \sqrt{\frac{1}{n} \sum_{i=1}^n (m_i - \bar{m})^2}.$$

The results of the spatial distribution of the obtained groups in 2007, 2009, 2014, 2019, 2020 and 2021 are presented on the following maps (Fig. 1-2). The darkest colors are the voivodeships belonging to group I, and the lightest ones belonging to group IV.

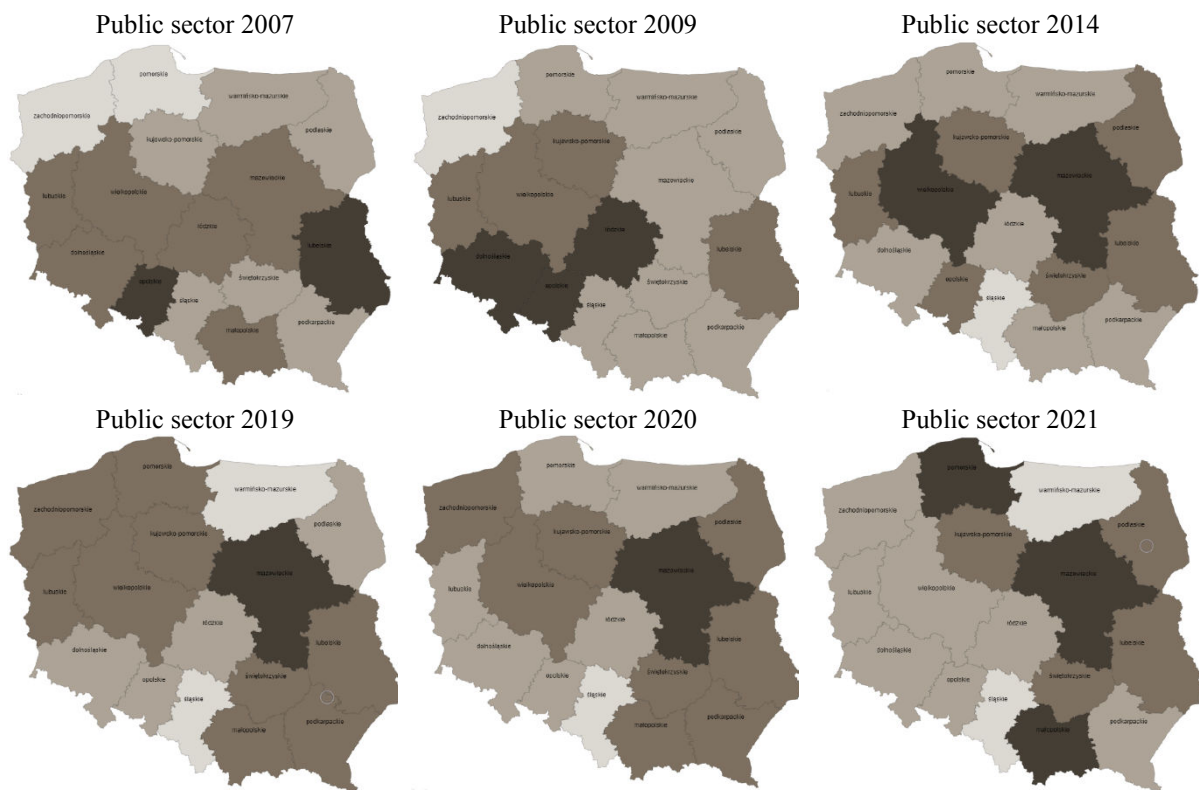


Figure 3. Spatial distribution of voivodeships in terms of the financial condition of public sector enterprises in 2007, 2009, 2014, 2019, 2020, 2021.

Based on the data presented in Table 9, it can be concluded that in the analyzed period the condition of public sector enterprises in individual voivodships has changed dynamically. The Mazowieckie Voivodeship is characterized by the greatest differentiation, which in 2011-2012 fell to the last position in the ranking, and since 2014 it has been ranked 1st. The smallest differentiation was recorded for the Warmińsko-Mazurskie voivodeship. During the pandemic, the greatest changes were recorded for the Pomorskie Voivodeship, while the positions of the Mazowieckie, Śląskie and Warmińsko-Mazurskie voivodships remained unchanged. On the basis of Figure 3, it can be seen that before the outbreak of the Covid19 pandemic, the financial condition of enterprises in the north-western voivodships of Poland improved compared to the others. During the pandemic, the voivodships of the eastern and central part of the country were in a better position - they took higher positions in the ranking. The voivodships in the western part of the country were in the 3rd and 4th groups, so the condition of enterprises in these voivodships was worse than in other voivodships

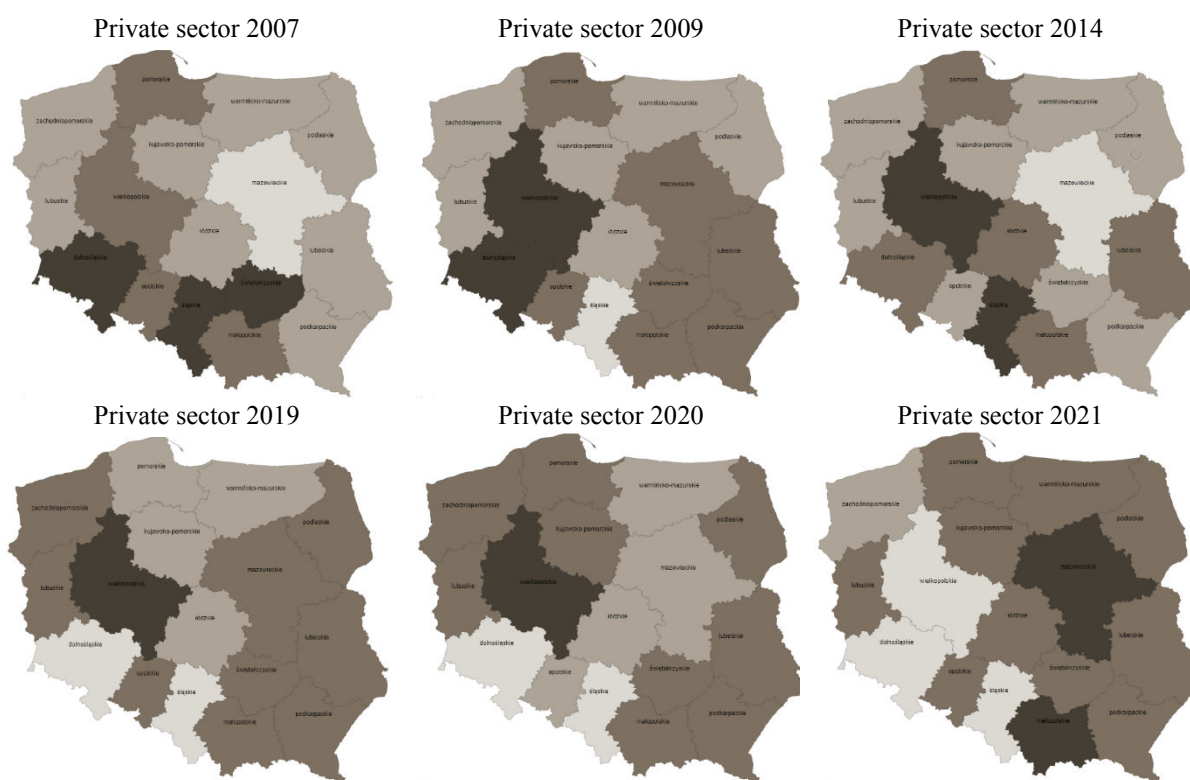


Figure 4. Spatial distribution of voivodships in terms of the financial condition of private sector enterprises in 2007, 2009, 2014, 2019, 2020, 2021.

Based on the data presented in Table 9, it can be concluded that in the analyzed period the condition of public sector enterprises in individual voivodships has changed dynamically. The Mazowieckie Voivodeship is characterized by the greatest differentiation, which in 2011-2012 fell to the last position in the ranking, and since 2014 it has been ranked 1st. The smallest differentiation was recorded for the Warmińsko-Mazurskie voivodeship. During the pandemic, the greatest changes were recorded for the Pomorskie Voivodeship, while the positions of the Mazowieckie, Śląskie and Warmińsko-Mazurskie voivodships remained unchanged.

On the basis of Figure 3, it can be seen that before the outbreak of the Covid19 pandemic, the financial condition of enterprises in the north-western voivodships of Poland improved compared to the others. During the pandemic, the voivodships of the eastern and central part of the country were in a better position - they took higher positions in the ranking. The voivodships in the western part of the country were in the 3rd and 4th groups, so the condition of enterprises in these voivodships was worse than in other voivodships

Based on the data presented in Table 10, it can be concluded that in the analyzed period the condition of large private sector enterprises has changed dynamically. The greatest diversification is characteristic for the Wielkopolskie Province, which in 2012 fell to the last position in the ranking, and since 2013 it has been ranked 1st, except for 2014 (2nd position). On the other hand, the smallest differentiation was noted for the Warmińsko-Mazurskie voivodship. During the pandemic, the greatest changes were recorded for Wielkopolskie, which fell from 1st position in the ranking to 16th, and then Mazowieckie and Małopolskie. The lowest differentiation is characteristic for Dolnośląskie (no change in position), followed by Śląskie, Warmińsko-Mazurskie and Opolskie. Based on the maps (Fig. 4), it can be noticed that during the economic crisis in 2007-2009, the voivodships of the south-eastern part of the country strengthened their positions in the ranking. A similar condition can be observed during the Covid19 pandemic, when voivodships from the central and eastern part of the country were included in groups 1 and 2. During the pandemic in 2021, the Wielkopolskie Voivodship was in the worst condition, falling to the last position in the ranking.

Conclusion

The study presents a taxonomic analysis of the financial condition of large enterprises in Polish voivodships using the TOPSIS aggregate measure. On the basis of the conducted research, it is possible to notice changes in the financial condition of enterprises in individual provinces, as well as differences in the financial condition between enterprises in the public and private sector.

When studying the impact of the Covid-19 pandemic on the financial condition of large non-financial enterprises, it can be noticed that enterprises started to reduce the costs of their economic activities, the total number of enterprises decreased, but the percentage of enterprises reporting a net profit on their economic activity increased. Despite the difficult condition caused by the pandemic, companies were able to pay off their obligations.

The Covid19 pandemic caused a decrease in the net profit of public sector enterprises in 8 voivodships compared to 2019, while in 2021 only in two. In the private sector, all voivodships recorded an increase in the net profit ratio. During the pandemic, both in the private and public sectors, the liquidity ratios of enterprises tended to increase for almost all

voivodships. Taking into account the administrative division, it can be noticed that for most voivodeships the financial liquidity ratios for public sector enterprises tended to increase and led to overliquidity. In the case of private sector enterprises, the 2nd degree liquidity ratios fluctuate at a constant level around 1 for almost all voivodships. During the pandemic, the gross sales profitability of enterprises increased, suggesting the phenomenon of excess liquidity, i.e. using current assets in an ineffective manner. Whereas the cost index for both public and private sector enterprises decreased compared to 2019.

The Covid-19 pandemic had an “equal effect” on the financial condition of large enterprises in individual provinces, as evidenced by slight changes in the ranking of provinces in 2019-2021. The exceptions are the Podlaskie, Kujawsko-Pomorskie and Wielkopolskie provinces. The biggest change, ie deterioration of the financial condition of enterprises, was recorded in the private sector for the Wielkopolskie voivodship.

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ANALYSIS OF THE DEVELOPMENT OF RENEWABLE ENERGY SOURCES IN POLAND

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Purpose: The analysis of the development of electricity obtained from renewable sources such as solar, wind and hydro in Poland.

Design/methodology/approach: The volume of electricity produced from three renewable energy sources in Poland: wind, hydro and solar, annually, from 2000 to 2020, was collected from Eurostat. Data were analyzed using the dynamics of phenomena tools and of time series forecasting.

Findings: The largest share of renewable energy sources for wind energy. Energy obtained from water has an ever-smaller share. The fastest-growing renewable energy source in Poland is photovoltaics. The arrangement of the share of individual resources will probably change in favour of solar energy.

Originality/value: The comparison analysis of three sources of renewable energy share from 2000 to 2020 was conducted. Forecasts for the next two years were made.

Keywords: photovoltaic, hydropower, wind energy, renewables.

Category of the paper: research paper.

1. Introduction

From the beginning of the 21st century, people facing the global warming effect are becoming increasingly conscious of the need to be concerned for the environment. On the other hand, the energy demand is growing very fast. Conversely, traditional energy sources are running out. The solution that combines environmental problems and the lack of energy resources is obtaining energy from renewable energy sources (RES). Overall, renewable energy sources are much more environmentally friendly than fossil fuels. It reduces the harmful effects of the energy sector on the natural environment (e.g. by reducing the emission of toxic substances, including greenhouse gases). In addition, increasing the use of these sources entails a greater degree of independence from imported energy supplies, which since the war in Ukrainian has begun, seems to be crucial. Legislative programs are introduced at the

government level to increase the share of renewable energy sources in the total energy supply (Fit for 55 2021; PEP2040 2021).

Regarding fit for 55, greenhouse gas emissions should be reduced by at least 55% by 2030 in European Union countries. Also, the share of renewable energy in gross final energy consumption should increase to 40%. Thus, in Poland, the PEP2040 program was introduced, which indicated that the share of renewable energy in the national structure should be at least 32% in 2030.

This article aims to analyze the development of RES as an electricity source in Poland from the beginning of the XXIst century. An analysis of electricity obtained from renewable sources such as solar, wind, and hydro was carried out to achieve this goal. Solar energy is converted into electricity using photovoltaic panels for direct electricity generation. Wind energy is used to generate electricity in wind turbines. Hydro energy is mechanical energy obtained from flowing water.

2. Literature review

Renewable energy sources are the subject of many scientific works. Researchers emphasize the significant role of RES in preventing climate change (Lin, Zhu, 2019; Cronin et al., 2018). Some scenarios of the development of RES in terms of the global warming effect were made by (Luderer et al., 2014). So the role of education in the development of RES was indicated in (Mehmood, 2021). The critical factor in the development of RES seems to be the attitude and motivation of potential investors in these sources. The factors influencing the decision to instal photovoltaics (Angowski et al., 2021; Zdonek et al., 2022; Ali et al., 2020; Jasiński et al., 2021; Tsaour, Lin, 2018; Angowski et al., 2021) as well as wind energy (Kaldellis et al., 2013) green technologies (Jabeen et al., 2021), and RES on the whole (Ropuszyńska-Surma, Węglarz, 2018) were investigated.

The situation of renewable energy has been explored in different regions of the world. In the European Union, research was conducted (Tutak, Brodny, 2022; Bórawski et al., 2019; Wolniak, Skotnicka-Zasadzień, 2022), also focusing on separate energy sources, like solar (Wolniak, Skotnicka-Zasadzień, 2022) or wind power potential (Enevoldsen et al., 2019; Leiren et al., 2020).

The research was also performed in individual countries such as Bangladesh (Uddin et al., 2019), China (Lin, Zhu, 2019), Spain (Heras-Saizarbitoria et al., 2011), Malaysia (Ahmad et al., 2017; Karooni et al., 2016), Greece (Tsantopoulos et al., 2014), Brasil (Corrêa da Silva et al., 2016), Nigeria (Wojuola, Alant, 2017), New Zeland (Stephenson, Loannou, 2010) or Afghanistan (Jahangiri et al., 2019).

In Poland, research on renewable energy development was carried out on the whole (Piwowar, Dzikuć 2019; Mularczyk 2016; Kaldellis et al., 2013; Zarębski et al., 2021; Ropuszyńska-Surma, Węglarz, 2018; Brodny et al., 2020) or focusing on solar sources (Szałata et al., 2016; Zdonek et al., 2022; Mularczyk, Hysa, 2015), wind (Gnatowska, Moryń-Kucharczyk, 2019; Drożdż, Mróz-Malik, 2020; Pronińska, Księżopolski, 2021) or hydropower (Igliński, 2019; Rabe et al., 2020; Kałuża et al., 2022a, 2022b; Kubiak-Wójcicka, Szczęch, 2021).

Solar photovoltaics and wind energy are the most efficient and well-known renewable energy sources rapidly developing (Lehtola, Zahedi, 2019).

Literature research prompted to focus on three renewable sources of electricity: wind, water and sun, assessing their use. Therefore, the following research questions were formulated:

RQ1: What were the analyzed renewable energy sources' dynamics in the studied years?

RQ2: How has the share of solar, wind and hydro energies in RES changed in the studied years in Poland?

3. Methods

Data for analysis have been obtained from the open data website: Eurostat (Database - Eurostat 2022). Data was collected on the volume of electricity produced from three renewable energy sources in Poland: wind, hydro and solar, annually, from 2000 to 2020 (in GWh). The methods of analyzing the dynamics of phenomena and of time series forecasting were used in analyzing the data. The visualizations needed to illustrate the phenomenon have been created.

4. Results and discussion

Figure 1 shows the volume of electricity produced from researched renewables. Renewable electric energy production has been increasing, especially in the last decade. Overall, the electricity production from renewables raised from 4152 GWh in 2000 to 22 111 GWh in 2020. That means a total increase of 433% over twenty years, with an average yearly growth of 9%. Simultaneously, the renewables share in total energy production changed from the level of 3% in 2000 to the level of 14% in 2020. That means a fundamental change of 389%, with an average yearly increase of about 8%. It can be assumed that this growth is mainly due to the development of wind farms.

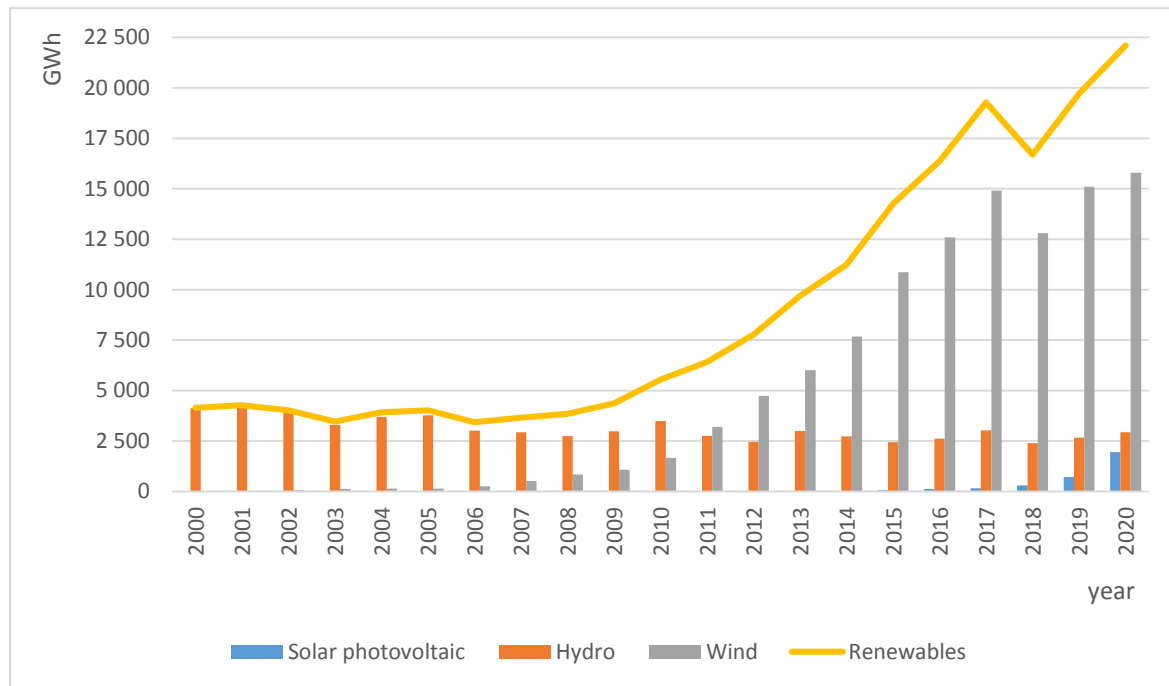


Figure 1. The production of electricity from solar, hydro and wind from 2000-2020.

Source: Eurostat.

In Figure 2, absolute changes in electricity production obtained from analyzed sources during the period studied are presented. To compare it, Table 1 illustrates individual chain indexes calculated for each source.

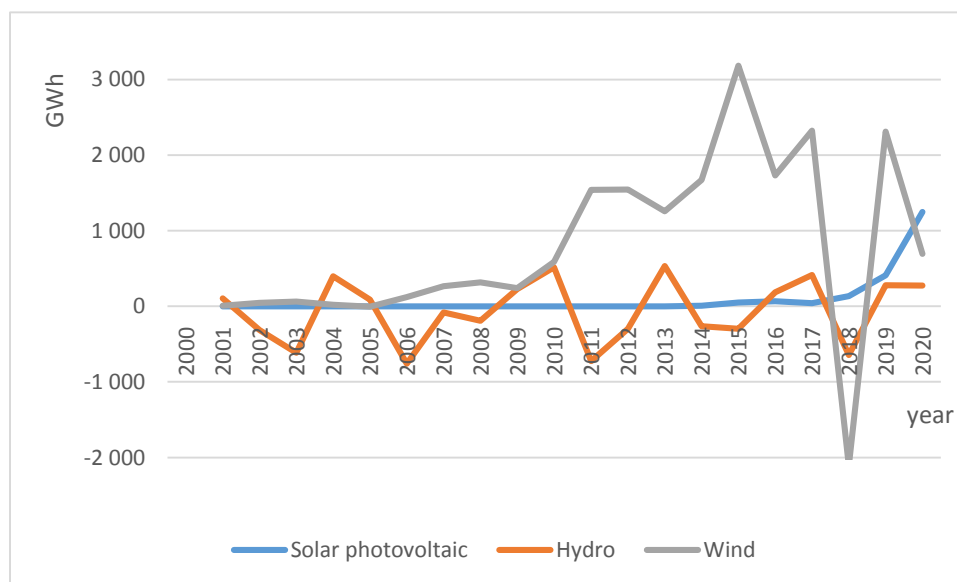


Figure 2. Absolute changes in the production of electricity from solar, hydro and wind from 2000-2020.

Source: own calculations based on Eurostat.

Table 1
Individual chain indexes

Year	Solar photovoltaic	Hydro	Wind	Renewables	Share of renewables in total energy
2001	-	1,03	2,80	1,03	1,03
2002	-	0,93	4,36	0,94	0,95
2003	-	0,84	2,03	0,87	0,82
2004	-	1,12	1,15	1,13	1,11
2005	-	1,02	0,95	1,03	1,01
2006	-	0,80	1,89	0,85	0,83
2007	-	0,97	2,04	1,06	1,08
2008	-	0,93	1,60	1,05	1,08
2009	-	1,08	1,29	1,14	1,17
2010	-	1,17	1,54	1,27	1,22
2011	-	0,79	1,93	1,16	1,11
2012	6,52	0,89	1,48	1,21	1,22
2013	1,30	1,22	1,26	1,25	1,23
2014	4,65	0,91	1,28	1,16	1,20
2015	8,22	0,89	1,41	1,27	1,22
2016	2,19	1,08	1,16	1,15	1,14
2017	1,34	1,16	1,18	1,18	1,15
2018	1,82	0,79	0,86	0,87	0,87
2019	2,37	1,12	1,18	1,18	1,23
2020	2,76	1,10	1,05	1,12	1,16
Geometric mean	2,82	0,98	1,50	5,33	4,89
Average growth from year to year	182%	-2%	50%	433%	389%

Source: own study.

As seen in Figure 2, the expansion of wind farms, starting from 2006, was very dynamic. The electricity produced through wind power increased from 5 GWh in 2000 to 15 800 GWh in 2020. That is more than 3 000 times growth, with an average yearly growth of 50% (Table 1). The sharp decline in electricity production in 2018 resulted from legislative fluctuations: changes in the scope of taxation of wind farms. 2019 is again seeing a significant increase (probably compensating for the decline in some way) followed by a slight decrease. Regarding hydropower, the amount of electricity produced from this source seemed to be more or less constant in the analyzed years. However, there is a 29% decrease over the studied period. An average decline takes about 2% yearly (from 4116 GWh in 2000 to 2937 GWh in 2020). On the other hand, observing solar electric energy volume produced by photovoltaics, there has been immense growth in the last years. Although the interest in this form of renewable energy sources began in Poland only in 2011, a constant, even exponential development of this industry can be observed. It developed from less than 0.2 GWh in 2011 to 1958 GWh in 2020, which means more than 11 000 times growth in only ten years. At that time, the average annual increase from year to year was 182%.

Willing to broaden the spectrum of the analysis, Table 2 presents the changes in shares of electricity from the three analyzed sources in renewables.

Table 2*Share of electricity from solar, hydro and wind in renewables in 2000-2020*

Year	Solar photovoltaic	Hydro	Wind	Other
2000	0,00%	99,1%	0,1%	0,7%
2001	0,00%	98,7%	0,3%	1,0%
2002	0,00%	97,3%	1,5%	1,2%
2003	0,00%	94,8%	3,6%	1,6%
2004	0,00%	94,2%	3,6%	2,2%
2005	0,00%	93,9%	3,4%	2,8%
2006	0,00%	87,9%	7,5%	4,7%
2007	0,00%	80,4%	14,3%	5,3%
2008	0,00%	71,6%	21,8%	6,6%
2009	0,00%	68,0%	24,6%	7,3%
2010	0,00%	62,8%	30,0%	7,2%
2011	0,00%	43,0%	49,9%	7,0%
2012	0,01%	31,7%	61,0%	7,3%
2013	0,02%	30,9%	61,9%	7,1%
2014	0,06%	24,3%	68,3%	7,3%
2015	0,40%	17,1%	76,2%	6,4%
2016	0,76%	16,0%	76,9%	6,4%
2017	0,86%	15,7%	77,3%	6,1%
2018	1,80%	14,3%	76,6%	7,3%
2019	3,60%	13,5%	76,6%	6,3%
2020	8,86%	13,3%	71,5%	6,4%

Source: own calculations.

Solar energy started to develop in about 2011, and its share in total renewables increased from almost 0% (0,03%) to 9% in 2020. The percentage of photovoltaics in renewables grew yearly by 123% on average. Regarding hydropower, it is worth noting that while in 2000, this energy was the basis of Polish renewable energy (it accounted for 99% of it), in 2020, it remained only 13% of the total. The annual average decrease was about 10%. The share of wind power in renewables has risen from 0,1% in 2000 to 77% in 2019, ending at 71% in 2020. That meant a 38% average annual increase. To sum up, in 2020, almost $\frac{3}{4}$ of electrical energy from renewables came from wind power, 13% was produced by hydropower, 9% by solar and 6% from other sources (among these are, for example, renewable municipal waste). It appears that energy obtained from the water has already reached its maximum. In turn, wind energy began to slow down, although it is still developing. However, the wind potential may develop further. There is progressively more debate about home wind farms. On the other hand, the amount of electricity from the solar sources shows a systematic exponential growth. Here, as well, inexhaustible potential can be assumed. Thus, the composition of shares will probably change in favour of solar energy in the coming years.

Attempting to discover what would occur in the future, forecasts for the share of the examined sources in renewable energy sources for the next two years were made. That was achieved through adjusting time trends: fourth and third-degree polynomial for hydro and wind and exponential for solar energy. Results are presented in figure 3, figure 4 and figure 5 and in table 3, table 4 and table 5.

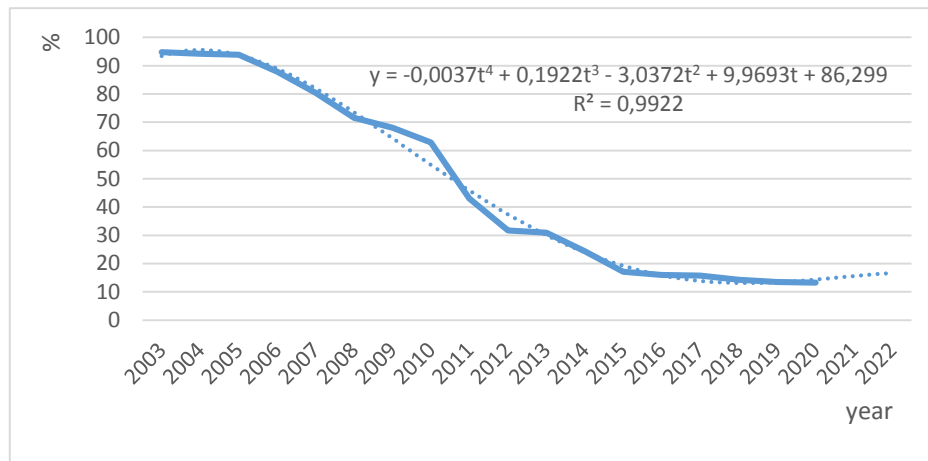


Figure 3. The prediction of share in renewables of hydroelectricity.

Source: own calculations.

Table 3.

Projected share of hydropower in renewable energy sources

Regression Statistics				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
<i>Intercept</i>	86,29945	5,62328	15,34681	0,00000
<i>t</i>	9,96926	3,86080	2,58218	0,02276
<i>t²</i>	-3,03717	0,79588	-3,81612	0,00214
<i>t³</i>	0,19217	0,06215	3,09205	0,00858
<i>t⁴</i>	-0,00370	0,00162	-2,27584	0,04043
<i>R Square</i>	0,99217		<i>F</i>	411,8014
<i>Adjusted R Square</i>	0,98976		<i>Significance F</i>	0,0000
<i>Standard Error</i>	3,28668			
Forecasts:	16% (2021)	17% (2022)		

Source: own calculations.

The estimated trend model for hydropower share in renewables is statistically significant and can be used for forecasting (all p-values are less than 0.05). According to calculations, the share of hydropower in renewables should be around 16% in 2021 and 17% in 2022. That means a very slight increase.

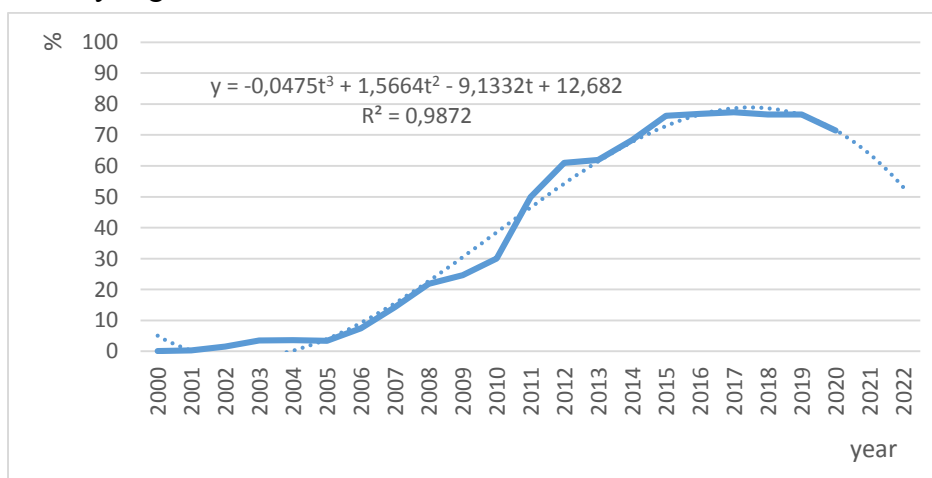


Figure 4. The prediction of share in renewables of wind electricity.

Source: own calculations.

Table 4

Projected share of wind energy in renewable energy sources

Regression Statistics				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
<i>Intercept</i>	0,12682	0,04157	3,05079	0,00723
<i>t</i>	-0,09133	0,01598	-5,71376	0,00003
<i>t²</i>	0,01566	0,00167	9,39202	0,00000
<i>t³</i>	-0,00048	0,00005	-9,52281	0,00000
R Square	0,98715	<i>F</i>	435,3517	
Adjusted R Square	0,98488	<i>Significance F</i>	0,0000	
Standard Error	0,03939			
Forecasts:	64% (2021)	53% (2022)		

Source: own calculations.

Similarly, the trend model is statistically significant in this case, allowing for forecasts. According to the estimate, the projected share of electricity generated by wind farms in renewable energy sources should be at the level of 64% and 53% in 2021 and 2022. That means a significant decrease in this share.

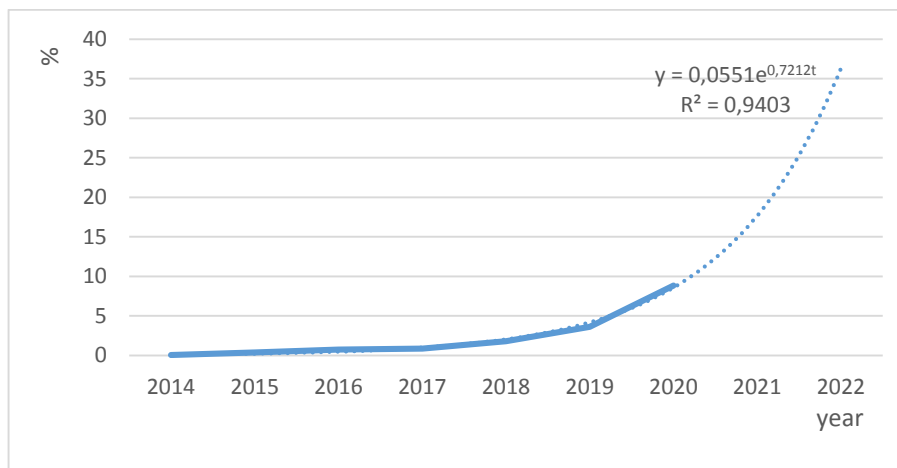


Figure 5. The prediction of share in renewables of solar electricity.

Source: own calculations.

Table 5.

Projected share of solar energy in renewable energy sources

Regression Statistics				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
<i>Ln(Intercept)</i>	-2,8984	0,3636	-7,9725	0,0005
<i>t</i>	0,7212	0,0813	8,8713	0,0003
<i>R Square</i>	0,9403	<i>F</i>	78,7005	
<i>Adjusted R Square</i>	0,9283	<i>Significance F</i>	0,0003	
<i>Standard Error</i>	0,4302			
Forecasts:	18%(2021)	36% (2022)		

Source: own calculations.

Photovoltaics develop currently the most dynamically. The pace of expansion takes an exponential form, so the exponential trend turned out to be the best suited to empirical data. Due to the good fit of the model, this trend could be used for the forecast. According to calculations, the share of electricity produced by photovoltaic panels may increase even to 18% and 36% in 2021 and 2022.

By examining the changes in the amount of electricity produced in the researched renewable sources, it is inevitable to observe a diminishing role of hydropower along with the growing percentage of the energy from wind and sun. Hydropower has been used in Poland for years (Igliński, 2019; Kałuża et al., 2022b). Its use, historically established (mills), however, becomes to have a lower share in the mix of energy from renewable sources, which, according to calculations, fell from 99% to 13%. Even even though forecasts have shown a slight increase, it should never again reach the point of 99%. Contrary to hydropower, wind energy has developed in the last two decades and nowadays is the most used source of renewable energy in Poland (Gnatowska, Moryń-Kucharczyk, 2019). The volume of electricity produced from this source is growing systematically, although not so fast as photovoltaics. As a result of various funding programs and tax reliefs, photovoltaics is one of Poland's fastest-growing renewable energy sectors (Fotowoltaika w Polsce, 2022; Zdonek et al., 2022; RaportPV2021, 2021). Even though the statement that solar photovoltaics and wind energy are the most efficient renewable energy sources rapidly developing (Lehtola, Zahedi, 2019) was confirmed in Poland.

5. Summary

The article's subject examined the development of renewable electricity sources from wind, water and sun from 2000 to 2020. A dynamic analysis of phenomena was conducted to answer the first research question about the dynamics of the researched renewable energy sources development in the studied years. The electricity produced through wind power increased from 5 GWh in 2000 to 15 800 GWh in 2020, with an average yearly growth of 50%. The electricity produced from hydro sources decreased from 4116 GWh in 2000 to 2937 GWh in 2020, meaning an average annual decline of about 2%. Regarding photovoltaics, it developed from less than 0.2 GWh in 2011 to 1958 GWh in 2020, with an average yearly increase of 182%.

Shares have been calculated to answer the second research question of how the segments of solar, wind and hydro energies in RES changed in the studied years in Poland. Afterwards, three trend models were estimated – to estimate the projected values for the next two years.

Despite the issue that photovoltaics has been very popular in recent years, wind farms have dominated Poland's renewable energy market so far. The reason for this could be presumably the country's temperate climate. However, comparing the average growth speeds, renewables' structure will almost certainly change in favour of solar energy in the coming years. According to forecasts, the share of solar energy should increase to 18% and 36% in the following years. Predicted hydropower is to be around 16% and 17%, respectively. In turn, the share of wind energy fell to 64% and then to 53%. It should be mentioned that this decrease is not equivalent to the production volume reduction. It simply indicates that the amount of wind energy

production is growing slower than the total amount of RES production. It should be considered that energy production from renewable sources is constantly and dynamically increasing. The substantial increase in interest in solar energy observed in recent years would constitute, if not competition, then an essential supplement to the basket of renewable energies in the study area. Legislative conditions are undeniably conducive to this situation.

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ISSUES OF INTELLECTUAL CAPITAL EVALUATION IN AN ENTERPRISE IN RELATION TO THE METHOD BASING ON THE DIFFERENCE BETWEEN ITS MARKET AND BOOK VALUE

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Purpose: The main goal of the article was to present the issues of the practical application of the method of measuring intellectual capital based on the difference between the market value and book value of enterprises.

Design/methodology/approach: By comparing the relation of the market value to the book value of companies listed on the Warsaw Stock Exchange in various time dimensions with the trends in their basic economic and financial categories, such as sales revenues and total assets, it was shown when the indicated approach to measuring the intellectual capital of the enterprise makes sense, and when it may be misleading.

Findings: The conducted research allows to conclude that the considered method of measuring intellectual capital is simple, but strongly imperfect. Its main burden is the high dynamics of changes in market quotations, which often occurs in the case of listed companies, which may lead to distortions. Hence, this method is more suitable for the initial identification of entities with a potentially high level of intellectual capital than for its precise measurement.

Research limitations/implications: Research is limited to a group of 20 companies listed on WSE with the highest P/BV values. In further, more detailed studies, other approaches to the selection of companies based on the P/BV ratio and to the verification of the level of intellectual capital through the prism of trends in the economic and financial situation of the surveyed entities can be considered more broadly.

Practical implications: In order to make the results of using the market to book value difference more objective in the identification and measurement of intellectual capital in enterprises, it is worth relying on quotations or P/BV ratios of the analyzed companies, in the form of an average, or even better a median, from a longer period (preferably several years). In addition, the indications of a high level of intellectual capital of the surveyed entities should be verified based on the assessment of changes in their economic and financial situation referring to the metaphor of the "tree" (invisible resources create visible effects).

Originality/value: The article presents a proprietary approach to the application of the relationship between the market and accounting value of enterprises in terms of identifying entities with a high level of intellectual capital. The article is addressed in particular to researchers dealing with the subject of valuation and measurement of intellectual capital in an enterprise, as well as analysts and stock market investors.

Keywords: intellectual capital, intellectual capital valuation methods, market to book value.

Category of the paper: Research paper.

1. Introduction

In the knowledge-based economy, where enterprises build their basic competences on intangible assets, intellectual capital is considered a key factor in productivity and long-term growth (Sveiby, 1997; Guthrie et al., 2001). This is due to the fact that intangible assets in the information society era have grown to the rank of strategic resources, increasingly determining the ability of enterprises to generate cash flows, and their value (Bombiak, 2016).

Intellectual capital is identified primarily with the knowledge used by the organization as a lever in the exchange of intangible assets for value-creating assets (Kianto, 2007). Previous research on intellectual capital shows, *inter alia*, that it positively influences the achieved economic results of enterprises (Menor et al., 2007; Hussinki et al., 2017), it is as important in an enterprise as material capital (Samul, 2013), or it is a key factor of innovation (Subramaniam, Youndt, 2005; Rossi et al., 2016).

The importance of intellectual capital in recent years has also been noticed by both investors and listed companies themselves. Investors realized that non-financial information, including in particular those related to the elements of intellectual capital, presents factors determining the competitiveness and development of enterprises in the future, and thus may constitute the basis for investment decisions (Michalak, 2017). On the other hand, listed companies, or rather their management boards, in a way responding to the growing information needs of investors, began to include non-financial information in the published reports to a much greater extent, wanting to present their situation in a more credible way (Bagieńska, Burchart, 2018). It should be noted, however, that despite the growing importance of this category of capital in the literature, there is still considerable variation in its definition, identification and measurement (Jardon, Martinez-Cobas, 2021).

Although the first mentions of intellectual capital date back to the 1930s (Chamberlin, 1939), and later to the end of the 1950s in the context of the resource theory of the enterprise (Penrose, 1959), this category gained more popularity in scientific research only at the end of the 20th century. One of the reasons for this interest was the observation of the deepening disproportions between the market and book value of companies listed on world stock exchanges (Ujwary-Gil, 2009; Bombiak, 2016), especially in the late 1990s during the so-called “dotcom” boom.

At the same time, the aforementioned difference between the market value, identified with the company's quotations on the capital market, and the book value, resulting from the balance sheet (the value of the so-called net assets, *i.e.* equity), remains, despite the passage of time, one of the basic and more popular general measures of intellectual capital of enterprises. Although from the conceptual point of view it is difficult to question it (the company's balance sheet does not include all resources at its disposal, in particular those intangible ones that determine the amount of intellectual capital), and its additional advantage is its simplicity and

ease of use, at the same time this measure cannot be used without reflection because stock quotes also have their own specificity, which may distort the results of measuring intellectual capital.

For this reason, the main aim of the article was to present the issues of the practical application of the method of measuring intellectual capital based on the difference between market and book value of enterprises. By comparing the relationship of the market value to the book value of companies listed on the Warsaw Stock Exchange in various time dimensions with the trends in their basic economic and financial categories, it was shown when the indicated approach to measuring the intellectual capital of an enterprise makes sense and when it can be misleading.

2. The concept of intellectual capital and methods of its evaluation

2.1. The concept and elements of intellectual capital

As noted in the introduction, the concept of intellectual capital appeared in the literature many years ago, but only the popularization of the resource theory of E. Penrose and the dynamic development of economies based on intangible assets in the 1980s and 1990s contributed to the increased interest in this category (Pirogova et al., 2020). At the same time, due to the dynamic nature of intellectual capital, no comprehensive, universally recognized definition of it has yet been developed (Buenechea-Elberdin, 2017). Thus, both in the literature and in economic practice, there are various approaches to defining this category (Table 1), and in research on the nature of intellectual capital, a certain terminological heterogeneity can be noticed. Most often it is identified with intangible assets, hidden assets, invisible assets, non-financial assets, intellectual resources, intangible resources, knowledge capital or intellectual matter. In this context, the specificity of intellectual capital is well reflected by the "iceberg" model and the "tree" metaphor. The "iceberg" model presents the company's resources broken down into tangible (e.g. land, buildings, equipment, stocks, securities) and intangible (e.g. employee competences, management philosophy, organizational culture, reputation, customer loyalty, brand), where it indicates that the latter, unlike the former, are less visible to the environment and more difficult to evaluate, but at the same time have a greater ability to generate added value for the enterprise (Dobiegała-Korona, Herman, 2006). In turn, the metaphor of "tree" indicates that what is visible to the environment (the crown, i.e. the trunk and leaves) is the so-called external image of the company, which is the effect of invisible, hidden values inside the company equated with intellectual capital (tree roots). Which leads to the conclusion that when the roots of a tree no longer fulfill their functions well, the entire tree will be destroyed (Adamska, 2015).

Table 1.
Selected definitions of intellectual capital

Author	Definition
L. Edvinsson M.S. Malone	Intellectual capital is a hidden asset that reflects the gap between a company's market value and book value.
M. Bratnicki	Intellectual capital is the sum of the knowledge possessed by people who make up the enterprise community and the practical transformation of this knowledge into components of the company's value.
D. Dobija	Intellectual capital is a source of financing the company's intangible resources contributing to the generation of future benefits, and thus significantly influencing the process of creating the company's value.
G. Urbanek	Intellectual capital is an invisible resource of an enterprise that creates visible effects. It is both knowledge in itself and the result of its transformation into intangible assets.
Słownik języka polskiego PWN	Intellectual capital is wealth created, resulting from the knowledge of employees of the enterprise engaged in the constant process of increasing its value.
G. Roos, J. Roos	Intellectual capital is the sum of hidden assets not included in the financial statements, including both what is in the minds of employees and what remains in the company after they go home.
L. Prusak	Intellectual capital is intellectual matter that has been materialized, captured and used to create high-value assets.
T. Steward	Intellectual capital is intellectual material that has been formalized, captured and forced to act to create wealth of greater value.
J. Fitz-Enz	Intellectual capital is the intellectual property of the company and a complex combination of processes and culture connected with a network of various types of relationships and human capital.
E. Skrzypek	Intellectual capital is intellectual assets that are the sum of the knowledge of individual employees and teams of employees. These resources are subject to constant changes resulting from the learning process of the organization.
M. Mroziewski	Intellectual capital is the concept of the company's and its employees' ability to generate income and build the potential of future competitiveness, in particular based on intellectual assets and social relations, focused on the search for knowledge, its processing, enrichment and transfer to stakeholders in the form of artifacts that generate various benefits and socio-economic progress.
A. Brooking	Intellectual capital covers four areas: <ul style="list-style-type: none"> – market power - sales markets, customer loyalty, – intellectual properties such as patents, brand value, – internal aspects, such as corporate culture, management, processes, systems, – properties that come from the company's employees, such as competencies related to work, know-how, knowledge, abilities, connections.
K.-E. Sveiby	The intellectual capital of the company consists of elements that make up the external structure, internal structure and employees' competences.
K.M. Wiig	Intellectual capital consists of assets created as a result of intellectual activities, ranging from the acquisition of new knowledge (learning) through invention to the formation of valuable relationships with others.
M. Marcinkowska	Intellectual capital is the knowledge of employees and management, which is a resource of strategic importance influencing the competitive position and market potential of the enterprise. It is a resource that is very difficult to value and protect against loss.

Source: own work based on: Bombiak, 2016, pp. 105-119; Sledzik, 2011.

Generally speaking, it can be said that the definitions of intellectual capital consider this category either as a factor that creates the value of an enterprise and strengthens its competitive advantage – (i), or the sum of its components, in particular such as: human capital, structural (internal) capital and relational (external) capital – (ii). Human capital includes the intellectual potential of employees (i.e. their knowledge, skills, abilities, experience, predispositions, personality traits, etc.) and the possibilities of using it determined by their motivation. Structural

(organizational) capital includes, among others: organizational culture, systems, methods and processes as well as organizational and information infrastructure facilitating the flow of knowledge within the organization and the use of human potential. On the other hand, relational capital (network architecture) concerns all connections with external stakeholders (investors, suppliers, customers), as well as the reputation resulting from these relations (Sydler et al., 2014; Bombiak, 2016; Hussinki et al., 2017).

At the same time, with regard to the second of the mentioned approaches, the literature indicates that the impact of individual components of intellectual capital on the market value of the enterprise is not immediate. Structural and relational capital positively affects the performance of enterprises only in the long term (Sardo, Serrasqueiro, 2017). At the same time, it is emphasized that the size of the enterprise or the period of its operation on the market does not affect the level of intellectual capital (Forte et al., 2017).

Numerous studies also show that there are multidirectional dependencies between the individual dimensions (components) of intellectual capital. It is noted, *inter alia*, that structural capital, by facilitating the sharing of uncoded knowledge between employees, affects their job satisfaction and encourages them to stay in the organization. Human capital has a positive effect on both structural and relational capital (Hsu, Fang, 2009). In addition, human capital along with relational capital significantly affects structural capital – investments made by an enterprise in human and relational capital significantly affect the accumulation of structural capital (Johnson, 1999). As noted by Staniewski and Szczepankowski (2012), such a broad influence of human capital makes it the main dimension (component) of intellectual capital.

It is also worth noting that some researchers question the ability of the tripartite model to recognize and measure the diverse nature of organizations. Therefore, human, structural and relational capital is supplemented with such dimensions as: renewal capital, trust capital, entrepreneurial capital, with a proposal to include them in the components of intellectual capital (Inkinen et al., 2017; Buenechea-Elberdin et al., 2017, 2018).

Summing up the deliberations on the concept of intellectual capital, it can be stated that it is undoubtedly a complex category, developed on the basis of the most valuable resource of modern organizations, which is knowledge (both hidden, accumulated in the minds of employees, as well as codified and preserved in the company's documents), which is foundation for the creation of various intangible assets. This knowledge is therefore not only an ingredient, but also the basis for the creation of this capital. The process of its generation is equally complex, carried out through complex interactions involving not only various assets, but also various groups of the company's stakeholders (investors, employees, suppliers, customers). As noted by E. Bombiak (2016), the difficulty in developing a uniform approach and a consistent definition of intellectual capital is primarily due to the fact that we are dealing with a complex and unique resource. In each enterprise, it is created by a specific configuration of intangible assets related to each other and complementing each other. This uniqueness, on the one hand, is an important advantage of this capital, as it enables building a permanent

competitive advantage of the organization, and on the other hand, it is a source of problems related to determining its value.

2.2. Methods of intellectual capital evaluation

The need to measure intellectual capital results directly from the needs of the process of managing it and the entire enterprise. Measuring intellectual capital is the starting point for taking steps to evaluate, develop, increase and communicate it. At the same time, however, the measurement and valuation of intellectual capital is extremely complicated. This is mainly due to the fact that the elements that make up intellectual capital are often difficult to identify, not always clearly defined, often function in close connection with other elements, and their isolation is impossible or changes their value. Moreover, most often the value of intellectual capital depends on the quality of its components, and not on their quantity. It is also often difficult to express in money the values that define intellectual capital, as they are usually descriptive (qualitative).

When classifying models and methods of measurement and valuation of intellectual capital in the literature, one can see their general division into two groups (Fijałkowska, 2012; Jardon, Martinez-Cobas, 2021):

- Internal-analytical, components, measures of intellectual capital, i.e. measures of the micro level, created mainly to support the decision-making process of the management board and for reporting purposes. Such a measurement is expected to provide detailed information, based on several measures or a set of indicators. These measures concern the quantification of individual components of intellectual capital on the basis of monetary units, but also percentage or natural units. Typically, the result of a measurement is a set of indicators and non-sumable values. In order to calculate these measures, it is most often necessary to obtain additional information from the enterprise, which is not presented in the financial statements, which makes it impossible to calculate these measures for external users of information published by enterprises. These measures are very useful for company management, if the company decides to disclose them, they can also be very useful for external stakeholders of the company. The measures of this group include, among others: Monitor of intangible assets, Navigator Skandia, Strategic scorecard.
- Synthetic, holistic, economic valuation measures that lead to a single overall quantity representing the value of intellectual capital in monetary units. They do not refer to individual elements of intellectual capital, have a high level of aggregation and usually try to assign a value to the total intellectual capital resources by determining their share in the total value of the enterprise. Examples include the Tobin Q index, the difference between market and book value, or the calculated value of an intangible asset CIV.

Another, more developed, approach to the classification of intellectual capital measurement and valuation methods is that proposed by Sveiby (2010), where four groups of methods are distinguished: direct measurement methods, market capitalization methods, return on assets methods, and scorecard methods. This division, along with the characteristics of individual groups of methods, is presented in Table 2.

Table 2.

Methods of classification, measurement and valuation of intellectual capital according to K.E. Sveiby

<p>Direct Intellectual Capital methods (DIC): estimate the money-value of intangible assets by identifying its various components. Once these components are identified, they can be directly evaluated, either individually or as an aggregated coefficient.</p>	<ul style="list-style-type: none"> – Citation – Weighted Patents – Total Value Creation (TVC) – Inclusive Valuation Methodology – The Value Explorer – Technology Broker – Intellectual Asset Valuation
<p>Market Capitalization methods (MC): calculate the difference between a company's market capitalization and its stockholders' equity as the value of its intellectual capital or intangible assets.</p>	<ul style="list-style-type: none"> – Market-to-Book Value – Q-Tobin's Indicator – Investor Assigned Market Value
<p>Return on Assets methods (ROA): average pre-tax earnings of a company for a period of time are divided by the average tangible assets of the company. The result is a company ROA that is then compared with its industry average. The difference is multiplied by the company's average tangible assets to calculate an average annual earnings from the Intangibles. Dividing the above average earnings by the company's average cost of capital or an interest rate, one can derive an estimate of the value of its intangible assets or intellectual capital.</p>	<ul style="list-style-type: none"> – Economic Value Added (EVA) – Human Resources Costing & Accounting – Calculated Intangible Value (CIV) – Knowledge Capital Earnings – Value Added Intellectual Coefficient (VAIC)
<p>Scorecard methods (SC): the various components of intangible assets or intellectual capital are identified, and indicators and indices are generated and reported in scorecards or as graphs. SC methods are similar to DIC methods, except that no estimate is made of the money-value of the intangible assets. A composite index may or may not be produced.</p>	<ul style="list-style-type: none"> – Human Capital Intelligence – Skandia's Navigator – Value Chain Scoreboard – IC-Index – Intangible Asset Monitor – Strategic Scorecard – IC-Rating

Source: own work based on: Sveiby.

It should be emphasized at this point that no measure of intellectual capital has so far been considered ideal, as each of the methods of measurement and valuation has certain advantages, but also some weaknesses. Usually, the desired simplicity of calculations, meaning lower costs of calculation and easier access to data, is associated with the consent to some simplifications in defining intellectual capital and the omission of many of its important elements, or possibly including components that do not affect its value.

Component methods have been criticized in the literature because they present contradictory aspects. Users of these methods believe that the interactions of individual components of intellectual capital make a significant contribution to the value of intellectual capital (van der Meer-Kooistra, Zijlstra, 2001), but they are ignored in the focus on measuring individual components (Mouritsen, 2009). In addition, it is difficult to obtain financial information on the individual components, and only component aspects that are measurable are

considered, but there are likely to be many other aspects that cannot be accurately measured (Goebel, 2015).

In turn, holistic methods are criticized because they are too general and identify the monetary value of intellectual capital with the value generated also by other types of capital in the enterprise (Jardon, Martinez-Cobas, 2021).

The further part of the article focuses on the problem of applying one of the simpler and more popular methods of measuring and valuing intellectual capital, which is the difference between market and book value of an enterprise.

3. Research methodology

The main aim of the article was to present the issues of the practical application of the method of measuring intellectual capital based on the difference between market and book value of enterprises. Due to the use of the same variables, this method is inextricably linked with one of the basic stock exchange indicators, i.e. P/BV. This ratio, which is the relation of the market price of the company's shares (P, market value) to equity per share (BV, book value), shows how much the market overvalues ($P/BV > 1$) or undervalues ($P/BV < 1$) shares of a given entity in relation to its book value, or balance sheet value (the so-called net assets being the difference between total assets and total liabilities).

In the context of intellectual capital valuation, particular attention is paid to situations in which listed companies are characterized by a P/BV ratio above 1, especially definitely above 1. Despite the fact that from an investment point of view, such cases are usually not treated as investment opportunities (Haugen, 1999), in the sciences of management, as already indicated in the previous paragraphs, the higher market value in relation to the book value is justified by the presence of intangible assets (human capital, structural capital, relational capital), which have not been fully included in the traditional balance sheet of the company, prepared in accordance with the applicable accounting standards.

At the same time, however, it should be borne in mind that the share price of companies on the stock exchange market is not influenced solely by objective and fundamental factors, but to a large extent is the result of investors' emotions on various information and related expectations (Zaremba-Śmietański, 2013). Hence, especially in short time ranges, it may be subject to rapid changes (both up and down), which may distort the result of the enterprise's intellectual capital valuation using the considered method.

For this reason, considering the issue of the application of the method of intellectual capital valuation, based on the difference between market and book value of an enterprise, it was decided to analyze its effectiveness in identifying entities with a high level of intellectual capital

depending on the application of various approaches to their selection using the P/BV ratio, and then subjecting selected companies to verification for the actual presence of intellectual capital.

In the context of selecting companies, three approaches were considered:

- i. the P/BV value on a given day,
- ii. average P/BV value for 12 quarters (P/BV taken at the end of each quarter),
- iii. median P/BV for 12 quarters (P/BV taken at the end of each quarter).

The indicated selection of approaches will allow to determine whether there are significant differences in the selection of companies between the short and long term (i. vs. ii. and iii.) and due to one-off high P/BV readings (i and ii. vs. iii.).

On the other hand, the verification for the presence of intellectual capital was based on the aforementioned "tree" metaphor, according to which the intellectual capital hidden in assets invisible in the traditional balance sheet of an enterprise gives visible effects in the form of its stable or improving financial and results condition. For this purpose, two simple criteria were used, referring to two basic economic and financial categories of enterprises, which are sales revenues and total assets:

- the average annual growth rate of revenues from sales and total assets, calculated as the arithmetic mean of their annual changes over the last 5 years – AAG,
- number of years with a year-on-year increase in sales revenues and total assets in the last 5 years – NoY.

For the purposes of the analysis, the verification was assumed to be carried out in relation to 20 companies with the highest P/BV selected under each of the three approaches indicated above. Enterprises with actual intellectual capital should be characterized by relatively higher values of the average annual growth rate of revenues from sales and total assets in the period under consideration and, in fact, their systematic growth (high number of years indicating improvement).

The companies listed on the Warsaw Stock Exchange were selected as the subjects of the analysis, and the data needed to conduct the analysis were obtained from the website of the WSE – www.gpw.pl (P/BV ratios) and the biznesradar website – www.biznesradar.pl (sales revenues and total assets).

4. Research results

The analysis of the effectiveness in identifying enterprises with high intellectual capital value based on the P/BV ratio was carried out in accordance with the methodology outlined in the previous section for companies listed on the Warsaw Stock Exchange. In the first approach to selecting companies (i.), i.e. for a given date, P/BV data as of June 17-th 2022 were taken into account, in the second (ii.) and the third approach (iii.), the average (avg.) and respectively

median (med.) P/BV assuming the values of the ratio from June 17-th 2022 and at the end of 11 previous quarters (from Q1 2022 to Q3 2019). In turn, the data on sales revenues, needed to verify intellectual capital, was adopted for the period from 2016 to 2022, and due to the fact that 2022 was "in progress", the data for this year constituted the sum of sales revenues for the last four quarters, i.e. Q2, Q3 and Q4 2021 and Q1 2022. The 20 companies with the highest P/BV values selected under each of the three approaches are listed in descending order in Table 3, in each case also taking into account the P/BV values for the other two approaches.

Table 3.

P/BV values for the 20 companies with the highest readings (decreasing order) under each of the three approaches to selecting entities with a potentially high level of intellectual capital

No.	P/BV sort by 17-06-2022			P/BV sort by average from 12 quarters			P/BV sort by median from 12 quarters					
	Company	17.06. 2022	avg. from 12 quart.	med. from 12 quart.	Company	17.06. 2022	avg. from 12 quart.	med. from 12 quart.	Company	17.06. 2022	avg. from 12 quart.	med. from 12 quart.
1	ADIUVO	59.23	9.93	2.76	GROCLIN	1.65	51.53	1.14	ZYWIEC	20.70	36.54	25.91
2	XTPL	26.10	21.26	17.48	ZYWIEC	20.70	36.54	25.91	LIVECHAT	16.99	24.13	22.82
3	ZYWIEC	20.70	36.54	25.91	DATAWALK	8.71	28.77	16.34	CDPROJEKT	4.65	19.10	21.14
4	ENTER	19.45	4.33	2.53	LIVECHAT	16.99	24.13	22.82	TSGAMES	2.06	17.86	18.09
5	LIVECHAT	16.99	24.13	22.82	XTPL	26.10	21.26	17.48	XTPL	26.10	21.26	17.48
6	IFIRMA	10.62	6.47	4.72	CDPROJEKT	4.65	19.10	21.14	DATAWALK	8.71	28.77	16.34
7	BRASTER	10.02	2.49	1.25	TSGAMES	2.06	17.86	18.09	PLAYWAY	4.24	10.87	11.51
8	DATAWALK	8.71	28.77	16.34	BIOMEDLUB	2.66	11.22	7.78	DINOPL	8.70	11.19	11.35
9	DINOPL	8.70	11.19	11.35	DINOPL	8.70	11.19	11.35	ULTGAMES	2.10	8.53	9.25
10	VIVID	5.90	2.92	2.40	PLAYWAY	4.24	10.87	11.51	SELVITA	5.31	8.68	8.21
11	11BIT	5.51	7.40	7.24	ADIUVO	59.23	9.93	2.76	BIOMEDLUB	2.66	11.22	7.78
12	SELVITA	5.31	8.68	8.21	SELVITA	5.31	8.68	8.21	11BIT	5.51	7.40	7.24
13	INTERSPPL	5.28	4.02	2.49	ULTGAMES	2.10	8.53	9.25	MOBRUK	4.74	6.24	5.94
14	MOBRUK	4.74	6.24	5.94	11BIT	5.51	7.40	7.24	BUDIMEX	3.86	5.94	5.53
15	CDPROJEKT	4.65	19.10	21.14	IFIRMA	10.62	6.47	4.72	CCC	3.04	6.05	5.41
16	LPP	4.62	5.74	5.29	MOBRUK	4.74	6.24	5.94	LPP	4.62	5.74	5.29
17	VOTUM	4.40	2.97	2.99	CCC	3.04	6.05	5.41	MDIENERGIA	4.00	4.73	4.73
18	PLAYWAY	4.24	10.87	11.51	BUDIMEX	3.86	5.94	5.53	IFIRMA	10.62	6.47	4.72
19	MDIENERGIA	4.00	4.73	4.73	LPP	4.62	5.74	5.29	VIGOSYS	3.19	4.55	4.72
20	SUNEX	3.90	2.58	2.35	R22	2.86	5.61	4.41	WIRTUALNA	3.09	4.62	4.60

Source: own work based on data from the website www.gpw.pl.

At this stage, the first differences between the various approaches to the selection of companies can already be identified. Compared to the P/BV approach for a given day (i.). The 12-quarter average approach (ii.) was indicated by seven other companies (instead of ENTER, BRASTER, VIVID, INTERSPPL, VOTUM, MDIENERGIA and SUNEX appeared GROCLIN, TSGAMES, BIOMEDLUB, ULTGAMES, CCC, BUDIMEX and R22). On the other hand, in the case of selection by the 12-quarter median (iii), ZYWIEC was the new company compared to the two previous approaches.

For a better understanding of the selected companies, Table 4 presents their activity profiles in a shortened manner. Out of 29 entities (a lot of entities repeated under individual approaches to selection based on P/BV), the largest representation can be found in relation to game developers (6 – 11BIT, CDPROJEKT, PLAYWAY, TSGAMES, ULTGAMES, VIVID), and then related entities with broadly understood activities in the field of health protection (4 – ADIUVO, BRASTER, BIOMEDLUB, SELVITA), IT activities in the field of software (3 – DATAWALK, IFIRMA, LIVECHAT), new technologies (3 – R22, VIGOSYS, XTPL) as well as clothing and footwear (3 – CCC, INTERSPPL, LPP).

Table 4.
Characteristics of the activities of the analysed companies

Company	Activity profile
11BIT	Developer of multiplatform games sold all over the world.
ADIUVO	The company focuses on the selection, development, financing and commercialization of innovative projects.
BIOMEDLUB	It deals with the production of medicinal preparations, medical devices and laboratory reagents.
BRASTER	The company has developed a breakthrough method of using liquid crystals in cancer diagnostics.
BUDIMEX	One of the largest construction companies on the Polish market.
CCC	One of the largest European companies in the footwear segment.
CDPROJEKT	The group operates in the dynamically developing industry of electronic entertainment - video games.
DATAWALK	The company deals with technologically advanced solutions for data analysis.
DINOPL	One of the largest chains of medium-sized supermarkets in Poland.
ENTER	Polish charter airline. It serves all the largest charter markets in Europe.
GROCLIN	The Group produces and sells car equipment and accessories (car seat covers).
IFIRMA	The company creates software, recruits IT staff and runs the ifirma.pl online accounting service.
INTERSPPL	The company deals with retail sale of branded sports equipment.
LIVECHAT	An IT company operating on the global market and offering services supporting sales and customer service.
LPP	It deals with the design, production and distribution of clothing.
MDIENERGIA	Specializes in the implementation of wind farm projects, biogas plants and photovoltaic installations.
MOBRUK	The company specializes in waste disposal, alternative fuels and concrete surfaces.
PLAYWAY	One of the leading producers and publishers of computer and mobile games.
R22	Holding of technology companies, offering, among others hosting services and domain sale.
SELVITA	He provides laboratory research and development services commissioned by pharmaceutical companies.
SUNEX	Producer of innovative solutions based on renewable energy sources.
TSGAMES	Producer and publisher of free to play games for mobile devices.
ULTGAMES	A producer of games for desktop computers and mobile devices.
VIGOSYS	A world leader in the production of uncooled, infrared photon detectors.
VIVID	A development studio dealing with the design, production and publishing of video games.
VOTUM	Comprehensive assistance in the field of their representation in personal injury cases and redress.
WIRTUALNA	The owner of one of the two most popular horizontal web portals in Poland - wp.pl.
XTPL	Commercialization of R&D works in order to develop the technology of ultra-precise printing of nanomaterials.
ZYWIEC	A beer producer from the Heineken group with the most diverse product portfolio on the Polish market.

Source: own work based on www.bankier.pl.

Subsequently, the selected companies were verified using the criteria for changes in sales revenues and total assets – average annual growth over a 5-year period (AAG) and the number of years showing improvement over a 5-year period (NoY). The obtained values of the above-mentioned criteria together with the annual changes in sales revenues and total assets for the analyzed companies are presented in Table 5.

Table 5.

Results of verification of the intellectual capital level in the analysed companies based on changes in sales revenues and total assets

Company	Sales revenues							Total assets						
	2018	2019	2020	2021	2022	AAG	NoY	2018	2019	2020	2021	2022	AAG	NoY
11BIT	328%	-13%	22%	-19%	4%	64%	3/5	125%	42%	20%	18%	3%	42%	5/5
ADIUVO	-52%	-36%	-47%	70%	-4%	-14%	1/5	24%	-8%	-6%	-20%	4%	-1%	2/5
BIOMEDLUB	3%	21%	3%	2%	6%	7%	5/5	-29%	-6%	6%	36%	5%	2%	3/5
BRASTER	118%	-33%	-67%	128%	-21%	25%	2/5	-26%	-10%	-27%	-34%	-2%	-20%	0/5
BUDIMEX	16%	2%	11%	-6%	10%	7%	4/5	-9%	22%	12%	-8%	0%	3%	3/5
CCC	13%	24%	-4%	35%	6%	15%	4/5	100%	6%	-7%	13%	-3%	22%	3/5
CDPROJEKT	-22%	44%	310%	-58%	-10%	53%	2/5	15%	25%	106%	-25%	2%	24%	4/5
DATAWALK	-1%	103%	348%	96%	13%	112%	4/5	-55%	156%	282%	-2%	36%	83%	3/5
DINOPL	29%	31%	32%	32%	20%	29%	5/5	34%	32%	28%	29%	7%	26%	5/5
ENTER	36%	25%	-71%	138%	12%	28%	4/5	39%	45%	-1%	2%	3%	18%	4/5
GROCLIN	-21%	-49%	-72%	-100%	-1753%	-399%	0/5	-56%	-58%	-42%	-27%	-3%	-37%	0/5
IFIRMA	14%	21%	15%	38%	18%	21%	5/5	8%	16%	15%	36%	5%	16%	5/5
INTERSPPL	32%	-14%	-25%	48%	112%	31%	3/5	5%	6%	-4%	-8%	455%	91%	3/5
LIVECHAT	22%	20%	37%	24%	8%	22%	5/5	26%	42%	40%	13%	27%	30%	5/5
LPP	14%	23%	-21%	79%	5%	20%	4/5	28%	79%	8%	37%	11%	32%	5/5
MDIENERGIA	-21%	31%	44%	-2%	-6%	9%	2/5	-4%	26%	0%	7%	-7%	4%	2/5
MOBRUK	41%	41%	37%	50%	-7%	32%	4/5	4%	9%	10%	24%	-27%	4%	4/5
PLAYWAY	80%	66%	38%	29%	2%	43%	5/5	59%	74%	117%	25%	6%	56%	5/5
R22	32%	34%	62%	-6%	12%	27%	4/5	20%	23%	17%	54%	49%	33%	5/5
SELVITA	30%	48%	36%	122%	18%	51%	5/5	51%	25%	141%	113%	6%	67%	5/5
SUNEX	48%	8%	36%	54%	25%	34%	5/5	12%	33%	21%	55%	16%	28%	5/5
TSGAMES	326%	109%	140%	10%	-10%	115%	4/5	274%	95%	205%	61%	-7%	125%	4/5
ULTGAMES	259%	88%	75%	52%	-1%	95%	4/5	98%	133%	500%	2%	-9%	145%	4/5
VIGOSYS	38%	15%	25%	34%	-3%	22%	4/5	60%	42%	31%	31%	7%	34%	5/5
VIVID	-1%	13%	55%	-16%	8%	12%	3/5	-18%	13%	10%	-46%	-2%	-8%	2/5
VOTUM	12%	35%	6%	31%	7%	18%	5/5	32%	13%	7%	16%	20%	18%	5/5
WIRTUALNA	22%	25%	-11%	38%	9%	17%	4/5	19%	8%	9%	2%	11%	10%	5/5
XTPL	3%	-9%	11%	105%	20%	26%	4/5	24%	-12%	71%	-17%	-4%	12%	2/5
ZYWIEC	49%	7%	5%	-8%	5%	12%	4/5	1%	39%	0%	0%	18%	12%	4/5

Source: own calculations based on data from the website www.biznesradar.pl.

As can be seen from the obtained calculation results, the high level of intellectual capital can be negatively verified, in particular in relation to the companies ADIUVO and GROCLIN, which stand out in terms of the negative average annual growth of revenues from sales and net assets and the low number of years with an increase in the above-mentioned values in the analyzed 5 summer period. It is also worth noting here that these two companies are also characterized by the largest P/BV spread among the analyzed entities within the three analyzed approaches to selection (Fig. 1).

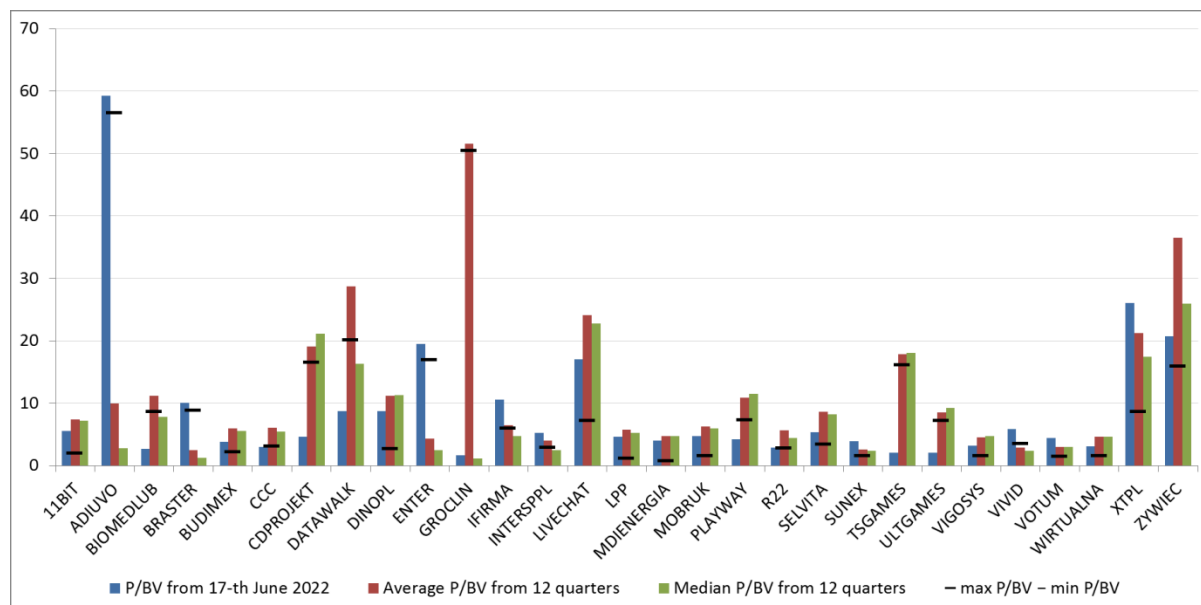


Figure 1. P/BV ratios of the analyzed companies in various perspectives (data as of the day, average and median for 12 quarters) with the difference between the highest and the lowest value.

Source: own work.

Certain objections as to the credibility of indications of a high level of intellectual capital, mainly due to changes in the scope of total assets, may also be raised in relation to BRASTER and VIVID. In the case of other entities, positive annual average increases in revenues were recorded, and in the vast majority a high or full number of years with an increase in revenues and total assets in the analyzed 5-year period. The P/BV spread under the three considered approaches to selection for these companies was also much smaller than for the two previously distinguished (ADIUVO, GROCLIN).

5. Summary

The research carried out on the application of the difference between the market value and the book value or their quotient in the form of the P/BV ratio as a measure of intellectual capital allows us to conclude that this method is simple, but strongly imperfect. Its main burden is the high dynamics of changes in their market quotations (prices), which often occurs in the case of listed companies, which may lead to distortions in the measurement or assessment of the intellectual capital level of the analyzed entities. Hence, this method is more suitable for the initial identification of entities with a potentially high level of intellectual capital than for its precise measurement.

Nevertheless, even if its application is limited to the aforementioned identification, in order to obtain more objective results, it is worth relying on quotations or P/BV ratios of the analysed companies, in the form of an average, or even better a median, from a longer period (preferably

several years). As a result, single high readings, often the result of a temporary increase in emotions among investors, will only have a limited impact on the situation of the analysed entities.

In addition, indications of a high level of intellectual capital of the surveyed entities, regardless of the approach to their identification using the P/BV ratio or the difference in market and book value (data from a given day or average or median from a longer period), it is worth verifying based on the assessment of changes in their economic and financial situation, also in a several-year time horizon, referring to the "tree" metaphor (invisible resources create visible effects). In the study carried out in this article, a simple verification, limited to the most basic financial parameters of enterprises, i.e. sales revenues and total assets, allowed to detect a few distorted cases of enterprises with an overstated level of intellectual capital.

In the course of broader, more detailed research, it is possible to expand the scope of this verification to other dimensions of the assessment of the economic and financial situation of enterprises (analysis of profitability, liquidity, debt, operational efficiency) or to test ready-made solutions, such as the F-Score model (Piotroski, 2000).

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CONDITIONS OF INTRODUCING CIRCULAR BUSINESS MODELS INTO CRAFT BREWERIES – LCA APPROACH

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Purpose: The objective of the paper is to assess the craft breweries sector with regard to the possibilities of introducing circular economy solutions and especially circular business models.
Design/methodology/approach: The assessment is made with life cycle assessment (LCA) method for single specific case of a craft brewery but the interpretation and conclusions are referred to the whole sector. The approach here is to focus on specific case of existing craft brewery and use its primary data to assess its regular business model and to compare it with possible circular business model (CBM).

Findings: According to the assessment of life cycle stages, the dominating role of internal factors in decision making towards CBM is a feature of production process only. All the other stages require strong commitment of external actors, especially while cultivation processes, packaging production and distribution are concerned. The decision of a single craft brewery itself has rather limited contribution to CBM requirements.

Research limitations/implications: The important limitation of this research is related to the economic outcome of CBM oriented changes that are not considered here. Probably, the decision making process would be much more susceptible to the economic constrains and should be considered once again with regard to current market opportunities of any decision making unit.

Practical implications: Certainly turning into CBM requires wide cooperation with different stakeholders, both from the down and upstream processing. It seems that the only solution is to build up a network of organizations, both from craft brewing industry and from other industries that could use its waste as a secondary raw material, in order to close down the open loops.

Originality/value: The results of the research provide meaningful insight into business circularity issue from the perspective of craft breweries. The results show that small scale of craft breweries operations might be a significant factor determining the possible way towards CBM.

Keywords: circular economy, circular business models, craft breweries, environmental life cycle assessment (LCA).

Category of the paper: Case study.

1. Craft breweries within the economy of circularity

Global economy is nowadays strongly directed towards circularity through legislation and regulation, economic incentives and innovation and conceptual support. The challenge though, is not only to accomplish it in a technical or organizational sense but also to reach it in both economically and environmentally sound manner. The challenge is imposed to all economic sectors as well as consumers and their habits. From the perspective of beer production sector, the circularity challenge should be referred to cultivation of beer relevant crops, malting and brewing processes, distribution modes and practices and consumption patterns, especially with regard to the packing.

Circular economy (CE) refers to the synchronization of forward and backward flows of goods and materials in a way to support the closure of all the loops, through application of different processes, such as reuse, repair and refurbishment, remanufacturing and recycling (EMF, 2013; Zink, Geyer, 2017). CE aims to minimize input materials from fossil or non-renewable sources in a production system and maximize the reuse of these materials within the same system aiming at the elimination of waste streams (Barros, Salvador, de Francisco, Piekarski, 2020; Korhonen, Nuur, Feldmann, Birkie, 2018). CE practices can offer opportunities for reducing emissions and waste generation in all the sectors, including agricultural sector through the circulation of raw materials, agricultural waste, and manure (Jurgilevich et al., 2016). Agricultural sector has by far the biggest potential of developing CE solutions (Barros et al., 2020).

Proposed CE solutions should be also due to environmental, economic or social monitoring that would be capable of not only measuring the degree of circularity of a system but also the extent to which circularity enables the achievement of sustainability goals (Helander et al., 2019). It seems that only by adapting systems perspective CE monitoring could contribute to the identification of the relationship between circular and environmental, economic or social indicators (Rufi-Salis, et al., 2021). Many researchers, accepts a life cycle approach as a systematic evaluation of the environmental impacts and benefits resulting from the implementation of circular strategies in different life cycle stages of a product, system or service (Haupt, Zschokke, 2017; Niero, Kalbar, 2019; Pauliuk, 2018; Sauv e, Bernard, Sloan, 2016). Additionally, life cycle approach could contribute to the detection of cases where circularity does not necessarily result in reduced environmental impact (Niero, Kalbar, 2019). It is also not clear how CE mainstreaming refers to the implementation of sustainability priorities, which represent much wider and more holistic approach towards the development of human kind. The interrelation between sustainability and circularity tends to be treated as a strategic vs. operational approaches, where sustainability is treated as a strategic goals, while circularity as one of the tools to implement it (Harris, Martin, Diener, 2021; Nitkiewicz, 2021).

If we take a closer look at the implementation process of CE we could refer to its key elements (physical changes) and enablers (mental changes). Key elements could be defined as (1) prioritize regenerative resources, (2) use a waste as a resource and (3) stretch the lifetime, while enabling factors are (a) rethink the business model, (b) team up to create joint value, (c) strengthen and advance knowledge, (d) design for future and € incorporate digital technology (Goodwin Brown et al., 2021).

Figure 1 presents the conceptualization of five circular business models as proposed by Lacy et al. (2014). All of proposed variants are at least partially appropriate for craft beer manufacturing. Circular Supplies BM are referring mainly to the cultivation of different types of cereals and hops for beer production, as well as, for beer packaging policy. Resource Recovery BM is most useful while grain and packaging waste is concerned. BM of Product Life Cycle Extension and Sharing Platforms have a very limited usefulness with regard to craft brewing process, with some extension to multiple use kegs, providing its repair and refurbishing systems or sharing production and bottling capabilities between different actors. Finally, Product as a Service BM could be based on switching to serving without packaging system.

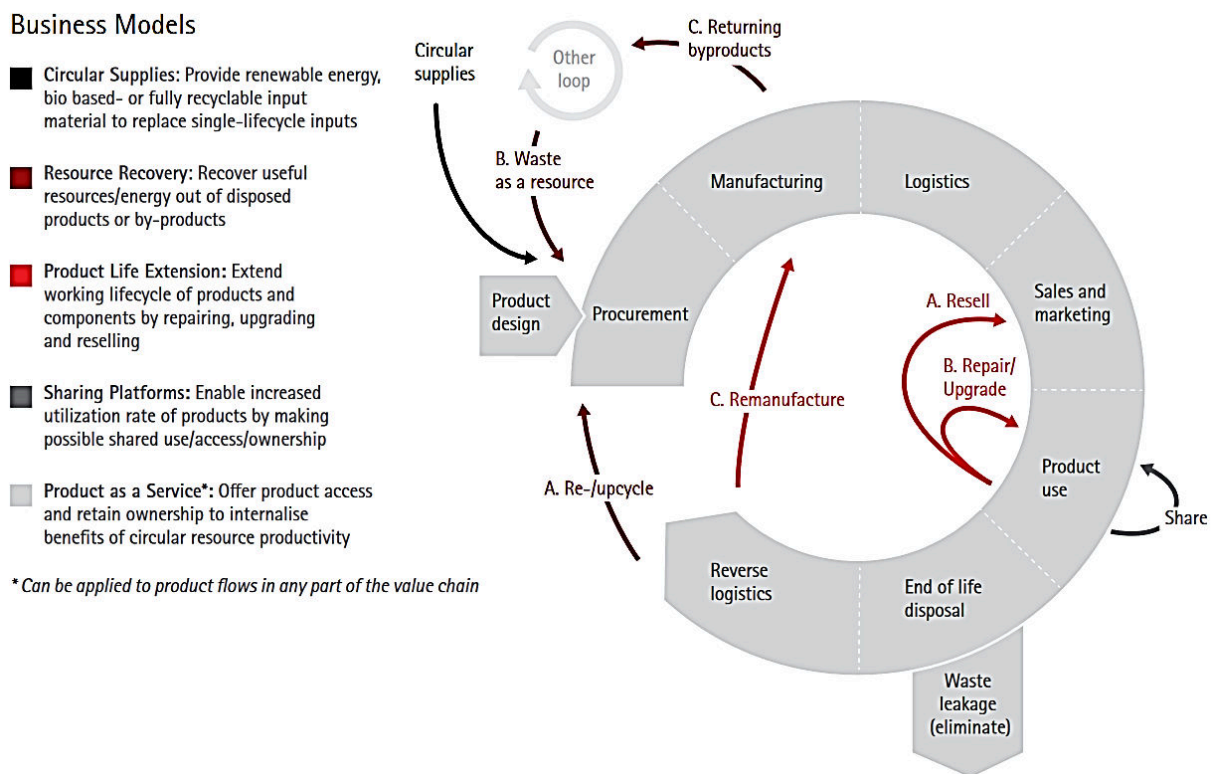


Figure 1. The five circular business models (Lacy et al., 2014).

It seems that the introduction of the circular economy on the ground of brewing industry is very much related to the reduction or elimination of industrial waste, which can enable new circular value propositions and biomass valorization in small breweries' value chains (Bonato, Augusto de Jesus Pacheco, Schwengber ten Caten, Caro, 2022). The approach that could be useful here is a life cycle originating cradle-to-cradle strategy that could assist breweries in implementing circular solutions (Braungart, McDonough, Bollinger, 2007; Niero, Negrelli,

Hoffmeyer, Olsen, Birkved, 2016), eventually bringing the benefits for the society (de Pauw, Karana, Kandachar, Poppelaars, 2014).

The studies within the scope of assessment of brewing industry environmental impact and circularity potential have used quite different approaches and focuses. Rajaniemi et al. (2011) have focused on the cultivation process of different types of inputs for brewing process and showed significant differences in environmental impacts between feedstock types. Another process that is assessed to have the highest contribution is packaging and its influence on distribution system (Koroneos et al., 2005; Cordella et al., 2008; Cimini et al., 2016). The different types of beer are also under investigation concerning the environmental impacts. The studies are showing significant differences between the share of brewing processes within overall impacts while different types of beer are concerned (Amienyo, Azapagic, 2016; De Marco, Miranda, Riemma, Iannone, 2016). The brewing stage has been found to be a relatively minor contributor to the overall environmental impacts of beer life cycle (Amienyo, Azapagic, 2016; Cimini, Moresi, 2016) and it is yet confirmed that this is also the case for small scale beer producers that do not have the large scale production volumes (Morgan, Styles, Lane, 2021, 2022).

The objective of the paper is to assess the craft breweries sector with regard to the possibilities of introducing circular economy solutions and especially circular business models. The perspective of the assessment is twofold and consist of decision making process and environmental soundness of possible actions. The craft brewing entity is defined in a way to underline the differences between craft and industrial brewery. The term “craft brewery” is defined as smaller and independent firm that deploy traditional production processes (as opposed to the industrial practices of large scale breweries); emphasize quality, flavor, and diversity; and produce limited quantities (Gatrell, Reid, Steiger, 2018; Gómez-Corona, Escalona-Buendía, García, Chollet, Valentin, 2016; Hieronymus, 2015). The assessment is made with life cycle assessment method for single specific case of a craft brewery but the interpretation and conclusions are referred to the whole sector.

2. Methods

Life Cycle Assessment (LCA) is very well suited method to assess the environmental impacts of sustainability and CE strategies. LCA is a science-based technique for assessing the environmental impacts associated with entire product life cycles, which can provide technical support to decision-makers. LCA procedure enables the assessment of environmental impacts and its trade-offs and may also be applied to identify the most promising CE strategies and options for improving the environmental performance of society's consumption and production patterns (Pena et al., 2020).

In order to support CE decisions, methods for assessing and quantifying the environmental benefits of CE strategies, such as LCA, are thus increasingly challenged by the need to reflect the systemic context of an organization (Schulz, et al., 2020).

Life Cycle Assessment (LCA) is a science-based technique for assessing the environmental impacts associated with entire product life cycles, processes and organizations, which can provide technical support to decision-makers. LCA as a methodological framework seems to be perfectly suited to assess the circular economy solutions as well as circular business models from the perspective of environmental aspects. LCA procedure enables the assessment of environmental impacts and its trade-offs and may also be applied to identify the most promising CBM and options for improving the environmental performance of society's consumption and production patterns (Pena et al., 2020).

In order to support CE development, such methods as LCA are increasingly challenged by the need to reflect the systemic context of an organization (Schulz et al., 2020). LCA finds its multiple uses within food and agricultural sectors, which also includes breweries and its supply chains and operations. There are many studies within the literature that apply LCA for the assessment within different scopes and context. From the perspective of breweries it is important to mention more general holistic approaches (Morgan et al., 2021) or approaches that are focusing on final stage of the beer life cycle (Ashraf, Ramamurthy, Rene, 2021; Bonato et al., 2022) or beer packaging specifically (Morgan et al., 2022).

Since the issue of CE is not only focused on environmental aspects the use of LCA and its scope should be considered as an element of a wider, decision support system. According to Wernet et al. (2016) the allocation of specific end-of-life and side flows, which are directed towards other life cycles, would be a critical issue in CE solutions assessments. Therefore, the combination of “cradle to cradle” definition of system boundaries with small scale consequential approach is the best possible, and very often the only feasible coverage for circular solutions.

2.1. Goal and scope definition

Since the objective of the paper is to assess the craft breweries sector with regard to the possibilities of introducing circular business models the main goal of LCA use is to assess the ecological aspects of such a change. Therefore, the assessment has comparative orientation and shows the possible changes within environmental impacts while CBM is introduced. The approach of the assessment is based on LCA screening and encompasses “cradle-to-cradle” life cycle perspective. The functional unit for the assessment is defined as life cycle of a yearly production of 85 000 liters of craft beer within two scenarios: 1) regular and 2) circular. The basic assumptions of material flows within life cycles, including key differences between the scenarios, are presented at Figure 2 and Figure 3. Black colored arrows represent downstream processing of a craft beer while red and turquoise color represent waste and revers

flows respectively. Straight line arrows symbolize flows directly related to the craft beer manufacturing while dotted arrows symbolize indirectly related flows.

The major difference between the scenarios is related to the allocation of the end-of-life processes and side flows. In regular business model scenario (RBM) the “cut-off” rule is used and end-of-life processes and side flows, which are not further affiliated to the craft beer manufacturing process are excluded from the assessment (Figure 2). This is regular practice with LCA, where side processes as a whole cannot be attributed to the primary production. For example spent grain comes out of the craft beer manufacturing process and it is not investigated further concerning its possible processing but is considered as a generic waste stream.

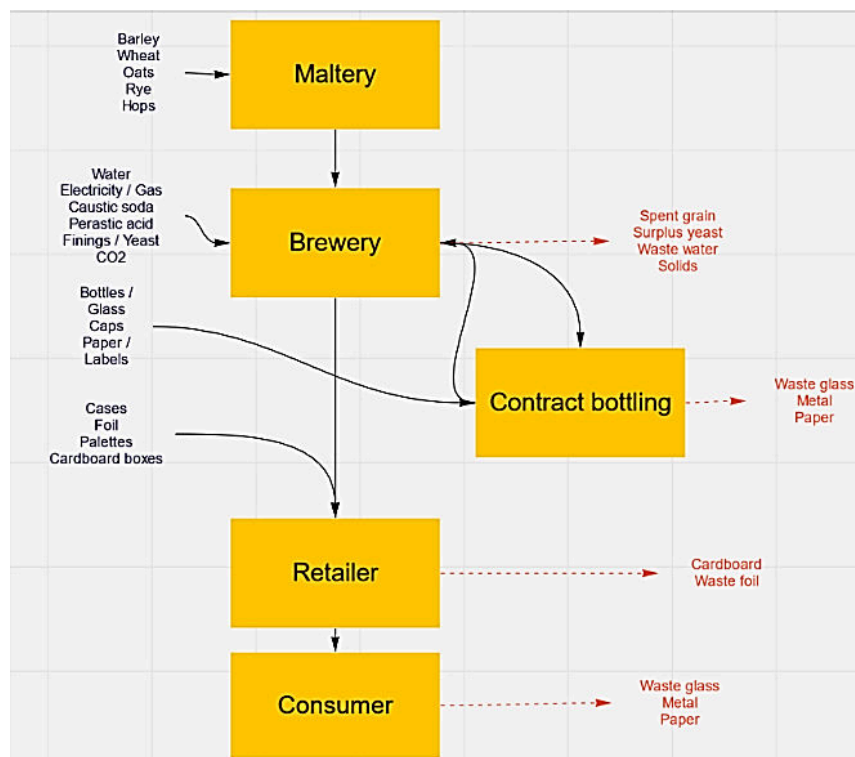


Figure 2. Regular business model scenario of craft beer life cycle.

In circular business model scenario (CBM) the assumption is made that all the flows are totally or partially attributed to the craft beer manufacturing process (Figure 3). All the flows are tracked to the point of its final fate, which is assumed to be recapture of its value and bringing them to the status of usable resources or energy. The CBM takes into account both kinds of contributions: positive environmental impacts related to recovering of the resources (avoided impacts) and negative impacts related to their processing, which is necessary to recover its value. In general, the implementation of circular business model within craft brewery should lead to directing all of the waste flows towards its recovery. The possible treatments and processing of a brewery originating waste flows are very diversified and numerous. Therefore, only the most common treatment with regard to the biggest flows is considered here.

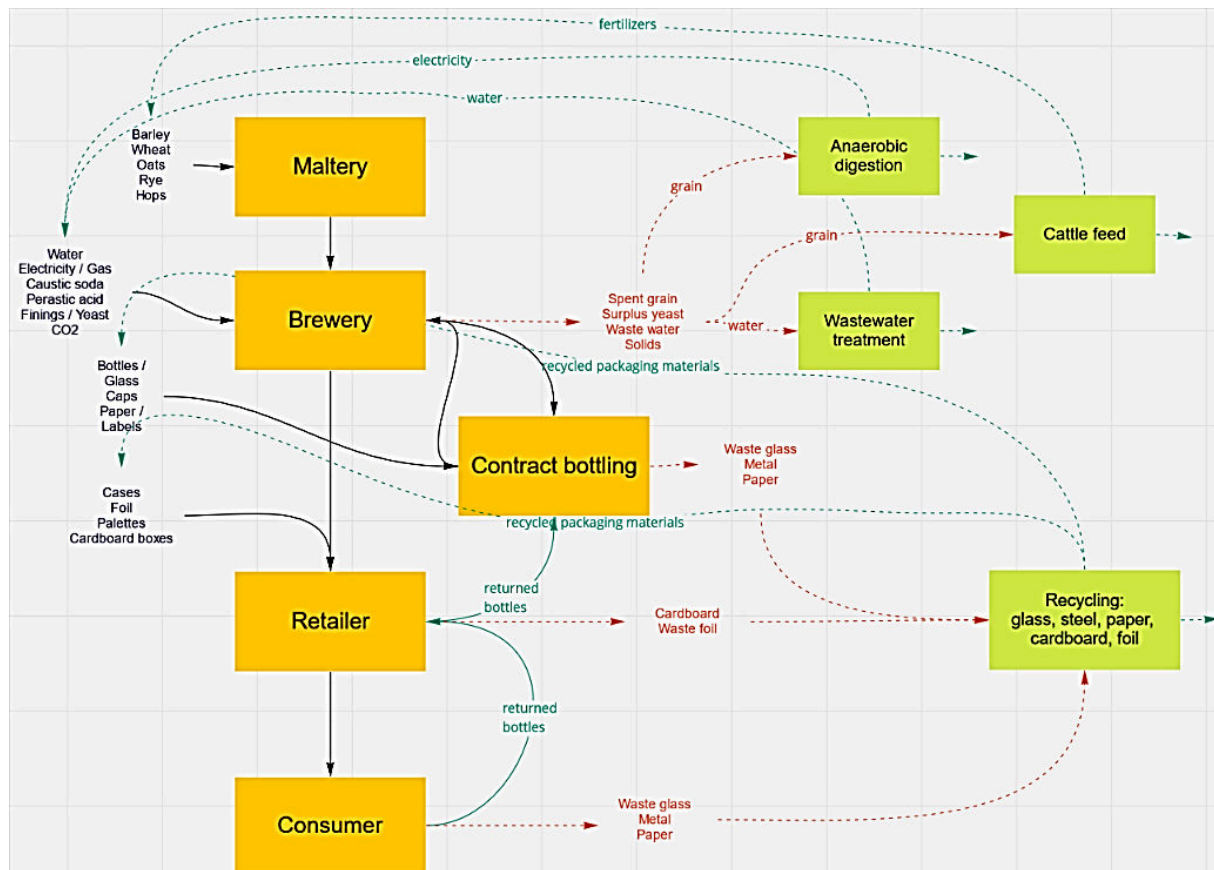


Figure 3. Circular business model scenario of craft beer life cycle.

The difference between the scenarios is visible on the level and type of open flows. In RS the open flows relate to the waste streams or potential secondary material but not processed to serve as one. On the other hand, CS has all the waste flows returned into the functional unit life cycle or to other life cycles as a ready secondary material. The returned flows are not too numerous while craft beer manufacturing process is concerned. It could be a wastewater treatment system, leading to the recovery of water used in brewing process, or packaging, like returnable bottles, that could fulfil its function several times. Most of the waste flow could be recovered but within different life cycle systems, contributing eventually to the original one (i.e. energy produced out of anaerobic digestion could feed the brewing process). While craft breweries are concerned, the scale of operations could be an organizational and economic obstacle in using this reverse flows directly.

The comparison of the two scenarios will bring out the differences in environmental impacts and its potential reasons.

2.2. Life cycle inventory

The analysis of material, energy and waste flows within considered life cycle is based on primary data from a single craft brewery. Primary data covers the brewing process, the distances and means of transport within supply and distribution chains and share of returned flows and recycled materials. All the flows related to the supply, end-of-life treatment and recovery rates

are modelled with secondary data from the literature and ecoinvent 3 database. Table 1 presents the inventory data for both scenarios included in the study.

Table 1.
Inventory for craft beer regular life cycle

Specification	Unit	Quantity
<i>Outcome</i>		
Beer	l	85000
<i>Resources</i>		
Water	l	430000
<i>Materials/fuels</i>		
Natural gas, high pressure	m3	83,6077
Heavy fuel oil	kg	0,42075
Biogas, from grass	m3	14,5146
Natural gas, low pressure	m3	4,1837
Diesel	kg	0,12155
Ammonia, liquid	kg	0,6477
Phosphorous chloride	kg	0,000357
Barley grain	kg	15980
Hop, organic, intensive	kg	136
Fodder yeast	kg	50
Ethoxylated alcohol (AE11)	kg	68
Chlorosulfonic acid	kg	25,5
Propyl amine	kg	25,5
Dimethenamide	kg	25,5
<i>Electricity/heat</i>		
Electricity, high voltage	kWh	49500
<i>Emissions to air</i>		
Co(II)	kg	896,6072
Nitrogen oxides	kg	0,41905
Sulfur oxides	kg	0,09265
<i>Emissions to water</i>		
Waste water/m3	m3	15,231405
Organic compounds (unspecified)	kg	77,32638889
Ammonia	kg	0,01275
Organic chlorine compounds (unspecified)	kg	0,0000085
<i>Final waste flows</i>		
Packaging waste, unspecified	ton	1,845605
Production waste	ton	0,0017
Waste to recycling	ton	1,8428
Waste, toxic	ton	0,000127245
<i>Packaging</i>		
Steel, low-alloyed	kg	260
Packaging glass, brown	kg	41600
<i>Transport</i>		
Transport, freight, light commercial vehicle	kgkm	36990
Transport, freight, lorry 3.5-7.5 metric ton, EURO5	kgkm	3398970
Transport, freight, lorry 7.5-16 metric ton, EURO5	kgkm	1815182
Transport, freight, lorry 16-32 metric ton, EURO5	kgkm	7679782

The inventory data presented here is used for all of the scenarios considered but for circular ones is modified in accordance to additional assumptions as presented in the following chapters. The change in data use is also visible at the level of secondary data and its records within ecoinvent database. RBM are modelled with “cut-off” approach while CBM are modelled with consequential approach.

2.3. Methodology for life cycle impact assessment

In order to give full coverage for possible life cycle impacts and include global as well as European perspective the ReCiPe method is used for the assessment. The impacts are calculated with SimaPro software and the endpoint variant of ReCiPe (H) V1.08 indicator. The ReCiPe method has a wide coverage within the literature and it is not furtherly described here (Huijbregts et al., 2017).

3. Results

Figure 4 presents the LCA results for different variants of craft beer life cycle. The results are presented for both scenarios, circular and regular, but for circular scenario one additional variant is created. CBM scenarios take into account different rates of bottles return, namely of 40% and 100%. 100% scenario is a hypothetical one, just to show the change of impacts related to the return rate. In 40% return rate CBM scenario it is assumed that all the remaining glass is recycled. Additionally, the benefits of using spent grain as an animal feed as well as treating waste water are taken into account. Moreover, the closed loop of used bottles needs some additional resources use due to washing process (washing agents, water, energy and heat) as well as additional transportation mass due to heavier bottles (22% heavier than non-returnable bottles) as observed by Morgan et al. (2022).

The processes of malting and brewing have the highest impact within RBM scenario. In the CBM scenario the impact is decreased due to the provision of spend grain as a secondary resource to the market and wastewater treatment for closed circuit. The bottling process has the highest overall impact within RBM and CBM scenarios, but with a significant vulnerability to the return rate of the bottles. When it is settled to 100% the bottling process is turning into the 3rd highest process. It is important to observe the difference between RBM and 40% CBM, which are close to current business practices, which is in favor of RBM scenario. It means that additional pressures that are appearing due to organizing close circuit of returnable bottles are overwhelming the benefits of decreasing the use of raw glass.

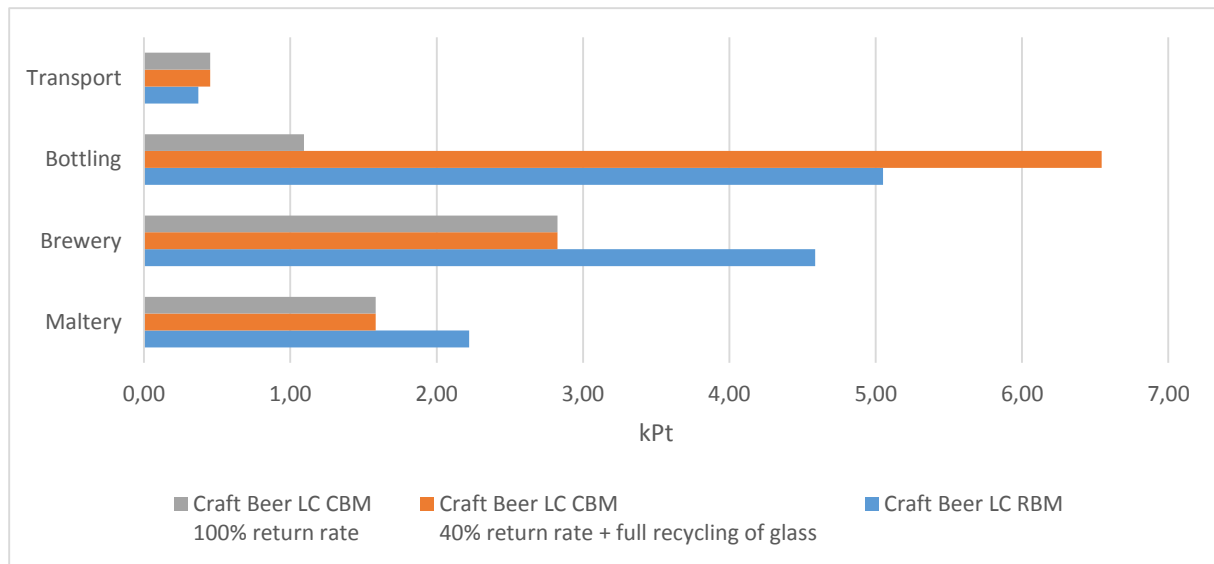


Figure 4. LCA results (ReCiPe single score weighted indicator) for different variants of craft beer life cycle.

Finally, the transportation process has the lowest impact in all of the scenarios but interestingly some more significant within CBM. This is due to some additional transport needed to close down the loops and heavier bottles used to increase their mechanical strength and durability.

4. Discussion

Table 2 presents decision making context for CBM implementation in craft breweries. The key parameter for decision making process is defined with regard to the capability of a single craft brewery to introduce CBM on its own and within its organizational scope (denoted as “Internal”) or a necessity to introduce it with cooperation with some other actors from its value chain (“External”). Each life cycle phase could be characterized by different changes or ventures that could turn BM towards circularity. The changes presented in table 2 are examples of circular ventures and characterized with potential change of environmental impact as measured with LCA. The symbol of “+” indicates the positive change of environmental impacts, while “-“ indicate negative consequences. The negative consequences that could appear are usually related to the energy use and infrastructure needed for extra processing. The impacts are also taking into account the effect of scale that could undermine some ventures. As an example we could bring out a wastewater treatment installation that could perfectly fit to the industrial scale production facility while for small scale craft brewery it is rather a burden in economic and eventually in environmental scale.

Table 2.*The decision making context for CBM implementation in craft breweries*

Life cycle stages	Decision context	Changes towards CBM	Environmental impact (LCA results)
Supply	External	Biological cultivation Local cultivation and supply Verification of suppliers	+ / – + + / –
Production	Internal/External	Closed water circuit Biogas production Animal feed production	+ / – ++ / – ++ / –
Packaging	External/Internal	Returnable bottles Keg based distribution	+ ++
Distribution/Serving	External/Internal	Serving without individual packaging	++
Consumption	External	Motivation to return packaging	+

According to the assessment of life cycle stages, the dominating role of internal factors in decision making towards CBM is a feature of production process only. All the other stages require strong commitment of external actors, especially while cultivation processes, packaging production and distribution are concerned. The decision of a single craft brewery itself has rather limited contribution to CBM requirements.

5. Conclusions

The results of the study show also limited possibilities of small scale breweries to achieve major breakthrough towards CBM and its direct operationalization. While for large industrial breweries the effects of scale are justifying the closures of material loops, for craft breweries it is undeniably more difficult. Firstly, the investment costs of waste treatment infrastructure are simply not bearable or feasible by small scale breweries. Secondly, relatively small streams of recoverable waste are not large enough for potential business partners.

The important decision is not only determined by scale of operations but also on the distribution model. Craft breweries could be organized in a different ways and turning into CBM could also mean changing the operational form into on-site serving ones such as brewpub or taproom brewery.

Certainly turning into CBM requires wide cooperation with different stakeholders, both from the down and upstream processing. It seems that the only solution is to build up a network of organizations, both from craft brewing industry and from other industries that could use its waste as a secondary raw material, in order to close down the open loops.

Finally, it is worth to notice that most of the circular loops proposed to craft breweries are quite demanding while additional processing is concerned. It is not a problem if the processing installations already exist and are easily reachable by craft breweries. But if it is also an issue of not existing infrastructure or distant connections, possible environmental benefits could be easily consumed by the necessary environmental burdens. The important limitation of this research is related to the economic outcome of CBM oriented changes that are not considered here. Probably, the decision making process would be much more susceptible to the economic constrains and should be considered once again with regard to current market opportunities of any decision making unit.

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DIVERSIFICATION OF REVENUE AS A CONTEMPORARY CHALLENGE IN THE ACTIVITIES OF PUBLIC BENEFIT ORGANIZATIONS

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Purpose: The aim of the study is to identify instruments to generate revenue among the largest Polish Public Benefit Organizations (PBOs). The study also assesses the studied PBOs in terms of their total revenue alongside their individual components (public and private sources) relative to the instruments of generating income they employ.

Design/methodology/approach: The 100 largest Polish public benefit organizations were selected as the subject of the research, in which a quantitative approach was adopted. In order to identify the 100 largest PBOs and compile a database containing basic information about each, over 8800 statements and technical reports were analyzed. Subsequently, in order to identify individual instruments of revenue generation implemented the 100 largest PBOs, the researchers examined the content of the websites of individual organizations. Computations were carried out to obtain the essential statistics of the quantitative variables concerned, while non-parametric tests were used to establish relationships between the variables.

Findings: The article focuses on determining the relationship between the number of earning instruments used (revenue diversification) and the economic outcomes (construed as total revenue and revenue from private sources). The article demonstrates that total revenue is not as efficient a parameter to link the number of earning instruments as the share of private revenue in total revenue. This is due to the fact that both the quantity of earning instruments used and the proportion of private revenue in total revenue attest to a pro-entrepreneurial attitude of the organization.

Research limitations/implications: Only the 100 largest PBOs out of more than 8000 organizations were surveyed (in future, all PBO groups should be examined as opposed to the largest organizations alone). The size of the organization was defined by only one parameter, i.e. the volume of total revenue. The study examined the number of earning instruments exclusively to align them with the revenue generated by the PBOs. The effectiveness of individual instruments was not analyzed.

Practical implications: For organizations which aim to be pro-entrepreneurial (i.e. increase their revenue levels and, in particular, the share of private revenue in total revenue), using more earning instruments is a better strategy than concentrating and developing a limited number of such solutions.

Social implications: Organizations which achieve greater revenue are able to pursue their mission effectively (e.g. help more end beneficiaries, undertake more efficient information and promotional activities targeting a specific social issue, etc.).

Originality/value: The relationship between the number of earning instruments applied online and the basic economic parameters of PBOs (such as their degree of economization) has not been examined previously. As a result, this study identifies new relationships which should be explored further through research.

Keywords: public benefit organization, revenue diversification, economization.

Category of the paper: Research paper.

1. Introduction

The concept of revenue diversification derives from the Modern Portfolio Theory formulated in 1952 by Markowitz (1952), which describes the process in which an investor selects a particular investment portfolio (Carroll, Stater, 2008, p. 948). Revenue diversification is directly linked to the concept of economization in non-profit organizations, whereby the latter shift their financial dependence on the public sector to self-generated income from so-called social entrepreneurship (Khieng, Dahles, 2015, p. 218). Thus, the idea is that non-profit organizations work towards their own means to gain greater independence, and the economization of the non-profit sector can be regarded as an attempt to "escape" from the peculiar trap of dependence on public administration (Wygnański, 2008, p. 9). The issue of non-profit organizations seeking economization and adopting an entrepreneurial approach in the modern market economy causes considerable controversy among both scholars and management practitioners as both proponents and opponents of market orientation among non-profit organizations have voiced their respective arguments in the debate (Deborah, Keely, 2009; Jutta, Schneiker, 2018). Also, the very degree to which non-profit organizations are commercialized raises a number of questions. Certain organizations function similar to administrative bodies, and their organizational culture is similar to what one sees in the public sector, whereas others resemble organized businesses in how they function. It is underlined in the relevant literature that many NGOs attach only minor significance to gaining a competitive advantage (Huczek, 2012, p. 33). Others, however, are beginning to function in the manner of typical commercial enterprises, and this also leads to much controversy and allegations of excessive departure from the mission of a non-profit organization. Generally, economization means a chance to raise funds for the organization's own activities; to regain "inner control", abandon the attitude of "soliciting handouts" and renounce total dependence on public and private donors; the possibility of avoiding a situation in which the organization becomes an "extension" of public institutions or a hostage to philanthropic favor (Wygnański, 2008, p. 9). Opponents of this approach stress the danger of non-profits becoming too similar to for-profit enterprises (Gibelman, Gelman, 2004) and the conflict of priorities (Foster, Bradach, 2005; Chetkovich, Frumkin, 2003), or they underscore the risks involved (Gras, Mendoza-Abarca, 2014), etc.

In turn, advocates of economization invoke the crisis of the welfare state (Tzifakis et al., 2017; Nga, 2015), the fact that such organizations should operate according to specific business models (Grassl, 2012; Cooney, 2011; Rodríguez, 2016; McDonald et al., 2021; Cucari et al., 2020) and generate socio-economic values (Weerawardena et al., 2021; Teegen et al., 2004).

A number of social enterprises emerge from donor-dependent non-profit organizations which are transitioning towards financially independent social enterprises. This is due in part to a decline in foreign aid and external funding, as well as to the increased competition that volatile economic circumstances bring about (Schoonwinkel et al., 2021). Such a transformation, however, requires the ability to use a range of earning instruments spanning both private and public sources.

As of 2004, Polish non-profit organizations which possess legal personality can apply for an additional status: a Public Benefit Organization. Currently, Public Benefit Organizations (PBOs) are one of the most important elements in the Polish landscape of non-profit organizations, functioning under the Act of 24 April 2003 on public benefit activity and voluntary service (Journal of Laws No. 96, item 873, 2003). Having obtained PBO status, such bodies have, e.g. the opportunity of receiving 1% transfers from personal income tax, are exempted from certain fiscal duties (corporate income tax, real estate tax, civil law transaction tax, as well as stamp duties and court fees), or may disseminate information on their activities via public radio and television free of charge. However, in order for an organization to obtain that status, a number of conditions have to be met. For instance, it is required that an NGO may engage in economic undertakings only as an additional activity to the efforts for public benefit, provided that the entire revenue of the organization is intended for the public benefit activity. PBO status also entails a number of obligations, such as accurate and transparent reporting (each public benefit organization must provide its financial statements and a report on its activities by 15 July of the year following the year for which the statements are submitted, on the website of the National Freedom Institute). Public benefit organizations account for approximately 10% of all registered third-sector organizations in Poland (with approximately 9000 PBOs). At the same time, they are often the largest and most active organizations among all non-profit organizations in Poland. At the end of 2019, there were 9400 PBOs operating in Poland (some of which were actually inactive, however). PBOs, therefore, constituted 10.5% of active non-profit organizations such as associations and similar social organizations, foundations, social religious entities and economic self-governance. In 2019, 8900 PBOs were eligible to receive 1% tax transfers, of which 98.9% did receive funds from that source. In 2020, the income of PBOs from 1% of personal income tax totaled nearly PLN 907,000,000, which exceeded the figure for the previous year by PLN 33,000,000 and was 2.5 times higher than ten years earlier (CSO, 2021).

The main aim of the article is to identify earning instruments used by major Polish PBOs (with the amount of total annual revenue achieved by a particular PBO as a principal criterion for selection).

This paper is structured as follows: Section 2 describes the theoretical foundations of various approaches to revenue diversification and economization in the non-profit sector as well as outlines the arguments of proponents and opponents of diversifying the revenue generated by non-profit organizations (Section 2.1). The theoretical underpinning of the research hypotheses is provided in Section 2.2. Subsequently, the research methodology is delineated in Section 3. Section 4 presents the results of the survey among the 100 largest Polish non-profit organizations, and Section 5 discusses the outcomes as well as the study implications.

2. Conceptual background

2.1. Literature review

Individual PBOs make use of a broader range of profit-making instruments in order to diversify their sources of revenue. Irrespective of whether these are attempts at commercial earning (e.g. online stores, services in the form of courses and training) or charity-oriented undertakings (charity auctions, premium text messaging), diversification of revenue sources is the goal. Based on economic and financial research, diversification of revenue in non-profit organizations appears to be a rational strategy (Mikolajczak, 2018, p. 774). Nevertheless, numerous researchers who study this issue cite both advantages and disadvantages of such solutions. Fig. 1 shows sample arguments of supporters and opponents of revenue diversification among non-profit organizations.



Figure 1. Advantages and disadvantages of diversifying revenue sources in non-profit organizations.

Source: own elaboration.

Proponents primarily emphasize that adaptive diversification should lead to greater stability of non-profit organizations, which potentially makes longevity, sustainability and predictability also more likely (Jegers, 1997; Kingma, 1993; Mikolajczak, 2019; Carroll, Stater, 2008; Ondiege et al., 2021). As greater stability often contributes to greater sustainability, longevity or reduced volatility, many authors use these terms interchangeably when highlighting the benefits of diversified revenue sources. Nevertheless, these very notions are most often mentioned by advocates of non-profit organizations diversifying their sources of revenue since they serve to underscore that even if one source proves unstable for various reasons, there are still other opportunities for generating funds. This resembles the situation when governments finance expenditure with multiple tax instruments so that potentially declining proceeds from one revenue source are compensated for by greater takings from other sources (Carroll, Stater, 2008, p. 949). Another frequently invoked argument in favor of revenue diversification is that more sources translate into more gains (by virtue of straightforward addition) (Grasse et al., 2016).

Another argument put forward by the proponents of diversified sources of revenue in non-profit organizations is that a higher number of sources of revenue (private and commercial ones in particular) promotes independence from the public sector. In this case, financial contributors (often politicians) cannot exert pressure on the organization's activities (Carroll, Stater, 2008; Chang, Tuckman, 1994). However, increased independence does not have to apply to the public sector exclusively. Indeed, skillful diversification can ensure autonomy from either sector – public or private (Mikolajczak, 2019; Han, 2017; Frumkin, Keating, 2011).

Proponents of diversification of revenue sources in non-profit organizations also argue that it enables flexible adaptation to the currently prevalent circumstances (Chang, Tuckman, 1994; Heengama, 2019). Thus, more revenue sources offer flexibility (Hung, Hager, 2019, p. 6), which is reflected not only in the responsive application of different revenue sources but ensures flexible functioning throughout the organization.

Furthermore, by diversifying revenue sources, PBOs are able to optimize costs (Burkart et al., 2017; Ortiz, 2001), which primarily means the possibility of breaking down fixed costs into a larger number of activities (i.e. earning instruments already in operation).

As for the arguments against the revenue diversification strategy, mission conflict is most often invoked (Wicker et al., 2013; Moeller, Valentinov, 2012; Froelich, 1999). The activities of NGOs are not oriented toward profit, which is one of their essential characteristics (Mikolajczak, 2019, p. 114). By so doing, one renounces the “social spirit”, in a sense betraying social ideals and functioning in a manner of a classic for-profit organization (Ferris, Graddy, 1989).

Opponents of diversification also contend that functional complexity increases in an organization which establishes new channels for gaining revenue. Its diversification gives rise to new concerns and greater complexity (Froelich, 1999, p. 263). Operating different revenue instruments may require different resources, knowledge and skills, which may at times

even be at odds with one another (Fischer et al., 2011). Moreover, the increased complexity of handling specific earning instruments is accompanied by the disappearance of specialization. If an organization does not focus on a limited number of instruments, it loses its specialization, and none of the instruments is operated expertly and with due diligence. On the other hand, specializing in multiple earning instruments requires distinct administrative apparatuses across the various approaches (Hager, Hung, 2020). This, in turn, reveals another disadvantage of revenue diversification, i.e. higher cost of maintaining technical infrastructure, personnel and other resources. Certain findings from the research show that managing multiple revenue instruments involves elevated costs incurred by non-profit organizations, such as increased administrative monitoring and higher reporting outlay (Gronjberg, 1993).

The crowding-out effect is another frequently cited argument against diversifying the activities of PBOs (Nikolova, 2014; Simmons, Emanuele, 2004; Andreoni, Payne, 2011). Numerous donors decide not to donate “because the organization makes money in other ways, after all”. In particular, this may apply to commercial activity through which a PBO “comes to resemble” a business (Mikolajczak, Bajak, 2021).

As can be seen, certain arguments concern the same issue, which, nonetheless, is approached from two opposite standpoints. For instance, the supporters of revenue diversification in PBOs may emphasize possible cost optimization, while the opponents will draw attention to the higher costs of maintaining the infrastructure and human resources required to operate a particular revenue instrument. Therefore, a situational approach is advisable in such cases. Each organization is unique: one will be able to make use of its staff and volunteers effectively to operate multiple communication and revenue channels, while another will need to acquire additional, expensive resources. Increased autonomy of the PBO in that it becomes independent of the public donor is another example: an organization is thus capable of pursuing its mission without political pressure but, on the other hand, "mission conflict" is often highlighted among the disadvantages of diversifying sources of revenue as already noted above. Therefore, the advantages and disadvantages cited should rather be considered as possible in non-profit organizations, but the question of whether they actually occur requires additional research within each organization.

2.2. Formulating hypotheses

The efficacy of non-profit organizations increasingly depends on the financial sources which support their social objectives (Mikolajczak, 2019, p. 113). Thus, non-profit organizations (including public benefit organizations, which are a significant proportion of that group in Poland) require adequate resources to pursue their goals effectively, just as for-profit entities. Hence, the Resource Dependency Theory offers a point of departure when explaining the rationale behind different instruments of earning since the effective use of such instruments enables an entity to acquire specific resources that the functioning of a PBO demands, including vital financial resources. Therefore one should particularly highlight PBO resource dependence

and simultaneously the Resource Dependency Theory which proved instrumental in the development of the resource approach conceived in the 1970s by Jeffrey Pfeffer and Gerald Salancik (1978). Within the RDT, the skill to garner resources is a prerequisite to organizational development; in other words: “the key to organizational survival is the ability to acquire and maintain resources” (Pfeffer, Salancik, 1978, p. 2). Efficient PBOs adapt to the circumstances by modifying their resource acquisition strategies. One such strategy is to increase revenue diversity by implementing more instruments to serve specific recipients (donors, clients, grant-givers, etc.). Derived directly from the RDT is the environmental dependency theory (e.g. with regard to acquiring resources), which, in turn, describes organizational adaptation theory (organizational congruence). Adaptation is perhaps one of the most ubiquitous notions in organizational theory and strategic management (Sarta et al., 2021, p. 44). The environment is construed as the dominant factor which determines the behavior of both the organization as a whole and its individual components. In a nutshell, larger organizations should have a greater capacity for introducing new earning instruments, which should then contribute to higher revenue. Conversely, continual change in the environments where major resource providers are involved translates into specific threats and novel opportunities for funding PBOs. In consequence, one observes variable funding sources and readjusted dependency relationships (Froelich, 1999, p. 248). Thus, Hypothesis H1 asserts as follows :

H1: There is a positive relationship between the number of earning instruments used by the largest Polish PBOs and the total revenue they generate.

It is thus assumed that the earning instruments in question are effectively used, leading to revenue diversification, which in its turn has a positive impact on total revenue.

From the standpoint of the RDT and organizational adaptation theory, it is possible to reverse the problem analyzed in the paper and conclude that the degree of revenue diversification in a particular PBO does not eliminate its resource dependence; notwithstanding, revenue diversification maximizes resource independence from single capital donors (Hung, Hager, 2019; Chang, Tuckman, 1994; Mozos et al., 2016). In particular, reliance on private sources reduces dependence on the public sector, as underlined in numerous relevant studies (e.g. Han, 2017; Frumkin, Keating, 2011; Carroll, Stater, 2008).

According to some authors (Guo, 2006; Stone, et al., 2001; Segal, Weisbrod, 1998), there is a negative relationship (i.e. Crowding-out effect) between raising funds from private sources (including commercial ones) and donations (especially from the public sector). However, other authors (Enjolras, 2002; LeRoux, 2005) have determined a positive relationship between diversified revenue from public and private sources and the absence of the crowding-out effect. Hypothesis H2 therefore states:

H2: There is a positive relationship between the earning instruments used by the largest Polish PBOs and the proportion of revenue from private sources (expressed as a percentage) in the total revenue of such organizations.

Thus, it is presumed that said earning instruments are effectively used and, being geared primarily towards private donors/clients, result in revenue diversification which does not cause the crowding-out effect and therefore contributes to increased revenue.

3. Research methodology

The research targeted public benefit organizations (PBOs) as defined in the Act of 24 April 2003 on public benefit activity and voluntary service. The largest PBOs were identified using a database of financial and substantive reports of public benefit organizations maintained by the National Freedom Institute—Centre for Civil Society Development. Reports for 2019 were analyzed at the turn of 2020/2021 (as PBOs are obliged to publish their annual reports by 15 July the following year). Therefore, the data on the revenue volume or total revenue cited in the paper refer to that very year. The analytical procedure consisted in reviewing each of over 8,800 reports and entering their respective values in an Excel spreadsheet (which made it possible to identify the largest Polish PBOs using their total revenue as the selection criterion). As may be expected, it was a laborious and time-consuming process.

The next stage involved the identification of revenue-generating instruments that the PBOs selected in the first stage took advantage of (this part of the study was conducted in October and November 2021). It should be clearly emphasized that they were identified based solely on the information obtained from the websites of respective organizations. For this purpose, it was verified whether each PBO runs their own website (in view of the fact that 100 of the largest Polish PBOs were concerned, each of the organizations proved to have one). A vast majority of the organizations posted a link to their website in their substantive report, which was publicly available on the Internet. In the remaining cases, a standard Google search was used to identify the website. The research framework is presented in Fig. 2.

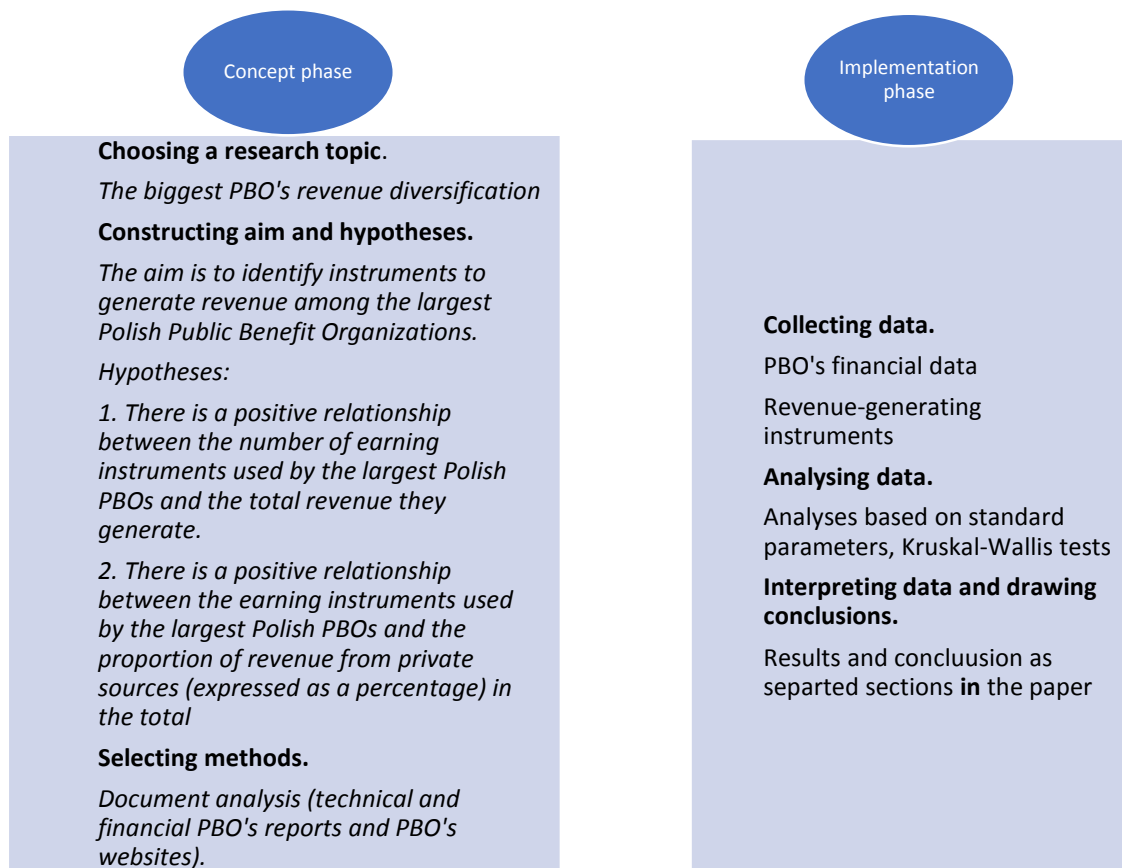


Figure 2. Research framework.

Source: own elaboration.

In order to verify posited hypotheses, statistical analyses were performed using the IBM SPSS Statistics 28 software package. Basic statistics of the quantitative variables examined in this study were computed together with a Kolmogorov-Smirnov test, which showed that the distribution of all variables differs extensively from a normal distribution, which required further analysis using non-parametric tests.

4. Research results

4.1. Identification of earning instruments and sources of revenue in public benefit organizations

Website analysis revealed 18 different solutions that the largest Polish public benefit organizations employ to generate revenue. These include instruments typical of purely commercial activities (e.g. online stores with merchandise or a range of training courses), as well as solutions one usually encounters with non-profit organizations (donations, fundraising or schemes exclusive to PBOs, such as 1 % transfers from personal income tax).

Specific mechanisms of revenue generation are characterized below (while Tab. 1 shows how frequently they are used by the largest organizations):

1. **Allegro Charity platform**—PBOs run auctions on the dedicated website, charytatywni.allegro.pl (the entire proceeds from sales go to a given charity).
2. **Ambassadors**—as an incentive to donate. Famous persons (e.g. actors, sportspeople, politicians) sell cards with their own signature, a celebrity dinner opportunity and so on for a specific amount of money. At the same time, the entire amount is earmarked for a specific PBO which carries out such an action.
3. **Donations as a gift**—the recipients gain a sense of contributing to worthwhile undertakings, supporting persons or animals in need, etc. For example, newlyweds are not bought flowers; instead, money is donated online to a specific organization, and the young couple receives a thank you note.
4. **Facebook (donation opportunity)**—a PBO is registered with the Facebook Payment service so that users can donate funds through Facebook.
5. **Facebook (fundraising)**—launching fundraisers for a particular PBO. The money thus raised is subsequently donated to the organization.
6. **Fanimani**—transferring a proportion of the money from purchase (tie-in). At a store, the customer pays the actual price of purchase, but the percentage of the amount goes to a selected charity (2.5% on average).
7. **Courses**—online courses run by PBOs in various fields (e.g. healthy lifestyle, nutrition, etc.).
8. **PayPal**—a fast and secure way to transfer money online (the service operates in a manner of an electronic wallet). When making a donation to a selected PBO, all a user has to do is log in with their password and authorize the payment with one click.
9. **Online tax return**—this mechanism involves a specially developed tax return program available on the website of an organization. The program facilitates completing tax returns; simultaneously, it automatically enters the data of that particular organization in order to transfer 1% of personal income tax.
10. **Premium text messaging**—upon agreement with a particular mobile service provider, a Public Benefit Organization receives all or part of what is charged for texts sent by donors.
11. **Online money transfer**—allows donations to be made directly from the website of the charity. These transfers are made using e-payment systems such as PayU, Tpay, Przelewy24 or Dotpay. Payments can be made to the PBO or to a specific initiative that the organization supports (e.g. donations to sick children, specific animals, etc.).
12. **Siepomaga**—PBO's website enables access to charity services run by Siepomaga Foundation. It is the largest charity crowdfunding platform in Poland.
13. **Store**—an online shopping venue (selling merchandise donated to or purchased by a PBO at discount prices).

14. **Sub-account**—enables PBOs to collect money from various sources, but there is a clearly defined recipient of the aid (e.g. a specifically named child affected by a medical condition or disability).
15. **Wills**—PBO's website offers help and provides instructions on how to bequeath part or all of one's financial or material assets to further the organization's mission.
16. **Traditional bank transfer**—anyone can donate by means of a traditional transfer to the account whose number is provided on the organization's website.
17. **Support from individual persons**—the PBO website lists specific categories (i.e. what is required, e.g. food, clothing) and advises how to donate.
18. **Support from enterprises**—help obtained through collaboration with business in various forms, including, e.g. pay-roll (an employee contribution scheme: a voluntary, regular financial contribution from employees of enterprises or other institutions to a PBO), Christmas cards or carols (purchases made by employees of a given enterprise, employee volunteering, donations in kind, advertising in return for sponsorship, etc.).

Table 1.

Earning instruments used by the largest public benefit organizations

No.	Instrument of revenue generation	Number of PBOs	No.	Instrument of revenue generation	Number of PBOs
1	Allegro Charity	3	10.	Premium SMS	4
2	Ambassadors	1	11.	Online transfer	51
3	Donation as a gift	3	12.	Siepomaga	4
4	Facebook donation	24	13.	Store	9
5	Facebook fundraisers	26	14.	Subaccount	26
6	Fanimani	7	15.	Wills	5
7	Courses	4	16.	Traditional bank transfer	71
8.	PayPal	7	17.	Support from individuals	13
9.	Tax return online	55	18.	Support from enterprises	18

Source: own elaboration.

PBO revenue generation instruments listed in Tab. 1 display degrees of popularity: from encouraging donors to make traditional bank transfers (incentives promoting this type of contribution receive substantial exposure on the websites of most organizations) to methods employed only by individual organizations, such as ambassadors or Allegro Charity. A number of the instruments are still to be found on the websites but, due to changes in legislation, they are of little use (e.g. the embedded software which enables one to complete the tax returns and transfer 1% of the tax to the organization; however, there were cases when information about free assistance in filling in tax forms was posted next to the application). Moreover, there are instruments whose operation depends not only on the organization, but on third parties, such as sub-accounts which, in principle, constitute an accounting service, enabling public benefit organizations to allocate funds for a specific beneficiary within a general bank account according to the donor's preference. In this case, the amount of the funds received is often contingent on the activity of the closest persons and friends of the direct beneficiary. Nevertheless, it seems that the number of methods to raise funds from immediate outside

sources is a useful gauge of a more or less proactive (pro-entrepreneurial) approach of an organization towards its environment.

A similar indicator which evinces a more or less pro-entrepreneurial attitude of the management in the surveyed organizations is not so much the volume of revenue itself or their being among the 100 largest PBOs in Poland, but the structure of the revenue obtained. Here, the ability to raise funds from the private sector is particularly important, as it demonstrates the degree of economization of a given organization and its ability to persuade clients/donors to transfer funds.

Individual components of public sources include:

1. **European funds within the meaning of public finance regulations**—any funds obtained as part of European funding schemes are stated here, e.g. funding from particular Regional Operational Programmes (allocated to PBOs operating in a given province) or under the Operational Programme Knowledge Education Development (with which numerous PBOs applied).
2. **State budgetary funds**—money obtained from the state budget and central bodies, e.g. from the Ministry of Family and Social Policy or the Ministry of Environment, as well as funds received as part of the programmes of the National Freedom Institute—Centre for Civil Society Development: Civil Initiatives Fund, Scout Movement Development Governmental Programme, Folk Universities, International Meeting Centers and others.
3. **Funds from the budgets of local government bodies**—money received from local self-governments, e.g. the value of grants received as part of open tenders organized by local authorities.
4. **Funds from state special-purpose funds**—such as funds from the State Fund for Rehabilitation of the Disabled, Physical Culture Development Fund, Culture Promotion Fund or programmes of the National Freedom Institute, e.g. the Solidarity Corps.

It should be noted that private sources include revenue obtained from:

1. **1% transfer from personal income tax**—one-hundredth of one's income tax which a taxpayer may donate to a public benefit organization of their choice.
2. **Membership fees**—membership fees paid by members of an organization.
3. **Donations from individuals**—all donations made to a public benefit organization by individuals.
4. **Corporate donations**—any donations made to the charity by a legal entity, such as a company.
5. **Contributions from the public** (community collections, fundraising)—organizing various events, collections, etc., to raise money for a specific purpose.
6. **Inheritances, bequests**—any form of will or bequest made to the benefit of a particular charity.

7. **Revenue from assets**—in the sale or rental/hire of assets.
8. **Business**—a component of private revenue which largely determines the degree to which a specific organization opts for commercial operation and defines its pro-entrepreneurial approach to its environment.

Tab. 2 shows particular components comprised in selected groups of revenue which constitute public and private sources, along with the amount of revenue expressed in millions PLN.

Table 2.
Sources of revenue of the largest PBOs

No.	Public sources	Received amounts (in millions PLN)	No.	Private sources	Received amounts (in millions PLN)
1.	European funds within the meaning of public finance regulations	215,047	1.	1% transfer from personal income tax	396,294
2.	state budgetary funds	248,308	2.	membership fees	18,059
3.	budget of local governance bodies	748,524	3.	donations from individuals	420,373
4.	state special-purpose funds	99,576	4.	corporate donations	308,276
			5.	contributions from the public (community collections, fundraising)	188,481
			6.	inheritances, bequests	5,478
			7.	revenue from assets	7,427
			8.	business activities	423,144

Source: own elaboration based on annual reports on PBO activities.

It remains debatable whether one should classify the revenue from the 1% of personal income tax to a specific group (i.e. public or private sources); because these funds originate from a part of the income tax, they are the property of the state. Nevertheless, it is the taxpayers themselves who decide which organizations should receive a proportion of the taxes they pay. As a result, legislative decisions gave rise to a specific market, which may be described as the one-per-cent market, which witnesses competition between entities entitled to receive 1% tax, while money is the object of exchange (Czetwertyński, 2016, p. 70). Since PBOs vie for the favor of taxpayers in terms of demand, certain competition mechanisms are in evidence, and the openness and ingenuity of PBOs which seek to acquire such funds are indicative of their pro-entrepreneurial attitude. Another issue is that revenue stated in the substantive reports on the activities of PBOs as *Other sources* has been omitted. This category makes it possible to show various revenue types (e.g. educational subsidies, but also financial revenue, etc.). Therefore, one cannot conclusively determine whether the latter funds qualify as public or private sources and, consequently, these items have not been included (the amount totaled PLN 680,000,000 for all organizations surveyed).

4.2. Scale of entrepreneurial orientation in public benefit organizations

Although the analysis focused solely on the group of the 100 largest public benefit organizations, a substantial diversity within this group should be stressed. There are organizations whose total revenue exceeds PLN 250,000,000, and there are also those which achieved no more than several million Polish zlotys in revenue. A similar disparity is observed in the revenue volumes from particular sources (private or public) and the extent of the organization's entrepreneurial attitude. Certain organizations rely almost entirely on private sources to gather financial resources (exceeding 99% of total revenue) whereas, for some, that share is negligible, reaching nearly a fraction of a percent (Tab. 3).

Table 3.

Basic descriptive statistics of the examined quantitative variables for the 100 largest PBOs

Specification	M	Me	SD	Sk.	Kurt.	Min.	Max.
Total revenue (in millions PLN)	37,594	22,014	41,474	3.150	10.970	13,743	254,576
Total private sources (in millions PLN)	17,675	5,158	36,977	3.999	18.426	0,042	242,770
Share of private sources in total revenue (%)	35,922	27,190	34,998	0,737	-0,910	0,132	99,871

M - mean; Me - median; SD - standard deviation; Sk. - skewness; Kurtosis - kurtosis; Min and Max - lowest and highest values of the distribution.

Source: own elaboration.

The 100 largest Polish PBOs also differ with respect to revenue-generating instruments they use. Having divided the entire set into four groups (Group 1: under 15,000,000 PLN; the limits for the subsequent groups are staggered by a factor of two), particularly notable differences are demonstrated between the smallest and the largest PBOs (the mean and the median differ twofold).

Table 4.

Earning instruments (actual figure) for the 100 largest PBOs with breakdown by groups in terms of total revenue

Groups*- total revenue (in millions)	Number	M	Me	SD	Sk.	Kurt.	Min	Max
under 15	17	2,647	3,000	2,178	0,515	-0,713	0	7
under 30	51	2,745	2,000	2,374	1,475	2,379	0	11
under 60	17	5,400	4,000	2,449	-0,233	-0,729	1	8
above 60	15	6,05	6,00	3,719	-0,076	-0,727	1	9
Total	100	3,370	3,000	2,791	0,957	0,334	0	12

Group 1 - under PLN 15,000,000; Group 2 - under PLN 30,000,000; Group 3 - under PLN 60,000,000; Group 4 - above PLN 60,000,000. M - mean; Me - median; SD - standard deviation; Sk. - skewness; Kurt. - kurtosis; Min and Max - lowest and highest values of the distribution.

Source: own elaboration.

Given that the figures for the four analyzed groups of PBOs were not identical, Kruskal-Wallis tests were performed in order to verify whether there was indeed a statistically significant difference between the number of revenue-generating instruments used and the size of the organization. The test ($\chi^2(3) = 9.710$, $p = 0.021$) apparently confirms that there is a relationship between the size of the organization and the earning instruments used. However,

the application of the Bonferroni correction indicates that the number of instruments for all analyzed groups is the same (pairwise comparison did not demonstrate any differences for that relationship, only achieving a result approaching statistical significance, i.e. $p = 0.054$, which would suggest that organizations in Group 4 were characterized by a minimally higher degree of instrument use compared to Group 2). Therefore, Hypothesis 1 (which presumed a positive relationship between the volume of generated revenue and the quantity of earning instruments employed) should be rejected.

Table 5.

Pairwise comparison of the quantity of earning instruments used relative to total revenue of the organization

Groups *	Test statistic	Standard error	Standardized test statistic	Significance	Adjusted significance **
*1-2	-0,461	8,034	-0,057	0,954	1,000
1-3	-16,147	9,840	-1,641	0,101	0,605
1-4	-22,486	10,163	-2,213	0,027	0,162
2-3	-15,686	8,034	-1,952	0,051	0,305
2-4	-22,025	8,427	-2,614	0,009	0,054
3-4	-6,339	10,163	-0,624	0,533	1,000

Each row tests null hypotheses about whether distributions for Samples 1 and 2 are the same. The table shows values for asymptotic significance (two-tailed tests). The significance level is 0.05.

*Groups: Group 1 - under PLN 15,000,000; Group 2 - under PLN 30,000,000; Group 3 - under PLN 60,000,000; Group 4 - above PLN 60,000,000. **Significance values for multiple tests were adjusted using the Bonferroni method.

Source: own elaboration.

More substantial discrepancies between the analyzed PBOs become evident when, instead of total revenue division, the share of either private or public sources in total revenue is adopted. Having divided the entire set into four groups in terms of the share of private revenue in total revenue in line with the adopted thresholds (Group 1 under 25% of private revenue in total revenue, Group 2 under 50%; Group 3 under 75% and Group 4 under 100%), one arrives at the basic parameters of descriptive statistics presented in Tab. 6. These groups are not homogeneous (e.g. the arithmetic mean for revenue instruments between the largest and the smallest PBOs is threefold higher for the former, while the median is sixfold).

Table 6.

Revenue generating instruments (actual figure) for the 100 largest PBOs and broken into groups by the proportion of private sources in total revenue

Groups*- share of private revenue in total revenue	Number	M	Me	SD	Sk.	Kurt.	Min	Max
under 25	49	2,000	1,000	1,780	0,833	-0,240	0	6
under 50	22	3,270	3,000	2,074	0,620	-0,535	1	8
under 75	8	5,000	5,000	2,449	-0,233	-0,729	1	8
under 100	21	6,05	6,00	3,339	0,088	-1,197	1	12
Total	100	3.370	3.000	2.791	0.957	0.334	0	12

*Groups: Group 1 - under 25% of private sources in total revenue; Group 2 - under 50%; Group 3 - under 75%; Group 4 - under 100%. M - mean; Me - median; SD - standard deviation; Sk. - skewness; Kurt. - kurtosis; Min and Max - lowest and highest values of the distribution.

Source: own elaboration.

A Kruskal-Wallis test ($\chi^2(3)=29.698$, $p<0.001$) confirmed that the size of the organization expressed in total annual revenue has an impact on the number of earning instruments they use. A pairwise comparison demonstrated that organizations with the lowest share of private sources in total revenue (Group 1 entities - under 25%) employ earning instruments to a lesser extent compared to larger entities (Groups 3 and 4). Thus, if the majority of an organization's revenue originates from private sources, it is characterized by a more entrepreneurial attitude in attracting clients/donors than those in which public funding predominates.

Table 7.

Pairwise comparison of the number of revenue-generating instruments used relative to share of private sources in total revenue

Groups *	Test statistic	Standard error	Standardized test statistic	Significance	Adjusted significance **
*1-2	-16,322	7,363	-2,217	0,027	0,160
1-3	-33,476	10,940	-3,060	0,002	0,013
1-4	-37,592	7,483	-5,024	<,001	0,000
2-3	-17,153	11,844	-1,448	0,148	0,885
2-4	-21,269	8,752	-2,430	0,015	0,091
3-4	-4,116	11,919	-,345	0,730	1,000

Each row tests null hypotheses about whether distributions for Samples 1 and 2 are the same. The table shows values for asymptotic significance (two-tailed tests). The significance level is 0.05.

*Groups: Group 1 - under 25% of private sources in total revenue; Group 2 - under 50%; Group 3 - under 75%; Group 4 - under 100%.

**Significance values for multiple tests were adjusted using the Bonferroni method.

Source: own elaboration.

To recapitulate, based on frequency analysis and Kruskal-Wallis tests, it may be stated that organizations with a higher share of private sources in total revenue tend to use more earning instruments compared to those with lower revenue; thus, Hypothesis 2 may be corroborated.

5. Conclusions

To support the pursuit of their mission in an increasingly challenging resource environment, PBOs seek different modalities of earning. The use of earning instruments such as online stores, services in the form of training and courses, membership fees, etc., are meant to complement funding from private donors (whether individuals or companies), as well as add to the public donations. Consequently, one may legitimately ask about the extent to which the largest Polish PBOs use various earning instruments to diversify their revenue.

According to the survey, the largest Polish PBOs employ, on average, 3.37 of the previously identified earning instruments. At the same time, although there are differences in the use of instruments between those entities which manage somewhere over 10 million zlotys in revenue and those which achieve several dozen or several hundred million, they are not substantial

enough to conclusively state that there is a positive relationship between the number of earning instruments used and the total revenue that the largest Polish PBOs achieve. One of the reasons is that public funding is prevalent among many of the latter. Computations made on the basis of data from PBO reports show that public funding was opted for by 71 out of 100 organizations (with public funding exceeding 99% in 14 and exceeding 90% in 32). Hence, many organizations financed from the sources of local government bodies or central state institutions do not see the need to supplement their funds with private sources (especially since this mode of raising money is anything but easy). As a result, the sheer volume of total revenue received by PBOs is not the best predictor in estimating the number of earning instruments used. A variable which reflects that relationship more effectively is the share of private sources in total revenue. When the size of an organization is taken into account (with a revenue figure in the denominator), the variable in question is also indicative of the pro-entrepreneurial attitude of an organization towards its environment. The research demonstrated statistically significant differences between the least pro-entrepreneurial PBOs among the analyzed organizations (i.e. those which raise less than 25% of their funds from private sources) and those where such an approach clearly dominates (i.e. organizations in which the share of the revenue from private sources is within 50% to 75% as well as those in which that share is in excess of 75%).

These findings indicate that for diversification of revenue, an advisable strategy for organizations which seek to increase the share of private sources in total revenue (and thus adopt a more pro-entrepreneurial model of operation) is to diversify their funding. It follows that—in the surveyed organizations—the advantages of diversification outweigh the disadvantages (referred to in the theoretical section of the article). Another likely argument in favor of the diversification strategy is that in the digital economy, maintaining multiple instruments of revenue is much cheaper than it would be in an "analog" business (e.g. online stores versus traditional outlets, organizing a fundraiser on Facebook versus traditional collection, etc.).

Resource diversification immediately involves the matter of acquiring funds through commercial activities. In this case, commercial undertakings are, on the one hand, seen as a sign of resourcefulness and entrepreneurial inclination of the organization. On the other, it is very frequently alleged that non-profit organizations become similar to their for-profit counterparts as a result. The studied PBOs were characterized by a moderate degree of entrepreneurship in this respect—revenue from business activities among some PBOs accounted for 100% of private income (not including proceeds from 1% income tax donations). Nevertheless, the average for the entire group reached 29.03%, and the share of business revenue in total revenue amounted to a similar rate of 9.22%.

The study was subject to certain limitations, the first of which was that survey spanned only the 100 largest PBOs out of more than 8,000 organizations, most of which qualified as smaller according to the adopted criteria. The characteristics of the studied group distinguish it to some extent from the entire population of PBOs. Therefore, the conducted research warrants

conclusions only with respect to the 100 largest Polish PBOs. Although this type of research (i.e. covering the 100 largest non-profit organizations in a given country) is commonly conducted (e.g. Lovejoy, Saxton 2012; Saxton, Waters, 2014; Esposito, Besana, 2018), a sample of such a limited size—dictated by statistical requirements—may distort specific conclusions.

Furthermore, the size of an organization was defined by only one parameter, i.e. the volume of total revenue. With organizations of other types (e.g. enterprises), more criteria are used to demarcate smaller entities from their larger counterparts (e.g. the number of employees). However, there were organizations in the surveyed group which, despite being classified among the 100 largest PBOs in terms of revenue, did not employ anyone on a full-time basis. There was also an organization which employed 1,948 people full-time (the only organization whose staff exceeded 1000 people). Given that only 16 organizations exceeded the 250-person threshold (i.e. the employment limit widely accepted in the European Union and in Poland to separate the SME sector from large enterprises), applying a similar criterion to the largest Polish PBOs would be inapposite. In fact, the analyzed organizations differ from commercial entities or public sector entities with regard to workforce, relying, for instance, on contracts governed by civil law or voluntary service.

Another limitation is the fact that the study focused only on the presence (number) of instruments but did not delve into their individual efficacy. The mere fact of having adopted an appropriate earning instrument does not yet determine the scale of revenue obtained from it (e.g. how much revenue is generated by an online store). The efficacy was estimated only in collective terms (i.e. by assessing how much revenue was generated from public or private sources by all instruments involved).

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INFORMATION AND COMMUNICATION TECHNOLOGY AND THE IMPLEMENTATION OF BUSINESS PROCESS MANAGEMENT IN PUBLIC ORGANIZATIONS IN POLAND

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Purpose: The article deals with the important topic of the impact of information and communication technology (ICT) used in public organizations in Poland on the possibility of implementing the Business Process Management (BPM) concept in these entities.

Design/methodology/approach: In order to assess the above indicated dependence, a research was conducted to identify the level of ICT use in selected public administration units, i.e. in the community offices. The research covered one of the voivodships of Poland, i.e. Warmian-Mazurian, where the entire population of community offices was surveyed. Then, referring to the literature on the subject, the obtained level was assessed for the possibility of implementing and developing the scope of BPM use in these entities.

Findings: The conducted research revealed that there are differences in the use of ICT between different types of community offices – the offices of urban type were the leaders in this matter. Thus, it was found that they were best prepared for the use of BPM. Overall, however, the research showed a low level of ICT use in the surveyed entities. Thus, it was concluded that ICT, perceived as a determinant of BPM, has a low potential to stimulate the use of the discussed concept in these entities and may constitute its barrier. The level of use of e-services is also low, and the surveyed offices to a large extent still operate in the traditional system, in which paper documents are the primary carrier of information.

Research limitations/implications: (if applicable) If research is reported on in the paper, this section must be completed and should include suggestions for future research and any identified limitations in the research process.

Originality/value: The conducted research, in the practical dimension, has the potential to raise the awareness of public managers as to the impact of ICT on the implementation and extension of the use of BPM in the entities they manage.

Keywords: ICT, process management (BPM), public organization, community office.

Category of the paper: research paper.

1. Introduction

Information and communication technology (ICT) refer to technologies that provide access to information through telecommunication. It is similar to Information technology (IT) but focuses primarily on communication technologies. This includes the internet, wireless networks, cell phones and other communication mediums (Ratheeswari, 2018). ICT, from the moment of its wider dissemination over the past 30 years, has been effectively supporting organizations of various types in optimizing the processes they implement and conduct (Ferris, 2012). The perception of the organization through the prism of the processes carried out in it, with a simultaneous departure from the traditional, functional view of the organization, is the basic determinant of the concept of Business Process Management (BPM, process approach). BPM, according to M. Weske, includes other concepts, methods and techniques that support designing processes, their administration, representation, configuration, implementation and analysis. Moreover, the basis of the discussed concept is a clear representation of processes along with their activities and implementation restrictions between them (Weske, 2007). Bearing in mind that the application of BPM in organizations brings many benefits to their functioning (including: better adaption to the challenges posed by the environment in which the organization operates, creation of new possibilities of gaining advantage over the competition, improvement of organization's profitability and customer satisfaction etc.), it becomes reasonable to define specific factors included in individual areas facilitating the implementation and development of the scope of BPM use (Bitkowska, 2020). These areas can be perceived as the conditions/determinants of the BPM use in organizations and, according to literature, these are, among others: organizational culture (the so-called "process culture"); organizational strategy expressed in the processes conducted in an organization; organizational structure that requires flattening and shaping it, considering the logic of the flow of processes in an organization; supporting leadership and, finally - the use of ICT (Kaziano do Amaral Castro et al., 2019). The indicated determinants are similar both in the case of business and public organizations (public administration units), although in the case of the public ones, legal conditions take on additional significance.

The modernization of public organizations in Poland has been taking place more or less since the 1990s, when New Public Management concept (NPM) was introduced in many countries, referring to a set of reforms that have come to radically redefine the nature of public sector organizations (Fredriksson, 2021). Since then, in the spirit of the assumptions of the NPM, reforms covering public administration units assumed the introduction of concepts originally used in business organizations. Thus, public organizations in Poland began to be introduced, inter alia, concepts such as: Total Quality Management, Outsourcing, Knowledge Management or BPM. It is worth mentioning here that the use of the process approach in transforming public organizations in Poland is not a whim, but a recommendation, which was

emphasized in various government documents, and is also reflected in many modernization projects that have been carried out, i.e., *System support for management processes in local government units* or the *Institutional Development Planning* (Raczyńska, Krukowski, 2019a). In addition, in Poland, there are ongoing activities aimed at the widest possible introduction of e-services in different public organizations. This process cannot be carried out without introducing at least some of the BPM elements, especially focused on implementing ICT solutions.

Given the above, according to the authors, it is important to know the factors that may constitute potential stimulators and barriers of implementing and developing the scope of use of BPM in public organizations in Poland. Identifying these elements would allow public managers to focus on supporting the elements conducive to BPM implementation and expansion, as well as trying to influence the aspects that may obstruct these activities.

Thus, the authors conducted a study aimed at identifying the presence of factors from the previously indicated areas in public organizations in Poland, in order to later determine whether these factors have the power to stimulate or inhibit the introduction of the process approach to these organizations. The area analyzed in this article is the information and communication technology, and the research subjects are the community offices in Poland, which provide public services to citizens. Therefore, the aim of the presented research in this paper was to identify factors from the ICT area, which occur in the community offices in Poland. Subsequently, the identified factors were assessed in the context of their significance in the introduction and development of BPM in the examined entities. In order to achieve the goal of the presented study, associations between BPM and ICT were indicated and literature review on ICT, supporting the implementation and development of BPM in organizations was reviewed (Section 2). Subsequently, the research methodology was described, emphasizing, among other factors, the applied methods and the potential limitations of the research (Section 3). Finally, the results of the survey were presented, together with their discussion and summary (Sections 4-6).

2. Theoretical background

At the beginning of theoretical considerations, one can confidently draw the opinion that the introduction and development of the process approach in organizations would not be possible at present without the support of information and communication technologies. In fact, ICT is considered a critical BPM construct by many authors (Gabryelczyk, Roztocki, 2018). Also, meeting the ever-changing needs of customers, be they business or public organizations, especially in the times of the Covid-19 pandemic (and probably in the post-Covid era), requires the automation of all or part of the processes carried out in organizations. It is worth noting,

however, that the use of ICT, and in particular - information technology, was already one of the main postulates announced by propagators of the use of e.g. the Business Process Reengineering concept, strongly related to the genesis of the process approach (Hammer, Champy, 2006). There is no doubt that processes carried out by organizations, including public entities, can be supported by various aspects of ICT use - for example, by introducing IT systems that enable their modeling, analysis, control, automation and integration, as well as supporting their implementation. For example, in the case of basic processes carried out strictly in public organizations, the recipient of which is most often a citizen, process automation has become one of the main postulates of e-government, which in Poland is called as "e-administration". According to G. Means and D. Schneider, e-government is the relationships between governments, their customers (businesses, other governments, and citizens) (Means, Schneider, 2000), and M.M. Brown and J.L. Brudney characterize this concept as the use of technology, especially Web-based applications to enhance access to and efficiently deliver government information and services (Brown, Brudney, 2004). As part of e-government, there are, among others, e-services. For the purposes of this study, e-services can be considered as a fully computerized form of processes provided by public organizations. In addition, in the case of public administration units, ICT systems support the transfer of data (e.g. information and decisions) between various departments. For example, thanks to the use of electronic document circulation systems, it is possible, among others, to deliver documents that have been sent by means of an electronic inbox, by e-mail or provided on external data carriers by citizens - to places of their further processing, or the documents that should be proceeded from chosen departments to the managerial board. Also, ICT conditions the success of processes implementation in public organizations, thanks to the possibility of continuous monitoring of their course and diagnosis of their bottlenecks (Kim, S.-B., Kim, D., 2020). Thus, the use of ICT provides these organizations with a number of various possibilities that seem not to be sufficiently noticed by managers of public administration units. This is evidenced by the still unsatisfactory state of use of information and communication technologies in public organizations in Poland, presented in various studies. One of such studies is carried out periodically by the United Nations. The United Nations ranks the countries of the world in terms of the development of their e-government using the EGDI index. The value of this indicator is within the range of 0-1, with the highest value, i.e. 0.9758 achieved in the world in 2020 by Denmark (publicadministration.un.org..., 2020). And since Poland was placed 36th in the world in 2016 (EGDI indicator value - 0.7211), in 2020 it achieved 24 position in the ranking (EGDI value - 0.8531) (United Nations E-government Survey..., 2016; E-government Survey..., 2020) - however, these results are still not satisfactory.

Among the studies carried out by researchers in Poland, there are not too many examples showing the level of ICT use in public organizations in Poland, and especially in the community offices. A good example of such research is the one carried out by E. Kuzionko-Ochrymiuk in 2014. The subjective scope of this research covered local government administration offices

(and thus the community offices) throughout Poland. And so, on the basis of the analysis carried out by the author, it can be concluded that the level of computerization of public administration in Poland should be considered unsatisfactory - 93% of local government administration offices indicated the traditional, i.e. paper-based system as the basic method of documenting the course of examining and resolving cases. In 60% of units, however, it was supported by electronic communication tools, but in most offices the traditional office model was still used (Kuzionko-Ochrymiuk, 2018).

The authors dealing with BPM-related issues also indicate that without the use of ICT it is difficult to increase the process maturity of an organization. Process maturity is most often expressed in the literature on the subject through the prism of the maturity of the processes occurring in the organization. Consequently, most of the process maturity models developed is also based on the processes existing in a given organization, and the achieved level of process maturity determines the advancement of a given organization in the implementation of the BPM concept. Based on the above, it can be concluded that process maturity mainly concerns the degree and scope of implementation of the discussed concept in an organization, through the use of methods and techniques characteristic for it (Bitkowska, 2009; Krukowski 2016). Therefore, in the literature, the term "BPM maturity" can sometimes be found (Rosemann, de Bruin, 2005). The view presented above is supported by the construction of many process maturity models, where at their higher levels there is a condition of automation of processes occurring in organizations, regardless of the type of these organizations, precisely through the use of ICT. In order to determine the impact of using IT (specifically) on the achievement of higher levels of process maturity by organizations, A. van Looy reviewed 37 selected process maturity models. The author noticed that in most of the analyzed models it is recommended to introduce IT in order to improve process modeling, facilitate their implementation and optimization, as well as simplify management, change the organizational culture towards the process profile, or influence structural aspects. In addition, with the increasing opportunities offered by the use of IT, processes are able to cross departmental boundaries in organizations, and even go beyond the area of the organization in general (van Looy, 2010).

The impact of the use of ICT on the achievement of higher levels of process maturity by public organizations (specifically the community offices) was emphasized in the study by I. Chomiak-Orsa and M. Flieger (they examined 107 community offices in the Lower Silesia). These authors assumed, on the basis of objective reasons (which are also appropriate for the research carried out by the authors of this article and will be indicated in the methodological part of the work) that the results of their research can be extended to the level of ICT use in the community offices throughout Poland. Based on the results of their research, Chomiak-Orsa and Flieger conclude that the use of ICT, especially modern solutions proposed in this area, is a necessity that determines the achievement of full process maturity, and thus the full use of the BPM potential by public organizations. Thus, by finding a statistical relationship between the level of process maturity achieved by the surveyed entities and the scope of using ICT in

these organizations, they proved that the wider the use of selected ICT tools, the higher the level of process maturity achieved by the community offices. The study of Chomiak-Orsa and Flieger also showed that less than half of Lower Silesia community offices had network solutions enabling, for example, internal sending of mail (45% of the surveyed entities) or sharing information in integrated databases (21%) - which is a limitation, inter alia, for the implementation of efficient horizontal communication in these organizations. In addition, only 32% of offices implemented document management systems (15% implemented a specific electronic document management system, enabling e.g. monitoring of the status of cases being handled), 12% used solutions enabling the provision of e-services, and 8% used tools for electronic monitoring and supervision of implementation processes. The conducted research got the above-mentioned authors to draw another conclusion that the main barrier to achieving higher levels of process maturity of the community offices in Poland is the low degree of integration of their internal IT systems (Chomiak-Orsa, Flieger, 2012).

Among the number of other limitations on the use of information and communication technologies in Polish public organizations the authors also include: inconsistency and ambiguity in the state computerization strategy or emphasis on the integration of ICT systems, but mainly within the given departments in public administration units – one have to remember that, in many cases, the processes carried out by public administration units are performed not by one, but by several departments of an office, where the organizational units are interested in only a specific part of the process carried out by this unit. Moreover, processes often go beyond the boundaries of a given organization and are related to processes carried out in other entities of the public sector. And in the current realities of the interoperability of ICT systems in Polish public administration, it practically prevents comprehensive implementation of a given service entirely electronically (as a e-service). The authors also point out to the: existence of an outdated organizational structure that is not adapted to the tasks and processes carried out by modern public administration; local specificity of the processes implemented in various units; unfavorable legal situation, which still demands using paper as the main carrier of information as the basis; low motivation of public organizations' managers to undertake the computerization process; low level of knowledge in the field of management and the possibility of its support by ICT; focusing the selection of an ICT system not on its potential impact on the effectiveness of the organization, but on the price - this consequently leads to the selection of the cheapest and not necessarily the best solutions; relatively low interest in e-services among the society (Świątek, 2019). And assuming that it will be possible to implement modern e-administration services on a large scale in Poland, one cannot expect the mass use of these services, because the problem of the still high digital exclusion of society, as well as the low level of its digital competences is a big barrier here. In addition, there is great dissatisfaction in the society with the quality of e-services offered by public administration, especially in the field of: the inability to "settle" a given case entirely electronically, a complicated description of the manner of carrying out the case, poorly constructed forms or the frequent inability to track progress of the

given case via the Internet. Moreover, Polish citizens are concerned about the security of their data and having too low competence in completing formalities when using e-services (Jedlińska, Rogowska, 2016; Śledziwska, Zięba, 2016).

It is also worth noting that in the case of public organizations, there is a separate category of models relating to the maturity of e-government processes. An example of one of the first models is the one proposed by K. Layne and J. Lee. They distinguished 4 levels of e-government development, which include: 1 - "catalogue", 2 - "transaction", 3 - "vertical integration" and 4 - "horizontal integration" (Table 1) (Layne, Lee, 2001).

Table 1.

K. Layne and J. Lee e-government processes maturity model

Level of e-government processes maturity	Characteristics
"catalogue"	An organization's website has been created, which mainly contains information about a given unit and procedures (the manner of their implementation, required documents, deadlines, etc.).
"transaction"	There is a potentiality of providing e-services to citizens, which boils down to providing a possibility of downloading forms from the website and enabling citizens to send them by e-mail.
"vertical integration"	There is an integration of databases of various public organizations that are parties to the implementation of some processes jointly provided to citizens.
"horizontal integration"	Various data systems are linked, bringing together separate groups of services provided for citizens, thanks to which the citizen gains the opportunity to "settle" many matters in one place.

Source: (Layne, Lee, 2001).

Some other interesting proposals have been created by, among others K.V. Andersen and H.Z. Henriksen, who extended the model presented above (Andersen, Henriksen, 2006), J. Zwicker, P. Fettke i P. Loos, authors of the "48-h promise" model (Zwicker et al., 2010) or experts of the United Nations, who introduced the United Nations Maturity Model (UN E-Government Survey..., 2012). Also, in Poland, one can find proposals of models aimed at assessing the process maturity of public organizations. A model dedicated to the process maturity assessment, created specifically for the community offices, is, for example, a proposal created under the Institutional Development Program, which was updated by M. Fliieger (Fliieger, 2016).

3. Methodology

In order to fulfill the research goal, aimed at identifying factors from the ICT area, which occur in the community offices in Poland, a study was conducted with the use of a questionnaire. The questionnaire included questions about the assessment of individual areas determining the implementation and development of the use of BPM in the community offices

in Poland, including the ICT area. In the field of that area, the survey respondents had the opportunity to assess the presence of 16 selected factors:

- ICT1 - regular updating of information in the Public Information Bulletin (BIP),
- ICT2 - the possibility of sending letters to the e-mail address of the office by the commune's inhabitants,
- ICT3 - the possibility of using the electronic inbox on the e-PUAP platform by the commune's inhabitants,
- ICT4 - the possibility of submitting documents on IT data carriers by the commune's inhabitants,
- ICT5 - electronic implementation of the most important services in the form of e-services,
- ICT6 - the possibility of using the electronic signature by the commune's inhabitants,
- ICT7 - the possibility of electronic reservation of the queue by the commune's inhabitants,
- ICT8 - possibility of checking the status of the case being handled by the commune's inhabitants,
- ICT9 - using the traditional system to perform office activities,
- ICT10 - using the Electronic Document Management System to perform office activities,
- ICT11 - using information from integrated IT databases available at the office in a network manner,
- ICT12 - use of the Intranet,
- ICT13 - using various information channels to communicate with the commune's inhabitants (e.g. newsletter, profiles on social media, text messages),
- ICT14 - active promotion of the use of e-services among the commune's inhabitants,
- ICT15 - conducting regular training for employees in the provision of e-services in the office,
- ICT16 - using IT tools for supporting the use of BPM in the office (e.g. Visio, Aris, Adonis).

These factors were assessed on a five-point Likert scale. The respondents had the opportunity to assess to what extent individual factors are present in the office, where: 1 - not present, 2 - low level of presence, 3 - moderate level of presence, 4 - high degree of presence, 5 - the factor always occurs.

The questionnaire was sent to respondents by post or delivered in person to each office.

The respondent in the surveyed entities was a person holding the position of the secretary of the office (secretary) and a person indicated by the secretary who, in his or her opinion, had experience in implementing and/or developing the scope of use of the BPM in the office. When selecting secretaries for respondents, their position in the organizational structure of the office, as well as the scope of duties performed (often requiring comprehensive knowledge on, among others, the functioning of the office, the methods and concepts of management used in the office, or the subject of activity of individual units in the organizational structure of the office) were considered (Raczyńska, Krukowski, 2019b).

The research was conducted in one of the voivodships in Poland, i.e. the Warmian-Mazurian voivodship. The research covered the entire population of the community offices in that voivodship - 116 offices, including: 67 offices of rural type (R), 33 offices of urban-rural (U-R) type and 16 offices of urban type (U). Responses were obtained from 99 offices (198 questionnaires). Thus, a return rate of 85% was achieved. However, 194 questionnaires were qualified for the final analysis - 97 pairs from individual offices. Therefore, the final research sample encountered for 97 entities. The vast majority of entities in the research sample were offices of rural type (54 entities, i.e. 55.7% of offices in the final sample). The second position was occupied by the offices of urban-rural type (28 entities, i.e. 28.9% of offices in the final sample), and the least numerous groups was consisted of the offices of urban type (15 entities, i.e. 15.4% of offices in the final sample).

The obtained results were entered into the electronic database and analyzed in the IBM SPSS Statistics 24.

Considering common method bias (CMB), the Brewer's Split Sample Method was used, when constructing the questionnaire (Brewer, 2006). To eliminate CMB, one of the assessed aspects, i.e. the type of the community office, was an objective administrative data and only the assessment of the occurrence of individual factors from the ICT area depended on the respondents' opinions (Podsakoff et al., 2012; Jakobsen, Jensen, 2015). Moreover, as it was mentioned before, the questionnaire was addressed to two people (the secretary and the person designated by the secretary) with sufficient specialist knowledge, so that the answers to the questions did not relate to vague concepts (MacKenzie, Podsakoff, 2012). Also, the respondents were to assess the present occurrence of factors, which should also reduce the risk of the discussed error. As a next step, the Cronbach's alpha test, the Kaiser-Meyer-Olkin test and the Barlett's test were conducted (Table 2) (Raczyńska, Krukowski, 2019b).

Table 2.

Measurement properties

Variable	Cronbach's Alpha Test	Kaiser-Meyer-Olkin Test	Barlett's Test *
ICT	0,809	0,766	874,558

Source: Own work based on research results.

Thanks to the Cronbach's alpha and Kaiser-Meyer-Olkin test results obtained, the reliability of the research tool was confirmed. The authors are aware that the factors selected for the study are correlated with one another. However, this is due to the fact that they relate to one phenomenon occurring in an organization. The purpose of the study, however, was not to indicate their relationship but to identify their occurrence and to evaluate them in context of their influence on using BPM in the researched community offices.

Finally, a one-way analysis of variance for independent samples was conducted (by the statistic method developed by R. Fisher) in order to verify whether individual types of community offices differed with respect to the occurrence of the individual factors from the area of ICT.

Despite the research being carried out only in one of the voivodships in Poland, in the opinion of the authors of the study, supported by the views of other researchers, the introduction of BPM into the organization is not conditioned by geographical factors, thus the obtained results provide the basis for drawing conclusions on the entire population of the community offices in Poland.

4. Research results

The results of the conducted one-way analysis of variance for independent samples showed that in case of ICT area, F is higher than 1. This means that the test is statistically significant (Table 3). Also, in the case of various types of offices in the area of ICT, there were statistically significant differences at the level of $p < 0.05$, and the size of the η^2 effect was 0.16.

Table 3.

The result of a one-way analysis of variance for independent samples for the ICT area

Dependent variable	Type of a community office	M	SE	LL	UL	F	p	η^{2*}
ICT	urban	3,55	0,1	3,35	3,75	18,59	<0,001	0,16
	urban-rural	2,96	0,08	2,81	3,11			
	rural	2,84	0,05	2,73	2,94			

Source: Own work based on research results.

In order to illustrate the disproportions between the city offices of various types in the use of ICT factors, an analysis of the frequency of these factors was carried out. The principle was adopted that the condition for qualifying a particular factor to those used in a given type of office is the sum of respondents' declarations of its high degree and absolute presence (indicating 4 and 5 on the numerical scale in the questionnaire) - it should be greater than 50%.

As mentioned in the "Methodology" section, the ICT area contained 16 different factors. On the basis of the data contained in Table 4, it can be noted that in the city offices from Warmian-Mazurian voivodship, respondents declared using 11 factors in these entities, and in the offices of urban-rural and rural type, 7 and 5 factors, respectively. Thus, it can be concluded that in urban communes, usually inhabited by a larger number of residents and in which more employees are employed in their respective community office, the need to use various tools from the ICT area increases, both for serving residents and those for supporting the management of the entire office.

Table 4.

Frequency of indications of the occurrence of specific factors from the ICT area in the community offices from the Warmian-Mazurian voivodship (in %)

Factor	Type of the community office														
	Urban					Urban - rural					Rural				
	Given answers					Given answers					Given answers				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ICT 1	-	-	6,7	20	73,3	-	-	7,1	39,3	53,6	-	-	10,2	38	51,8
ICT 2	-	3,3	3,3	10	83,4	-	1,8	14,3	17,9	66	-	7,4	9,3	22,2	61,1
ICT 3	3,3	13,3	10	16,7	56,7	19,7	7,1	12,5	8,9	51,8	5,6	28,7	12	12	41,7
ICT 4	26,7	10	6,7	20	36,6	16,1	44,6	5,4	7,1	26,8	34,3	24,1	16,6	7,4	6,5
ICT 5	3,3	30	13,3	33,4	20	23,2	42,9	23,2	7,1	3,6	9,3	28,7	48,1	7,4	6,5
ICT 6	13,3	16,7	-	10	60	12,5	46,4	3,6	3,6	33,9	32,4	21,3	13,9	9,3	23,1
ICT 7	79,9	6,7	-	6,7	6,7	89,3	10,7	-	-	-	91,7	3,7	1,8	1	1,8
ICT 8	46,7	-	20	20	13,3	69,5	3,6	16,1	5,4	5,4	62,1	18,5	6,5	8,3	4,6
ICT 9	6,7	3,3	-	3,3	86,7	-	-	5,4	16	78,6	1,8	2,8	12,1	17,6	65,7
ICT 10	23,3	23,3	6,7	13,3	33,4	67,8	3,6	16,1	5,4	7,1	71,3	13	10,2	3,7	1,8
ICT 11	6,7	10	16,7	30	36,6	12,5	3,6	30,4	23,2	30,3	18,5	14,9	20,4	23,1	23,1
ICT 12	6,7	10	-	23,3	60	17,9	-	7,1	10,7	64,3	28,6	6,5	5,6	17,6	41,7
ICT 13	6,7	-	6,7	53,5	33,3	10,7	12,5	23,2	28,6	25	11,1	25,9	19,5	25,9	17,6
ICT 14	-	20	23,3	20	36,7	8,9	35,7	41,1	8,9	5,4	14,8	36,1	35,2	8,3	5,6
ICT 15	6,7	10	46,6	20	16,7	16,1	44,7	25	7,1	7,1	17,6	27,7	30,6	17,6	6,5
ICT 16	66,7	3,3	10	13,3	6,7	87,5	7,1	5,4	-	-	77,8	16,7	1,8	0,9	2,8

Where: ICT1–ICT16 - are the abbreviations of the factors listed in “Research methodology” section; 1 - not present, 2 - low level of presence, 3 - moderate level of presence, 4 - high degree of presence, 5 - the factor always occurs.

Source: Own work based on research results.

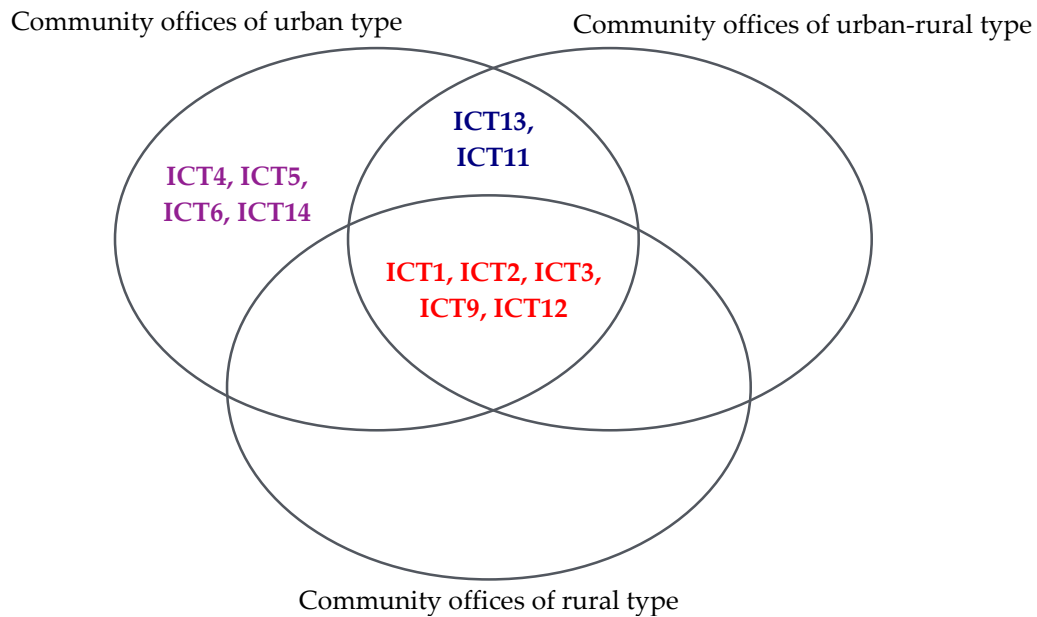
In the case of factors such as: regular updating of information in the Public Information Bulletin (BIP) (ICT1), the possibility of sending letters (e.g. complaints, requests for public information) to the e-mail address of the office by commune’s inhabitants (ICT2), the possibility of using the electronic inbox on the e-PUAP platform by the commune’s inhabitants (ICT3) and using the traditional system to perform office activities (ICT9), their presence was declared by the majority of respondents from the researched offices of all types (for ICT1 - 93.3% indications of respondents from U, 92.9% from U-R and 89.8% from R; for ICT2 - 93.4% indications of respondents from U, 83.9% from U-R and 83.3% from R; for ICT3 - 73.4% indications of respondents from U, 60.7% from U-R and 53.7% from R; for ICT9 - 90% indications of respondents from U, 94.6% from U-R and 83.3% from R). Also, more than half of the respondents from the offices of every type indicated that their organizations used the Intranet (ICT12 - 83.3% indications of respondents from U, 75% from U-R and 59.3% from R).

Based on the research results it was also possible to determine the solutions that were more popular in the offices of urban and urban-rural type, than in the offices competent for the rural communes. These factors include: using various information channels to communicate with the commune’s inhabitants (e.g. newsletter, profiles on social media, text messages) (ICT13 - 86.6% of indications of respondents from U, 53.6% from U-R and 43.5% from R) and using information from integrated IT databases available at the office in a network manner (ICT11 - 66.6% of indications of respondents from U, 56.2% from U-R and 46.2% from R).

On the other hand, in the case of factors such as: the possibility of submitting documents on IT data carriers by the commune's inhabitants (ICT4), electronic implementation of the most important services in the form of e-services (ICT5), the possibility of using the electronic signature by the commune's inhabitants (ICT6) and the active promotion of the use of e-services among the commune's inhabitants (ICT14), their use was each time indicated only by the majority of respondents from the offices of urban type, while respondents from the offices of urban-rural and rural type indicated rather to the occurrence of these factors to a small extent. Only in the case of factor ICT5, almost half of the respondents from the offices of rural type (48.1%) declared the average degree of electronic implementation of the most important services in the form of e-services, and in the case of factor ICT14, almost half of the respondents from the offices of urban-rural type (41.1%) declared the average level of active promotion of the use of e-services among the commune's inhabitants.

The least popular undertakings in the field of information and communication technology, carried out in the researched community offices in the Warmian-Mazurian voivodship, were: the possibility of electronic reservation of the queue by the commune's inhabitants (ICT7), possibility of checking the status of the case being handled by the commune's inhabitants (ICT8), using the Electronic Document Management System to perform office activities (ICT10), conducting regular training for employees in the provision of e-services in the office (ICT15) and using IT tools for supporting the use of BPM in the office (e.g. Visio, Aris, Adonis) (ICT16). The ICT7 was indicated only by every eighth respondent from the offices of urban type (12.4%) and less than 4% of respondents from the rural ones. The occurrence of ICT8 was declared by every third respondent from the offices of urban type (33.3%) and, respectively, 10.8% and 12.9% of respondents from the urban-rural and rural ones. ICT10 was mentioned sporadically, and only in the case of the offices of urban type, responses confirming the presence of this factor were provided by 46.7% of respondents, and in the case of the urban-rural and rural entities - it was 12.5% and 5.5%, respectively. Based on the conducted research, it can also be concluded that conducting regular training for employees in the provision of e-services in the office (ICT15) was conducted more often in the offices of urban type (36.7%) than in urban-rural (14.2%) or rural ones (13.9%). The same applied to the use of IT tools for BPM (e.g. Visio, Aris, Adonis) (ICT16 - 20% of respondents' indications from U, no indications from U-R and 3.7% of indications from R). However, one has to remember that the above factors were still implemented in the community offices in the Warmian-Mazurian voivodship at a low level.

Similarities and differences in the use of individual factors in the area of information and communication technology in the researched community offices, depending on their type, are presented in Figure 1.



Where ICT1–ICT14—are the abbreviations of the factors listed in the “Research methodology” section.

Figure 1. Similarities and differences in the occurrence of factors from the ICT area in the community offices of the Warmian-Mazurian voivodship, depending on their type.

Source: Own work based on research results.

In the field of information and communication technology, five factors were recognized as common for the all types of the community offices in the voivodship covered by the study, two factors for the offices of urban and urban-rural type, as well as four factors specific only for the offices of urban type.

5. Discussion

On the basis of the presented research results it can be conducted that the examined community offices use the solutions from the ICT area to a small extent and, despite the continuous development of public organizations in Poland towards the implementation of e-services, most of the cases in the offices are still carried out in the traditional office system. The results of the research carried out by I. Chmiak-Orsa and M. Flieger (2012), as well as the research of E. Kuzionko-Ochrymiuk (2018), are thus confirmed. And assuming that from a technological and technical point of view there are no obstacles, e.g. in the implementation of most tasks of local government units in Poland in form of e-services, the situation presented in the above study may result from barriers of a different nature. Regardless of the type of community offices, typical for the surveyed entities is the existence of elements of one-way interaction with residents through a static website, or the provision of traditional ICT tools for communicating with the office (such as e-mail or electronic inbox). Therefore, if the ICT

solutions used were not distinguished according to the type of community offices, it could be concluded that the maturity of the processes implemented within e-government by the examined entities is at the "transaction" level, according to the previously presented model by K. Layne and J. Lee (2001).

However, it has been shown that there are differences in the use of specific ICT solutions between community offices of various types. The lead in the implementation of individual ICT factors is the urban offices, i.e. entities employing a greater number of employees than the urban-rural and rural ones, due to the fact that they provide services to a greater number of inhabitants of the communes they respond [the relationship between the number of inhabitants of communes and the number of workers employed in the corresponding offices was established on the basis of the existence of significant statistical relationships through the analysis of the correlation of ranks with the Spearman's *rho* coefficient. It was subsequently checked whether the urban communes from the sample were occupied by more inhabitants than the urban-rural and rural ones. For this purpose, an analysis of variance for ranks (Kruskal-Wallis test) was performed, also confirming the existence of significant statistical relationships]. Thus, it can be assumed that managing a larger number of employees and servicing a larger number of inhabitants usually entails the need to use more solutions in the field of ICT like e.g. facilitating customer service by introducing a certain level of use of e-services and promoting this form of meeting needs among the inhabitants of communes or enabling the use of an electronic signature. In these larger entities (and also in the offices of urban-rural type), more emphasis was also placed on using information from integrated IT databases available at the office in a network manner or for the use of various information channels to communicate with the commune's inhabitants (e.g. newsletter, profiles on social media, text messages). The above elements undoubtedly determine the possibility of introducing and developing the process approach in the surveyed entities. One of the basic principles of introducing the process approach in organizations is focusing on the client's needs. And, despite the fact that, as indicated, Polish society is not yet fully prepared to use e-services, or is not satisfied with their level, managers of public organizations should pay special attention to developing this form of cooperation with residents. The effective introduction of e-services on a large scale has the potential to improve the processes of providing services to citizens through, inter alia, shortening their duration, reducing the resources used for their implementation, and thus - reducing the costs of their implementation. A positive action implemented by the offices of urban type, indicated by the respondents, is using various channels to communicate with the society. And, especially in the case of younger citizens, the use of social media in communication can be considered meeting their needs. In the era of emphasis on the emergence of new styles of governance, which promote higher levels of transparency and the engagement of citizens, comprehensive communication with citizens using the Internet not only enhance the interactivity, transparency, and openness of public sector entities but also presents the ability to promote new forms of accountability (Bonsón et al., 2012).

A very important aspect of introducing and developing BPM in organizations is to enable the most efficient horizontal communication (and to eliminate barriers to communication in general, e.g. by creating an environment for undisturbed use of the information needed in the implementation of processes). The conducted research shows that the entities of urban and urban-rural type are much better prepared in this field than the offices of rural type, because only respondents from these entities indicated using information from integrated IT databases available at the office in a network manner. Unfortunately, the use of information from integrated IT databases was not commonly followed by the Electronic Document Management System to perform office activities. And, based on the views of the authors presented in the Theoretical Background section, this is not a favorable situation for increasing the level of process maturity of the researched entities, but even a situation that may inhibit this process.

The conducted research has shown that the least popular ICT solutions in the surveyed entities (regardless of their type) are those activities, the potential use of which would allow for full implementation of processes in the form of e-services. Unfortunately, the inability to even check the status of the case being handled by the users of these services, or the electronic reservation of the queue, may be one of the important reasons for their dissatisfaction with the process output. The fact that the respondents of the survey indicated that in their entities training increasing employee competences in the field of e-service implementation is also a scarceness, is not without significance for the created and perceived quality of this services. It is also unfavorable that in the community offices of the Warmian-Mazurian voivodship, IT programs helpful in process management are not used in principle. This situation undoubtedly limits the possibility of increasing the process maturity of these entities.

It is worth mentioning here the activities that, in the literature on the subject, are perceived as potential stimulators of increasing the scope of ICT use in public administration units in Poland, aimed in particular at supporting and developing the processes they implement. These include, among others: unifying and simplifying to the maximum e-services and documents necessary for their implementation; adapting the provisions of applicable law to the possibility of relying in the implementation of e-services only on electronic documents; extending the possibility of handling a wide range of e-services using various types of mobile devices (e.g. smartphones, tablets, etc.); the implementation of e-services through the electronic communication channel selected by the client; an appropriate and trustworthy level of security of the e-services offered; relieving citizens from the need to provide data that already exist in the resources of various units of public administration; providing offices with standard programming solutions, as well as the necessary infrastructure for the implementation of e-services (e.g. providing a simple CRM platform via the Internet, which would facilitate contact with residents and register all data from each contact in a common database, regardless of the communication channel used by the client); securing all offices of a sufficiently fast internet connection; continuous education of office employees in the scope regarding the possibilities and conditions of using ICT in public administration units (Czajkowski, 2016).

6. Conclusions

Based on the research carried out and presented in the article, one can conclude that public organizations in Poland still make little use of information and communication technology solutions. Considering the presented dependencies between ICT and the possibility of implementing and developing the process approach in organizations, it can also be concluded that the low level of ICT use is not conducive to the use of BPM in public organizations and can be considered a barrier to this activity.

Among the entities participating in the study, i.e. the community offices in the Warmian-Mazurian voivodship, the largest entities, i.e. the offices of urban type, were the most advanced in terms of ICT implementation. It was also these entities that to the greatest extent implemented and promoted the implementation of processes provided to citizens in the form of e-services.

A limitation of the presented study may be its survey nature. And, despite the attempt to reduce the common method bias, it should be assumed that the respondents did not avoid at least an element of subjectivity in their answers. Another limitation is focusing only on entities from one voivodship. However, the authors showed that the results of their research can be considered representative for the entire territory of Poland, and the research carried out by other authors in other voivodships of Poland showed similar results.

An interesting direction of research, extending the topic under consideration, would be to examine the level of process maturity of the community offices in Poland and correlate this level with the level of use of ICT solutions by these entities. Thus, the view presented in the article, that the use of information and communication technology actually determines the level of process maturity achieved by organizations, could be verified. It would also be worth recognizing the current limitations of such low use of ICT by public organizations in Poland.

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THE SIGNIFICANCE OF THE SMART CITY CONCEPT FOR CREATORS OF BIG DATA SOLUTIONS

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Purpose: The main purpose of this article was to research how is the concept of smart cities perceived by IT developers involved in programming Big Data solutions, as well as to highlight their opinions concerning the relation between Big Data technology and creating a smart technological and business environment.

Design/methodology/approach: The theoretical part of the article presents the issue of a smart city. The issue of Big Data in the context of the functioning of contemporary cities was also discussed. Empirical research was carried out using an online survey among participants who are employees of the IT industry.

Findings: The conducted research constitutes the first step in assessing the relations between modern cities and their users and creators. Employees of organizations dealing with Big Data technology are familiar with the basic assumptions of the smart city concept. However, a problematic issue consists in identifying the impact of this concept on the life and immediate environment of the research participants.

Research limitations/implications: The main research limitation consists in the number of analysed surveys. In the case of more feedback, the research sample could be even more reliable, which in turn can lead to extensive conclusions.

Social implications: Publishing the article may contribute to raising the awareness of Big Data developers concerning their contribution to building and developing smart solutions.

Originality/value: The contribution of the research to determine how smart cities impact their users and creators. The article is addressed to all stakeholders of modern cities, including primarily local governments, citizens, enterprises, as well as research and technological units.

Keywords: Big Data, decision-making, IT developers, smart cities impact.

Category of the paper: Research paper.

1. Introduction

The progressing technological and social development requires using innovative solutions to meet the challenges faced by modern cities. The available information indicates that 55% of the world's population lives in cities, while forecasts show that by 2050, 68% of the global

population will be living in urban areas, and this trend is going to become stronger (United Nations, 2019, p. 1). It is expected that dynamically progressing urbanization driven, among others, by economic factors will constitute one of the main factors intensifying problems related to environmental pollution, high energy demand, private transport, availability of infrastructure or public transport (Ministerstwo Cyfryzacji, 2019, p. 34). Due to this, plans are being drawn up worldwide to ensure the sustainability of both existing and developing cities. Effective city management, taking into account the long-term needs of the residents, can become a source of benefits from the development of urban units. This has resulted in an increased use of modern technologies in tackling complex problems, which in turn contributed to popularizing the concept of smart cities.

An important aspect of the functioning of cities is the generated data. It is estimated that, in an overall manner, expenditure on digital information in Poland amounted to USD 32.1 million in 2020, which means an increase of 17.5% when compared to 2019 (Figure 1). This leads to the conclusion that the pandemic and its unpredictability motivated Polish companies to invest in Big Data. These figures mainly include expenditure on data used in automated advertising as well as the costs of information processing, including data management platforms. Analysts assume that the value of the global and Polish data markets will constantly increase (Marzouk, Othman, 2020, p. 121).

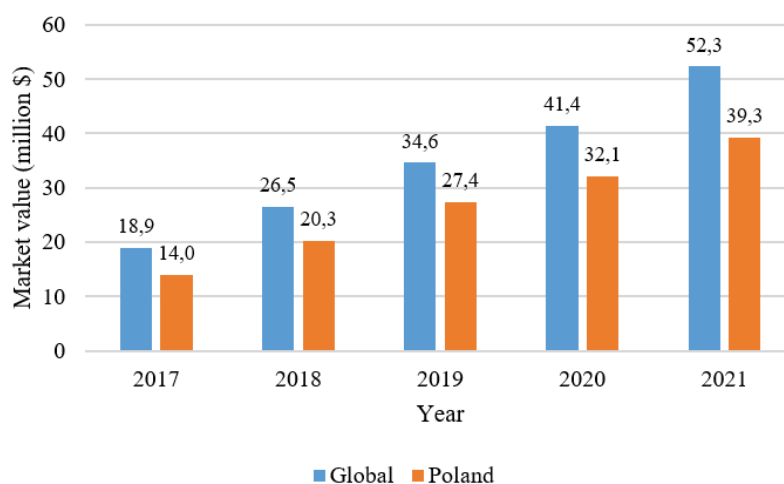


Figure 1. Value of the data market in the world and in Poland in 2017-2021. Source: own elaboration based on Report Global Data Market Size, pp. 8, 18.

A condition necessary for the real development and implementation of the concept of a smart city is to undertake a joint effort by people from various disciplines, i.e. engineering, architecture, urban design, economics, etc. (Ahmad et al., 2022, p. 1). Due to the observed trend of ubiquitous digitization, IT specialists constitute an important professional group for developing modern cities, the demand for which will constantly increase around the world. According to the 20th edition of the State of the Developer Nation report, there were 26.8 million active programmers in the world at the end of 2021. Experts predict that the number of developers will increase to 45 million by 2030 (State of the Developer Nation, 2021).

2. Smart city concept

The smart city concept finds application in virtually all fields of research concerning a modern city, as well as in the issues of related disciplines. The meaning of the word smart includes a wide range of options regarding its interpretation, thanks to which the spectrum of its applications is almost unlimited (Tota, 2017, p. 5; Cocchia, 2014, p. 17). Although the concept of a smart city is extremely broad and popular, there is no universal and unambiguous definition. This is mainly due to the fact that the components of a smart city have not been clearly established so far. In recent years, a number of attempts have been made to define this concept in a coherent way. The term smart city found in literature sources distribute the emphasis in various ways, often focusing to different degrees on various spheres of the city's functioning. One of the most popular approaches to the concept of a smart city is to consider it through the prism of six areas, which include: economy, transport, environment, people, quality of living, and smart management (Table 1) (Rubisz, 2020, p. 239).

Table 1.

Main areas of a smart city including determining factors

Area	Determining factors
smart economy	entrepreneurship; innovation; labour market flexibility; position in the national and international economy; ability to adapt to upcoming changes
smart mobility	local and international accessibility; accessibility of infrastructure; ICT; sustainable, innovative, and secure transport systems
smart environment	attractiveness of natural conditions; level of environmental pollution; environmental protection; sustainable methods of resource management
smart people	level of qualifications; lifelong learning; social and ethnic diversity; creativity, openness, participation in public life
smart living	existing cultural facilities; living conditions (health, safety, housing); educational institutions; tourist attractiveness; social cohesion
smart governance	transparent city management; social participation; level of public services; implementing development strategies

Source: own elaboration based on Rozpondek, 2021, pp. 14-15.

In the initial vision, smart city stood for a concept in which using technology was aimed at achieving efficient results in the field of energy economy and reducing CO₂ emissions into the atmosphere (Stawasz, Sikora-Fernandez, 2016, p. 7). At the beginning of the 21st century, a dynamic increase in interest in the smart city concept began, as a result of which many approaches in terms of establishing the conceptual framework of a smart city have been formulated. The diversity in terms of individual views results, for example, from using a diverse perspective in describing phenomena (e.g. scientists, business people) or attempting to analyse them in relation to various fields (e.g. urban planning, economics, sociology, etc.). The common determinant of a smart city observed in many views is the aspect of a creative society, whose actions are undertaken using technical and technological innovations, as well as information and communication technologies (Korenik, 2019, p. 19). In their definitions, many authors also emphasize the extensive specificity of investments and manners of managing a smart city by

summing up technological and information elements with economic, socio-cultural, and organizational development (Daszkiewicz, 2015, p. 264). In reference to legal regulations and other regulations, the ISO 3720:2014 standard constitutes a set of standards determining the concept of a smart city in relation to acts of international law. This document constitutes the result of joint activities of the European Union Standards Organisations and the Geneva Standards Organisation, as well as the national bodies for standardization. However, the developed standards are not mandatory, as they do not have a legal nature (Korenik, 2019, pp. 22-23).

Smart cities are constantly evolving and undergoing dynamic transformation. It is assumed that there are three stages of smart city development, named as smart city 1.0, smart city 2.0, and smart city 3.0. In the first generation, technology and communication companies show a high initiative. They offer their products and services to local authorities in order to achieve greater efficiency in city management, however, not being fully aware of the benefits and potential risks. The second stage of development focuses on the fact that urban authorities are the initiator of change, choosing technologies and solutions that they consider to be beneficial for the city. In the third generation, the implemented solutions respond to the problems of residents and are consulted with them. Technology and business are becoming less significant, and priority is given to participation and solving specific problems reported by residents in a way that is appropriate to them (not necessarily using the latest technologies) (Szczep-Pietkiewicz, 2018, pp. 245-247).

3. Big Data in contemporary cities

Along with technological development, smart devices and objects equipped with various types of sensors began to affect the lifestyle of city residents, and all actions undertaken by the society transformed into large, irregular, and diverse data sets (Sun, Wu, 2019, p. 663), which can be described as Big Data. Collecting and developing this type of data is a difficult process, and at the same time extremely valuable. Storing, managing, and analysing this data is not possible using commonly available methods, but taking advantage of advanced solutions, they lead to new and useful information (Zhang et al., 2022, p. 2). Therefore, the concept of Big Data should be considered not only through the prism of data sets, but also as a combination of techniques enabling their processing and analysis. In the initial phase of developing the concept of Big Data, its three main attributes were provided, constituting the so-called 3V model, i.e. variety, velocity, and volume. As the term developed, new dimensions (value, variability, veracity) were added, which in turn led to creating the 6V model (Rozpondek, Pachura, 2020, pp. 20-21).

Sources of Big Data in reference to a city can be divided into five types: data from urban infrastructure sensors and moving objects, data generated by the public, administrative data, data concerning customers and transactions, as well as art and humanities data. The Table 2 presents examples and user groups for designated sources.

Table 2.

Big Data sources in the city

Source	Example	User group
data from urban infrastructure sensors and moving objects	A sensor system for environmental, water, buildings, and transport management; Internet of Things	Public and private municipal and management organisations, independent ICT developers, engineering researchers
data generated by the public	Participatory sensing system; using of social media and online social network; global positioning system (GPS)	Private companies, customer-focused public organisations, independent programmers, researchers of data science and urban social sciences
administrative data	Public administration data concerning transactions, taxes, and revenues, payments, and registration; basic public data concerning employment, health, social benefits, education	Open data: innovators, hackers, researchers. Confidential data: government data agencies, urban social scientists involved in economic and social policy research, public health and medical researchers
data concerning customers and transactions	Data concerning customer transactions coming from business documents; user data from public utility and enterprises and financial institutions; product purchases, and service contract terms	Private enterprises, public institutions, independent developers, and researchers of science concerning data and urban social sciences
data concerning art and humanities	Text, image, sound, video, language data, film, culture, digital objects, and other media	Urban designers in the field of history, art of architecture, and digitization; private and social organizations; data programmers and scientists

Source: Thakuria, Tilahun, Zellner, 2015, p. 7.

Data collected as a result of actions undertaken in a city provides comprehensive information reflecting the real state of its operation. Traditional data processing technologies often prove insufficient in order to obtain an in-depth level of information from it. It is necessary to implement precise collection, storage, and processing of large data sets, which will make the obtained information useful in developing the smart city concept. In the era of Big Data, building a smart city cannot be based solely on the computerization and digitization of various data sources, but primarily on smart data analysis allowing to obtain useful information supporting the decision-making process on their basis (Sun, Wu, 2019, pp. 664- 665). Such effectiveness constitutes a factor stimulating cooperation and communication between stakeholder groups, which results in developing innovative solutions. The use of Big Data finds its application in almost every field of a city's functioning, including units called smart cities. Big data allows a city to obtain innovative and valuable insights from a vast amount of data obtained from various sources, which in turn support decision-making processes, promote sustainable development, and provide innovative services improving the quality of living for citizens. This technology contributes, for example, to improving the quality of public services, informing about how to manage environmental pollution, or promoting public safety (Zhang et al., 2022, pp. 2-3). Data network infrastructures linking parking systems, traffic lights,

municipal buildings, smart measuring systems, and electric vehicle charging stations support citizens to quickly locate free parking spaces, work in favour of optimal energy consumption or adapting the street lighting system to weather conditions (Rozpondek, 2021, p. 82).

4. Description of the research method

The empirical research has been carried out in May and June 2022 among people working in IT organizations. The surveys were conducted using an online tool consisting in Google Form. Due to the need to systematize a wide spectrum of analysed issues, the research was divided into two main areas – the first one concerning the concept of a smart city, and the second one concerning the relation between a smart city and Big Data. In order to obtain fair and reliable results, the research participants were granted total anonymity. A total of 42 responses of participants were selected for the research analysis. The Table 3 presents basic information concerning the target group of respondents.

Table 3.
Basic information concerning respondents

Information about respondents		
Feature	Number	Share
Gender:		
Female	2	5%
Man	40	95%
Age (in years):		
18-24	5	12%
25-29	21	50%
30-34	13	31%
35-39	3	7%
Activities related to projects implemented by respondents in their professional work:		
Medicine, pharmacy, healthcare	14	33%
Trade, E-commerce	12	29%
Banking	9	21%
Insurance	7	17%
Cities with which the respondents are associated:		
Warszawa	19	45%
Wrocław	10	24%
Gdańsk	6	14%
Poznań	4	10%
Częstochowa	3	7%

Source: own elaboration based on research results.

The first criterion that was adopted to create the target research group was determining whether the professional work of a given person is related to the programming of solutions in the field of Big Data technology. The second criterion consisted in determining whether the city with which the respondent is associated is considered smart or whether it implements innovative initiatives into its structure.

5. Results and discussion

During the first stage, the issue of understanding the concept of a smart city in the surveyed group of respondents was analysed. The obtained results showed that more than half of the respondents say that they are aware of the concept (5% of them declare their state of knowledge as "very good", 12% as "good", and 38% as "rather good"). However, almost one third of respondents assess their knowledge concerning the assumptions of the above-mentioned idea rather poorly (19% of them declare their state of knowledge as "rather poor", 5% as "poor" and 5% as "very poor"). In the following question, the respondents exchanged the keywords, which in their opinion make up the definition of a smart city. The set of designated phrases underwent a quantitative analysis with the use of the so-called word cloud, which allows illustrating which of the keywords appear most often in the provided answers (Figure 2). The size of the individual words forming the cloud reflects the frequency of their occurrence. Taking advantage of a generator for creating word clouds, the frequency of assigning specific attributes to the smart city concept was identified.



Figure 2. Word cloud of the main issues related to the concept of "smart city".

Source: own study.

When analysing the presented cloud of elements constituting the definition of a "smart city", the following observations can be made:

- Persons providing the definitions agree that a smart city is an entity, which in its operation and development takes advantage of modern technologies allowing to combine different urban systems and stimulate innovation facilitating implementing urban policy objectives. The obtained results also show that the idea of Smart City is inextricably linked with the so-called Internet of Things (IoT), which bases on a network of interconnected smart devices that can collect, process, and exchange information through an electrical or computer network.

- Next, the most frequently identified issues were those that together make up transport and urban infrastructure. Respondents paying attention to these aspects may suggest that improving the flow of traffic or increasing the comfort of movement significantly affects the comfort of living and staying in the city.
- It is surprising that the answers did not include the concept of "data" or "Big data", which are an integral part of the functioning of cities. Perhaps they were not exposed due to their overly general nature, and they were included by the respondents in other, more detailed issues.
- Phrases indicating issues related to human capital were mentioned relatively rarely. One of the reasons for this could be that people are present in every place and at every level of a city's functioning (both as providers and as recipients), and that is why the human aspect was considered as obvious.

The following question in the conducted research concerned assessing the smartness of cities with which respondents are associated. An analysis of the answers shows that only 31% of the respondents chose the "rather yes" answer, and 19% of them chose the "hard to say" answer. Half of the respondents do not have a positive opinion about the smartness of the city with which they are associated (31% of "rather no" answers, 12% of "no" answers, and 7% of "definitely no" answers). However, according to the available rankings and lists, cities related to respondents are actually considered smart or innovative. In the Smart City Index 2021, Warsaw was listed as 75th (Smart City Index, 2021, p. 8). Whereas, in the IESE Cities in Motion Index 2019, this city ranked 69th among the capitals of innovation and advanced technologies, reaching the CIMI index of 60.13, and Wrocław ranked 95th with a score of 53.39. In comparison, the CIMI for London, the leader of the ranking, was 100 (Berrone, Ricart, 2019, p. 26). According to the analysed classification, among the aspects that make up the quality of life in a city, social cohesion deserves the greatest attention in both Warsaw and Wrocław, while areas such as human capital, city management, technology, and the environment should be improved.

Wrocław is a laureate of many awards in the field of smart solutions. One of them consists in the 2018 Green & Smart City Awards received at the global Smart City Expo in China in the category of Top Level Design. During the Smart City Forum, Wrocław received recognition in the category of 2018 city of over 500 thousand residents for innovative projects in the field of electromobility. Whereas, in 2016, in the same category, it received the award for taking action towards formulating Wrocław as a Smart City based on key elements, i.e. strategy, residents and communicating with them, attractiveness of living, as well as development and creativity, expressed, for example, in open data and promoting the startup environment (Knight, 2018, p. 7). Poznań won the Smart City 2019 Competition. The jury distinguished the capital of Wielkopolska for implementing the idea of a smart city, taking advantage of innovative solutions, and effectively managing resources and the development strategy for improving the lives of residents in the field of transport, infrastructure, energy, spatial management,

and the environment. The Tri-City (Gdańsk, Gdynia, Sopot) received the Human Smart City 2019 award for the example of cooperation and harmonious development of the entire metropolitan area, by making the best use of the potential of member states and municipalities, respecting their distinctiveness and specificity (smartcityforum.pl). Gdańsk, Wrocław, Poznań, and Częstochowa have also been recognized as the most innovative cities in Poland according to a Forbes 2019 ranking (Forbes.pl).

In the following step, based on the characteristics of smart city 1.0, smart city 2.0, and smart city 3.0 included in the survey, the respondents were asked to determine the degree of development of the city with which they are associated. The second degree of city development was indicated by 95% of respondents, and the remaining answers indicated the third degree. This result confirms the observations of other authors (Szaja, 2018, p. 351; Legutko-Kobus, 2021, p. 76) that most Polish cities should be classified as second-generation cities. The following question, in which the respondents had the opportunity to choose many answers, concerned the benefits that cities achieve by implementing the concept of a smart city into their activity. According to research, the most significant thing is to change the manner of managing traffic lights and city lighting, while the least chosen response was to increase the level of health care. These results confirm the previously cited examples of using Big Data in cities. The Figure 3 presents detailed data.

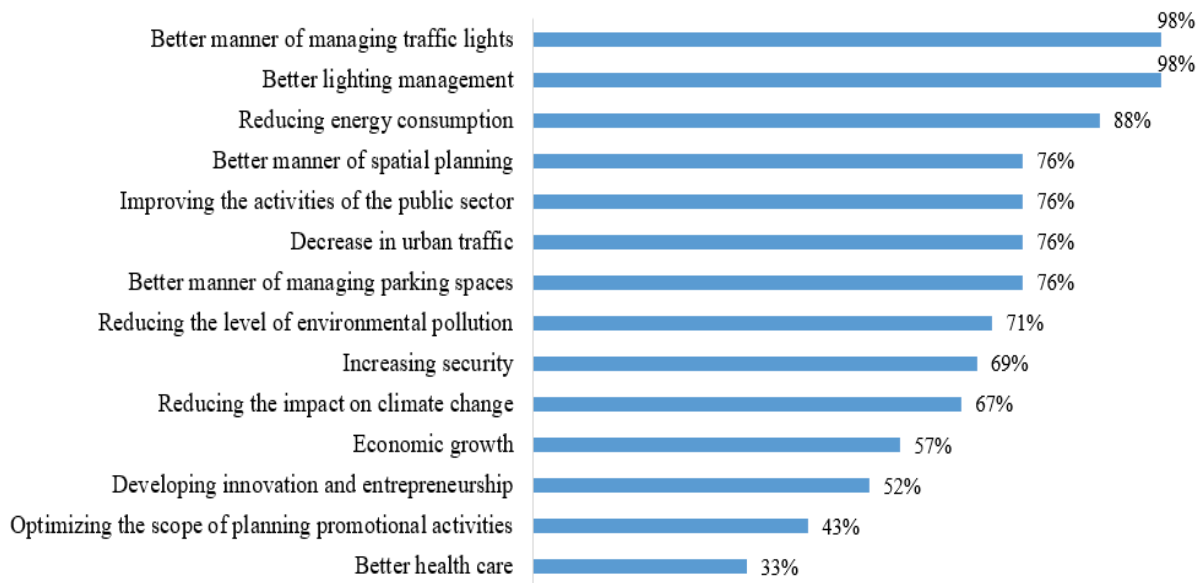


Figure 3. The benefits that cities achieve by implementing the concept of a smart city into their structures.

Source: own study.

The second area of the conducted research concerned the issue of Big Data and its connection with the concept of a smart city. The first question showed that 69% of the respondents do not feel responsible for building and developing a smart city by working in the Big Data analytics industry, 19% of them answered "hard to say", and only 12% of the respondents had a positive opinion concerning this relation.

The respondents also assessed the impact of Big Data and smart city analytics on decision-making and shaping business strategies. The research shows that 93% of respondents believe that both Big Data analytics and actions undertaken in terms of a smart city affect the functioning of enterprises (Figure 4).

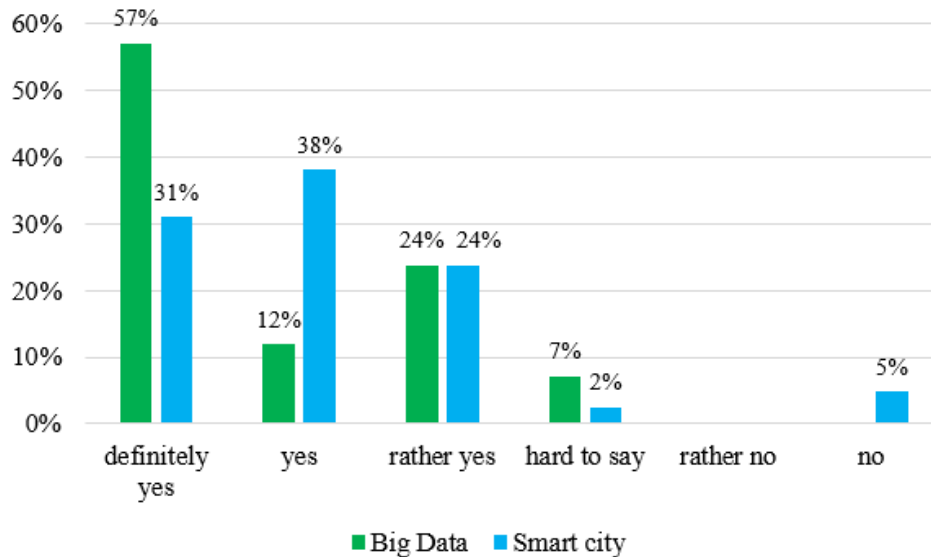


Figure 4. Impact of Big Data and smart city on decision making and business strategy shaping.

Source: own study.

In the following step, the respondents assessed the possibilities of applying Big Data analytics in individual areas of a smart city's functioning. In order to better familiarize the respondents with the analysed issues, examples illustrating its essence were provided for each of the categories. According to research most people point to the use of Big Data in smart mobility (88% of respondents in total) and smart environment (81% of respondents in total). In turn, the area where, according to the respondents, the possibility of applying this technology is the smallest consists in smart governance (a total of 50% of responses indicating the applicability, and 31% indicating its lack) (Figure 5).

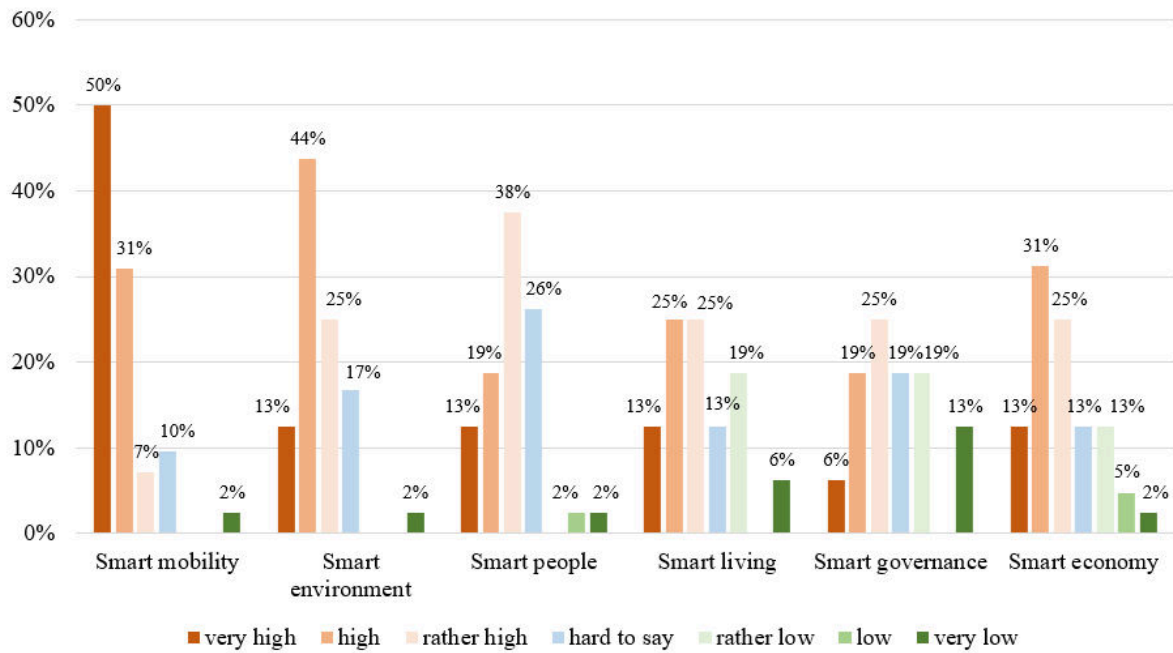


Figure 5. General assessment of using Big Data in smart city areas.

Source: own study.

The conducted research also shows that only 13% of respondents declare the impact of the concept of a smart city on the functioning and development of the company in which they currently work, 50% of them have problems with determining the level of impact, and 37% of respondents do not see a connection with this aspect.

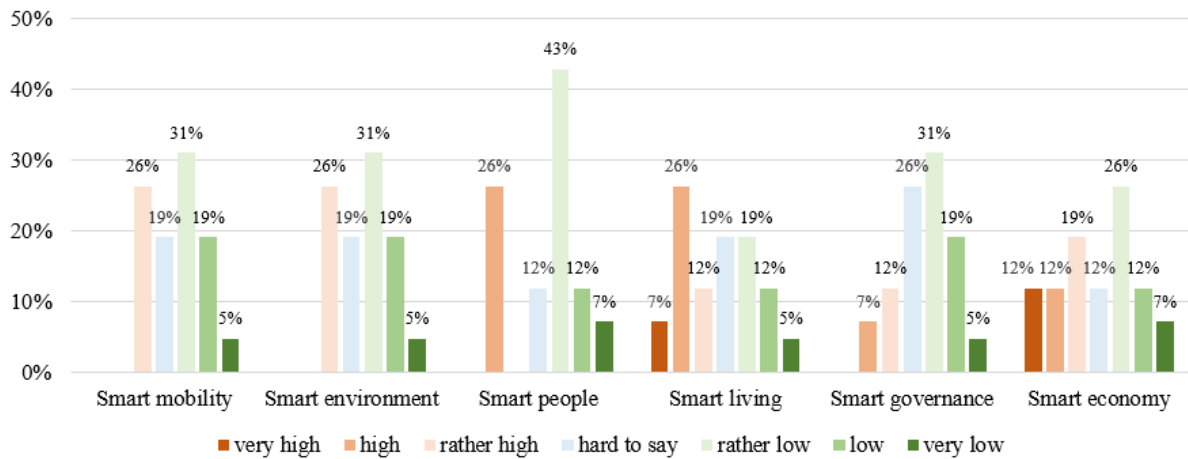


Figure 6. Assessment of the impact of individual areas of a smart city on the functioning and development of the company.

Source: own study.

The obtained outcomes are confirmed by results in which the significance of specific areas of a smart city was assessed in terms of the dynamics of companies associated with the research participants (Figure 6). More than half of the respondents do not see a relation between smart mobility, smart environment, smart people, and smart governance and the functioning and development of the company in which they work. Only in the area of smart economy

(43% of the total answers indicating "yes", 45% for "no") and smart living (45% of the total answers indicating "yes", 36% for "no"), the respondents provided answers with a similar quantitative distribution.

6. Summary

The aim of this article was primarily to research how the concept of a smart city is perceived by Big Data employees, as well as to reveal their opinions concerning the relation between Big Data technology and creating a smart technological and business environment. An attempt was also made to determine how a smart city affects the functioning of companies with which respondents were associated. Proper analysis and interpretation of the ever-growing amount of data play an important role in the development of each city, and many processes are directed towards complete optimization and automation. This trend is reflected in the growing professional group of IT specialists who are also residents and experts in the development of smart urban solutions technologies. Due to this, the participants of the research consisted in people involved in programming solutions in the field of Big Data, who generally have little experience in the field of the smart city concept. Turning to a group, which is not an expert in this topic, intended to obtain an objective image of the analysed issues. It is worth mentioning here that 100% of the participants who decided to complete the survey were between the ages of 18 and 39. This result shows that young people are probably more interested in new trends concerning programming, as well as current issues related to the functioning and development of cities.

Research results show that the respondents understand the concept of a smart city and notice the benefits of implementing this concept into urban structures. Even though the professional work of the respondents is related to Big Data, they do not feel as the creators of smart solutions. The respondents notice the practical application of Big Data analytics in the areas of city functioning (primarily in smart mobility and smart environment), but do not declare the impact of a smart city on the development and making business decisions of the companies in which they work. One of the reasons for the observed situation consists in the sole openness of the society to understanding issues aimed at facilitating living. This is also confirmed by the results of the Digital City Report, where representatives of local governments and residents indicate that an important barrier when implementing smart solutions in cities consists in the poor awareness of the public concerning the benefits of such projects. Furthermore, most implementations in Poland consists in individual actions, which are very often implemented on an ad hoc basis, but still fit into the definition of a smart city. A city constitutes a complex system that only as a whole can adapt to the dynamically changing conditions of the environment. Its efficient operation is based on harmonious activities based on clearly defined

goals included in the assumptions of multifaceted development. An important issue in this area consists in engaging in dialogue and cooperation between individual representatives of an urban society. Formulating own beliefs and opinions by individuals, while actively participating in the city's development, constitutes the foundation for creating a modern space based on the creative potential of its inhabitants.

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CONTRIBUTION OF SELECTED FACTORS TO THE CREATION OF REGIONAL AND NATIONAL ECONOMIC GROWTH. EXAMPLE OF POLAND IN YEARS 2000-2020

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Purpose: The purpose of this article is to present the role of regions in Polish economic growth in 2000-2020 with an attempt to identify the main factors driving regional and national growth.

Design/methodology/approach: The study is based on both literature and statistical data analysis. The factors of regional growth are identified using the selected elements of growth decomposition method. The analysis covered 16 regions in Poland in the period of 2000-2020.

Findings: Through the literature and statistical analysis, sources of economic growth at regional and national level are identified. The research, based on the GDP decomposition method, indicated regional differences between 16 Polish voivodeships. The shares of regions in the national and European GDP vary both in time and across regions. Regions with higher GDP growth than the Polish and European GDP one are also characterized by increase in the shares of employment, productivity, and the service sector in the values of these indicators for the whole Polish economy. The economic performance of both regions and the country is also significantly influenced by the direction of regional structural. The characteristic phenomenon for the Polish economy is still the lack of improvement of the analyzed components in regional growth with their low share in the national GDP.

Research limitations/implications: Data analysis is limited to 16 regions in Poland in 2000-2022. Further research may cover more regions of other countries, may involve a different aggregation of them, or a larger time horizon. Growth decomposition can also be carried out using more factors, at a deeper level of specification, especially in the areas of employment and productivity.

Practical implications: Knowledge of regional development factors may be the basis for policymaking, which is one of the factors ensuring high and sustainable economic development dynamics, both at regional and macroeconomic level.

Social implications: Excessive economic inequalities lead to social conflicts. Therefore, one of the objectives of the state's economic and social policy should be to reduce regional inequalities to promote development and improve the quality of life in all regions.

Originality/value: The statistical analysis covers the most recent statistical data of selected factors of regional growth. The article is addressed to all stakeholders of regional development, including local authorities, citizens, enterprises, as well as other researchers.

Keywords: regional economic growth, decomposition of economic growth, sources of regional economic growth.

Category of the paper: Research paper.

1. Introduction

The economic growth problem has long been the subject of theoretical and empirical works. Its mechanisms and causes have been the most important research topic in the economic thought history. The research direction dealing with those problem was the one termed the growth theory. The foundations of that trend were created by Robert Solow studies (Crafts, 2009) which have still been the standard research approach to explain the income level differences between countries by decomposing the economic growth (Rapacki, Próchnik, 2009). The model created by Solow indicated that the economic growth rate in the long term is determined by technological progress which increases productivity of production factors (Solow, 1957). However, subsequent studies indicated also other factors, thus reducing the technical progress contribution to shaping the economic growth. Examples of such views can be found in the works of Denison (Denison, 1962), Dale Jorgenson and Griliches (Dale Jorgenson, Griliches, 1967), Mankiw, Romer and Weil (Mankiw, Romer, Weil, 1992), in which the authors proved the relevance of human capital accumulation and labour force quality as the production growth factors. One of the most comprehensive attempts to explaining the causes of productivity growth was made by Maddison (Maddison, 1987), although, as he admitted, it was a more speculative one than the one supported by research. He concluded that the economic growth should be attributed to a combination of numerous factors, not just to the quality of labour and better allocation of resources, but also to changes in using of production factor, reduction of technology gaps and the economies of scale, believing that the technical change may bring about just a small increase. Kuznets, who studied the reasons for the economic growth in industrial economies together with Abramowitz, proved that only 25% of production growth per capita results from the increase in capital per one worker (Kuznets, 1971). Broadberry linked the changes in productivity to changes in economic structures, claiming that the productivity increases thanks to shift of resources from the agricultural to the service sector, while assuming that the productivity level in industry remained constant for 150 years (Broadberry, 1998). One of the most important works which was a frequent point of reference for analytical works was the Krugman's article in which he argued for the importance of industry specialization in the production as a factor of economic growth (Krugman, 1991). Based on the mentioned study results, it can be inferred that the stable and permanent economic growth exists if the undertaken measures improve the production factors' productivity. However, these results referred to the macroeconomic scale of economy. It was only in 1980s that both scientists and politicians sensed that the state's boundaries were not the only boundaries delineating important economic areas (Spiezia, Weiler, 2007). In subsequent years, the region began to form in economic theory and practice as crucial "competitive space" (Brenner, 2000).

2. Sources of regional economic growth. Review of the literature

The newly emerging 'new regionalism' idea in research, raised the importance of the regional scale (Bristow, 2010). Even before that, Schumpeter (Schumpeter, 1960) noticed that the entrepreneur who, striving to maximize profits, introduced new combinations of production factors by using new innovative solutions on the market was a creator of economic development. This view pointed to the fundamental importance of business behavior as a driving force of development processes in the economy. For the new regionalism proponents, the region and regional entities became a site of economic development and wealth creation where the force driving the competitive advantage throughout the whole economy was born (Storper, 1997). This statement started a scientific debate which attempted to explain the determinants of differences between regions and their impact on the entire economy results. The detailed analysis of the self-accelerating changes in regional inequalities according on the stage of development in the industrialization period was carried out by Williamson in his work (Williamson, 1965). In his opinion, they could be perceived, in a sense, as a by-product of the process of development and industrialization, and any attempt to reduce its level may ultimately inhibit this process. Similar conclusions were presented in the works by Kim and Marago who proved that the increased industrialization in the United States in the second half of 19th century aggravated the regional differences in region income (Kim, Margo, 2003). European experiences may be considered relatively significant when it comes to the increased dynamics of regional inequalities as a result of the adaptation of the poorest Member States of the European Union (Quah, 1996; Petrakos, Saratsis, 2000; Davies, Hallet, 2002). This was also confirmed by the European Commission's 2004 Report (European Commission, 2004) which indicated that the regional inequalities displayed a growing trend in such countries as the Czech Republic, Hungary, Poland, and the Slovak Republic due to the need to catch up quickly with highly developed members. The Report also indicated that regional inequalities tend to increase on average as the relative level of domestic GDP per capita increases, and then they start to have a decreasing tendency, after reaching a certain relative level of domestic GDP per capita. The identification of the sources of economic growth and development inequalities in regions is carried out by e.g. Spiezia (Spiezia, 2003), Ottaviono and Thisse (Ottaviono, Thisse, 2004), Gorzelak (Gorzelak, 1997), Winiarski (Winiarski, 1999), Skrzyp (Skrzyp, 2009), and Łażniewska (Łażniewska, 2013). Those authors usually point to three groups of interrelated factors. The first group includes the measures determining the regional potential which may be perceived as a result of irregular distribution of natural resources, climatic and natural conditions. The second group is based on the belief that the observed differences result from economic and political activities (Ottaviono, Thisse, 2004). The third group of regional development determinants is the structural characteristics of the region, including transport, infrastructure, labor market and human capital (Spiezia, Weiler, 2007). These factors are

determined by a combination of regional factors such as: natural endowments and regional assets, and the economic policies as a national factor. Their distinction is relevant in identifying the sources of economic growth. Problems of regional development and competitiveness were also analyzed by Polish economists (Malaga, 2004; Łązniewska et al., 2011; Smętkowski, 2015; Gorzelak, 1997; Zaucha et al., 2015; Lewandowski, 2018). The authors published comprehensive literature studies and empirical analyses to explain the regional divergence processes of European Union countries (UE) or, more broadly, of economies belonging to the Organisation for Economic Co-operation and Development (OECD), basically covering statistical data only from the first decade of 21st century. Based on the quoted studies, it may be inferred that the economies do not constitute a homogenous unit, their regions develop at different rates and with different intensities. The regional development level may be differentiated permanently, but it is not necessarily unidirectional, irreversible, and repeatable process. Regional disparities may be either the consequence of or the reason for the development of an economy. This makes the economic growth analysis on the regional level and its contribution to the economic performance of the country constantly relevant and worthwhile. Therefore, this article attempts to analyze the regions' role on the economic growth based on data on the Polish economy in the first twenty years of the 21st century. This issue is important because the knowledge of mechanisms and regularities of regional development may be the basis for shaping a policy, constituting also a factor ensuring high and sustained economic growth dynamics both on the regional and on the macroeconomic level.

3. Methods

Scientists use different methods to measure the sources and disparities of regional development. The most important of them include the methods using the traditional, theoretical competitiveness models, the methods decomposing competitiveness into identified factors and indexes of general competitiveness and regional competitiveness (Łązniewska, 2013). The method used in this article is based on selected components of methodology described by Spiezia (Spiezia, 2003) and used by such statistical analyses' centers like OECD (OECD Regions at a Glance), Statistics Poland and in some Polish and foreign papers (Łązniewska, 2013; Lewandowski, 2018). The method proposed by Spiezia (Spiezia, 2003; Spiezia, Weiler, 2007), based partially on the shift-share analysis presented by Creamer and formalized by Dunn (Dunn, 1960), consists in decomposing the gross domestic product into a number of components which, when summed up, make its value. The author of this method proposed 7 main components of regional conditions of gross domestic product: average productivity, industry specialization, change in specialization, employment rates, participant rates, activity rates and population. The advantage of this approach is the simplicity of presentation and

interpretation of results, but it does not include any components expressing the simultaneous impact of several factors included in the decomposition and difficult to ascribe to a specific factor (Lewandowski, 2018).

In this article, the term “region” stands for the territories of individual 16 Polish voivodeships, based on NUTS-2 classification: Dolnośląskie, Kujawsko-Pomorskie, Lubelskie, Lubuskie, Łódzkie, Małopolskie, Mazowieckie, Opolskie, Podkarpackie, Podlaskie, Pomorskie, Śląskie, Świętokrzyskie, Warmińsko-Mazurskie, Wielkopolskie and Zachodniopomorskie. The research in this article is based on annual indicators of the level and dynamics of gross domestic product (GDP) and GDP per capita as the measurements of economic growth, and the gross value added (GVA). The analysis refers to the share of individual regions output in creating the national (total Polish GDP) and EU GDP (total EU) GDP and the national GDP per capita (total Polish GDP per capita). The shares in creating the EU and national GDP are calculated using formulas 1 and 2 (Appendix). Faster production growth in all analyzed voivodeships than the production growth calculated for all European Union regions is explained using national factors. On the other hand, the faster production growth of a given region when compared to the growth characteristic of the European Union or Poland will be ascribed to regional factors. In this article, the decomposition of economic growth is based on the following components: employment rate, average productivity, sectoral specialization, and population. The selected components correspond to the economic growth determinants and regional growth factors presented in this article. The employment rate component means the regional employment rate in individual voivodships in 2000-2020. Its contribution to the national GDP is calculated based on formula 3 (Appendix). Changes in this component can result from both improvements in the quality of the labour force and appropriate state and regional regulations that contribute to labour market efficiency. Therefore, it can be considered rather as result of regional assets because state regulation will apply identically to all regions. The employment share changes are compared to the GDP per capita and population changes. Population changes are a result of demographic characteristics, i.e. regional endowments, and state migration policies determine employment changes. The average productivity component is calculated for each region as the value of the regional GVA divided by the number of employees in the region in 2000-2020. The contribution of regional productivity to the value for the entire Polish economy is calculated based on formula 4 (Appendix). The changes of the share of regional productivity are compared to the regional GDP per capita changes. Growth in productivity may result, as described, from improvements in technology, in the quality of the labour force, structural changes and better allocation of resources, thus being the result of regional assets. Higher productivity means higher competitiveness, faster production growth on the one hand, but on the other it may mean decrease in employment. However, a decrease in productivity may result from an increase in employment. The next component, sectoral specialization, is understood, in this article, as the share of three economic sectors in each region: agriculture, industry and services. According to the three-sector theory, introduced by Fisher and developed

by Clark and Fourastie (Kwiatkowski, 1982), the economic development is first accompanied by the industrialization process with reduced share of the agricultural sector. This is followed by a process of reducing the share of the industrial sector, together with a process of servitization (Rostow, 1971). Consequently, the most developed economies are characterized by the highest share of the service sector. The economic structure can be shaped by several factors, among which can be mentioned: the natural resources available, technical progress, foreign trade, economic policy, and the institutional system of the state (Kempny, 1991). Hence, the factors that differentiate regional performance can be defined as a certain combination of natural endowments and regional assets. The sectoral specialization changes are analyzed through the changes in the agriculture, industry, and services shares of individual regions according to national values of these sectors and its correlation with changes in national GDP per capita. Correlation coefficients, calculated using formula 5 (Appendix), take values between 0 and 1 where the higher value indicating greater correlation between variables. The analysis is summed up by the summary compilation of individual regional GDP components. The main source of data is the Local Data Bank of Statistics Poland (GUS-Local Data Bank). The statistical data comes from the period of more than twenty years, from 2000 to 2020, except for the one concerning the EU GDP value (the data available in Eurostat covers the years up to 2019).

4. Results and discussion

The analysis of changes in GDP values reveals regional disparities among 16 voivodeships of the Polish economy in 2000-2020. Figure 1 presents changes in shares of Polish regions and Poland in the total GDP of the European Union in 2000-2019. Although the general trend of changes in these shares is identical for every voivodeship in 2000-2019, the graph shows differences between regions' shares. The voivodeships with the share in the EU GDP higher than that of the entire Polish economy include: Dolnośląskie, Mazowieckie, Wielkopolskie and Śląskie. This means that those regions use their regional resources better than the other voivodeships. The same situation characterizes the value and dynamics of changes in GDP per capita. Figure 2 presents changes in the share in GDP per capita in comparison with the initial value. Again, voivodeships as Dolnośląskie, Łódzkie, Małopolskie, Mazowieckie and Wielkopolskie are characterized with the highest (over 75%) increase in GDP per capita. It is worth mentioning, that those voivodeships are also characterized by higher increase in share in the EU's GDP per capita than that of Poland. The lowest growth dynamics (below 50%) has just one voivodeship, i.e. Zachodniopomorskie. The other voivodeships, in the range of 50-75% of the share in the EU GDP, are regions whose share in GDP is lower than 30%, at the beginning of the analyzed period. The positive aspect is that all voivodeships experienced

the increase in their share in EU GDP per capita. However, the voivodeships with a low share retained their low position. Attention should be paid to the following two voivodeships: Małopolskie and Łódzkie, which note high increase in the analyzed period despite the low initial share level. This gives the highest share in EU GDP at the end of the analyzed period.

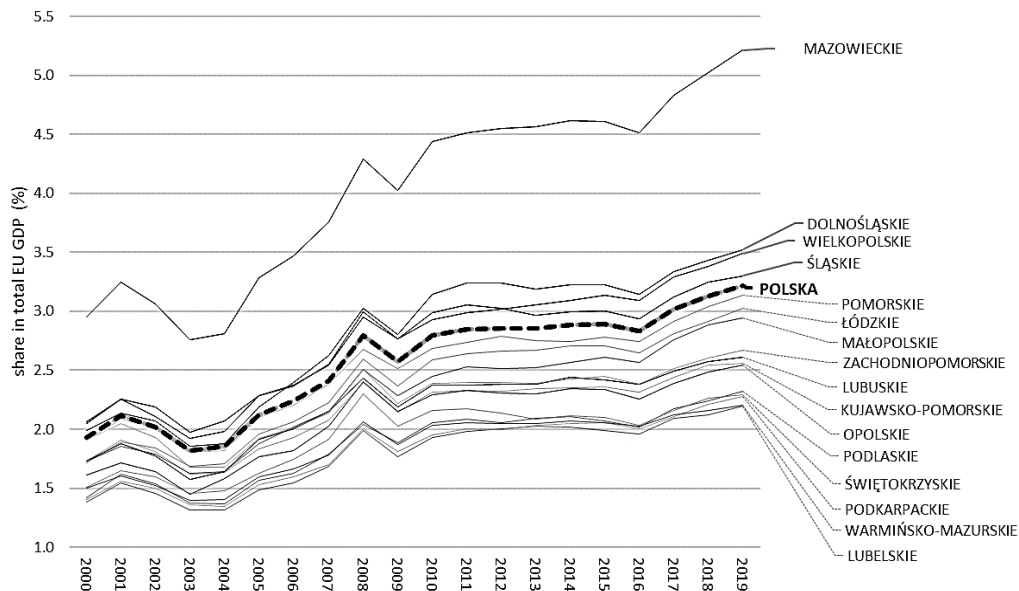


Figure 1. Regional GDP share in total European Union GDP.

Source: own elaboration based on statistical data of the Central Statistical Office of Poland and Eurostat.

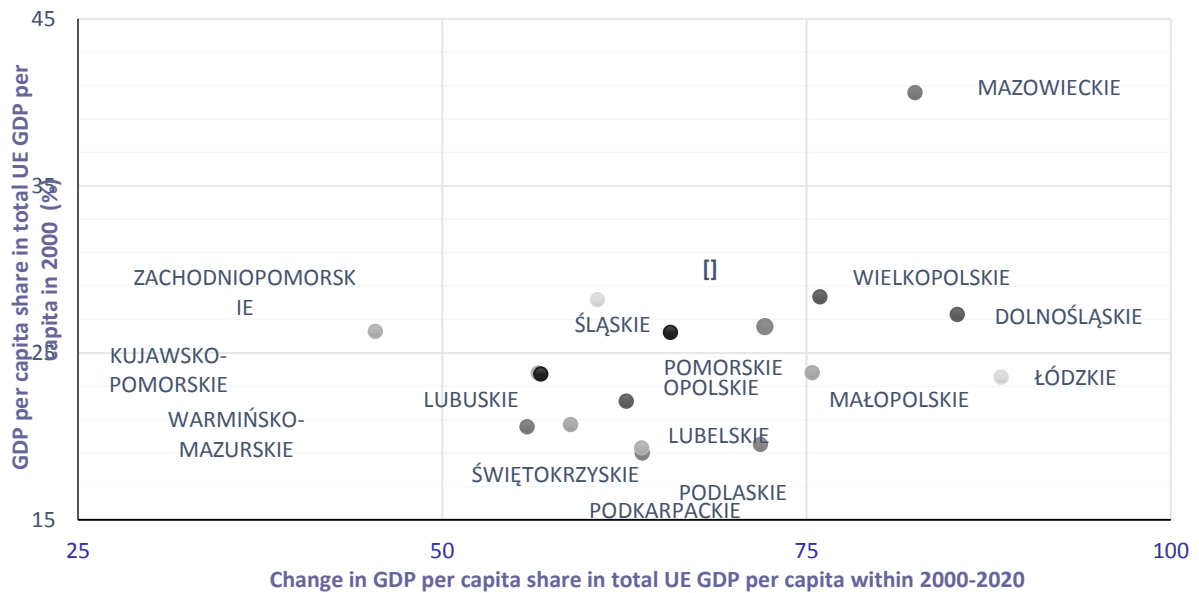


Figure 2. Changes in regional and Polish GDP per capita share in total UE GDP per capita within 2000-2020 in relation to 2000.

Source: own elaboration based on statistical data of the Central Statistical Office of Poland.

Figure 3 presents changes in the share of regional GDP per capita in total national GDP per capita, when compared to the initial value in 2000. The highest increase is recorded in Mazowieckie voivodeship, which is also characterized by the highest share in total national GDP. The Śląskie voivodeship, however, records significant percentage decrease in that share, still takes the second place, after Mazowieckie. Relatively high percentage decrease in share is characteristic of voivodeships with a low initial share in GDP per capita (up to 5%). It is not consistent with the processes observed by Spiezia (Spiezia, Weiler, 2007), who claimed that the lower initial share, the higher its increase is. In the analyzed period, this rule is characteristic only for Wielkopolskie voivodeship (low initial percentage share and significant percentage increase). Voivodeships with medium share (5-10%): Dolnośląskie, Łódzkie, Małopolskie and Pomorskie, note increase. The voivodeships are also characterized by higher GDP increase than the average increase for Poland.

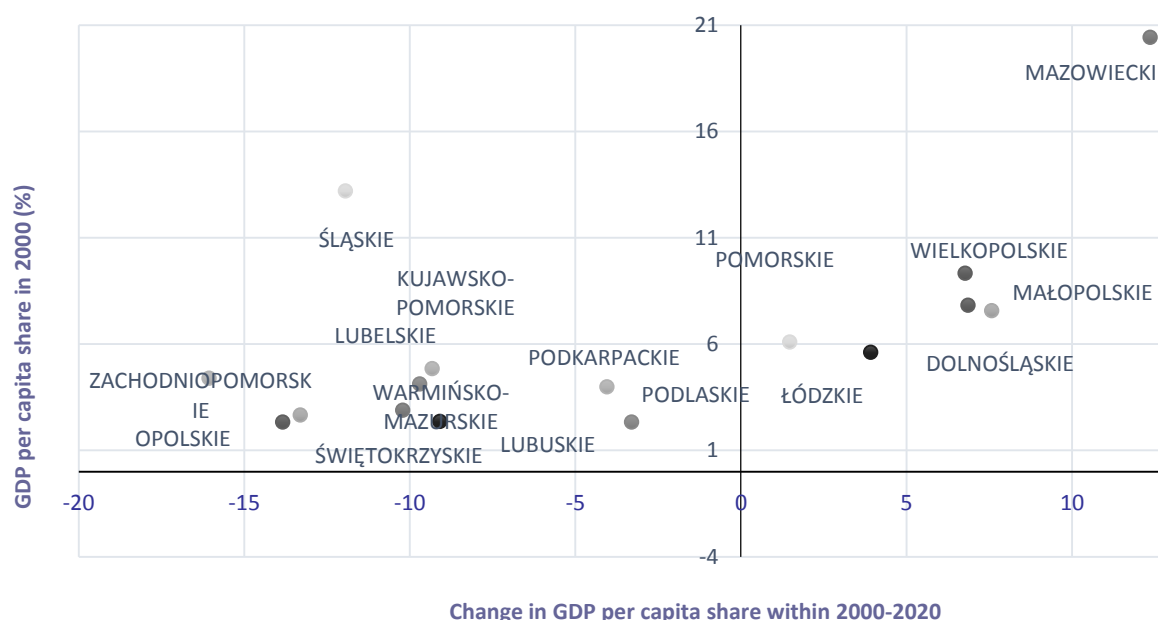


Figure 3. Changes in regional GDP per capita share in total GDP per capita of Poland within 2000-2020 in relation to 2000.

Source: own elaboration based on statistical data of the Central Statistical Office.

The voivodeships in the left part of Figure 3, with decreasing shares, are characterized by lower growth than Poland. To sum up, the voivodeships with the lowest share in EU GDP and GDP per capita note the decreased share in Polish GDP as well. The aggregate results are presented in Table 1. The leading voivodeships in 2000-2020 in this area include Dolnośląskie, Łódzkie, Małopolskie, Mazowieckie, Pomorskie and Wielkopolskie. Figure 4 presents changes in shares of the population in voivodeships in relation to changes in the share of GDP per capita. The total population in many regions of Poland decreases in the analyzed years. The most significant decline rates are recorded for Łódzkie and Opolskie. It can be also observed the growing concentration of the population in the regions with the highest increase of GDP per capita. In the other regions, the population decreased, but only in two voivodeships: Dolnośląskie and Łódzkie, it is accompanied by the increase in GDP per capita.

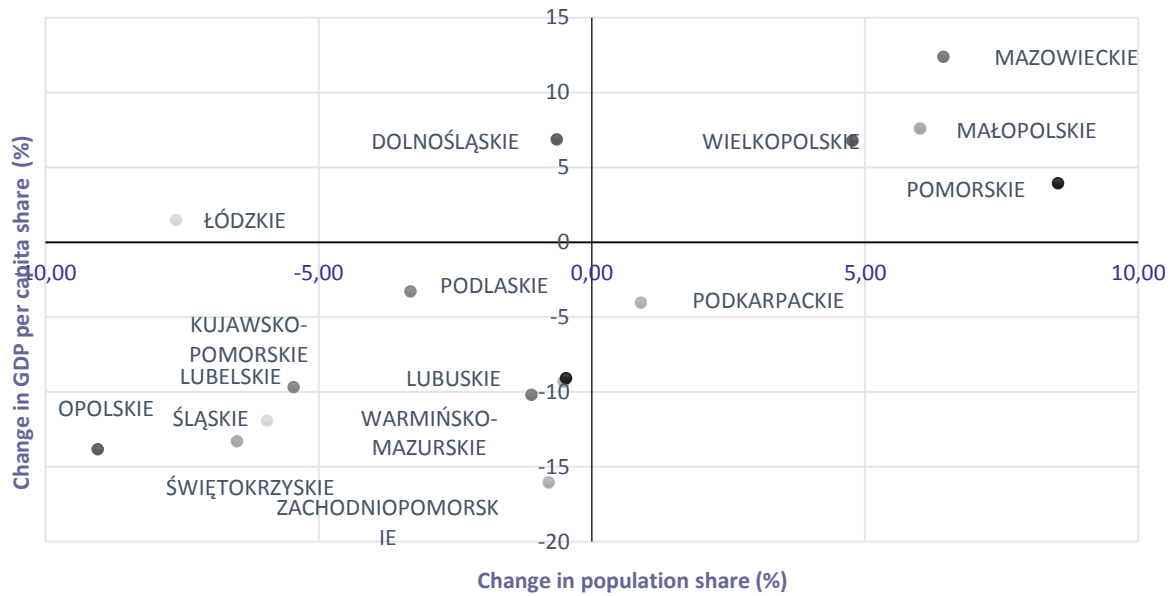


Figure 4. Changes in regional GDP per capita share in total GDP in Poland in relation to changes in regional population in total population in Poland.

Source: own elaboration based on statistical data of the Central Statistical Office of Poland.

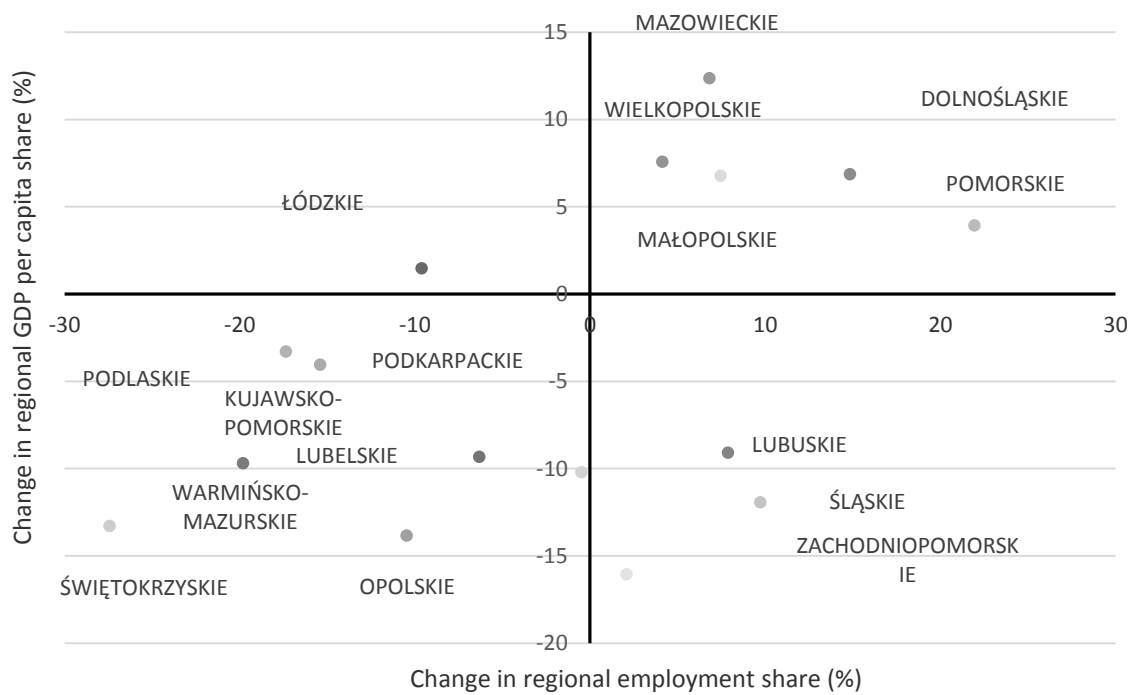


Figure 5. Changes in regional GDP per capita share in total GDP in Poland in relation to changes in regional employment share in total employment in Poland within 2000-2020.

Source: own elaboration based on statistical data of the Central Statistical Office of Poland.

Increase in employment rate share, shown in Figure 5, is characteristic for following regions: Dolnośląskie, Lubuskie, Mazowieckie, Pomorskie, Śląskie, Wielkopolskie, and Zachodniopomorskie (also Table 1). The analysis of the tendency in employment rate changes in individual regions in Poland, the same voivodeships can be mentioned, characterized both by the increase in share in Polish national GDP per capita and employment rate (Figure 5): Dolnośląskie, Małopolskie, Mazowieckie, Pomorskie, and Wielkopolskie. Figure 5 also quite clearly shows that most Polish regions are characterized by decrease in both the share in GDP per capita and in share in employment. In three voivodeships, Lubuskie, Śląskie and Zachodniopomorskie, there is a negative change despite an increase in share of employment rate with relatively significant decrease in GDP per capita share. All three regions are experiencing population decline (Figure 6). To understand the reasons for this phenomenon occurrence and to interpret it, it would be necessary to decompose it further based on the population age structure and activity when compared to the number of workers. Among the above-mentioned three voivodeships characterized by the decrease in the share in population with increased share of employment there is also Dolnośląskie. This voivodeship note the increase in the share in GDP per capita of Poland and EU, as well as increased share of employment, with simultaneous decrease in the population (Figure 6). This points to the increased productivity (Figure 7).

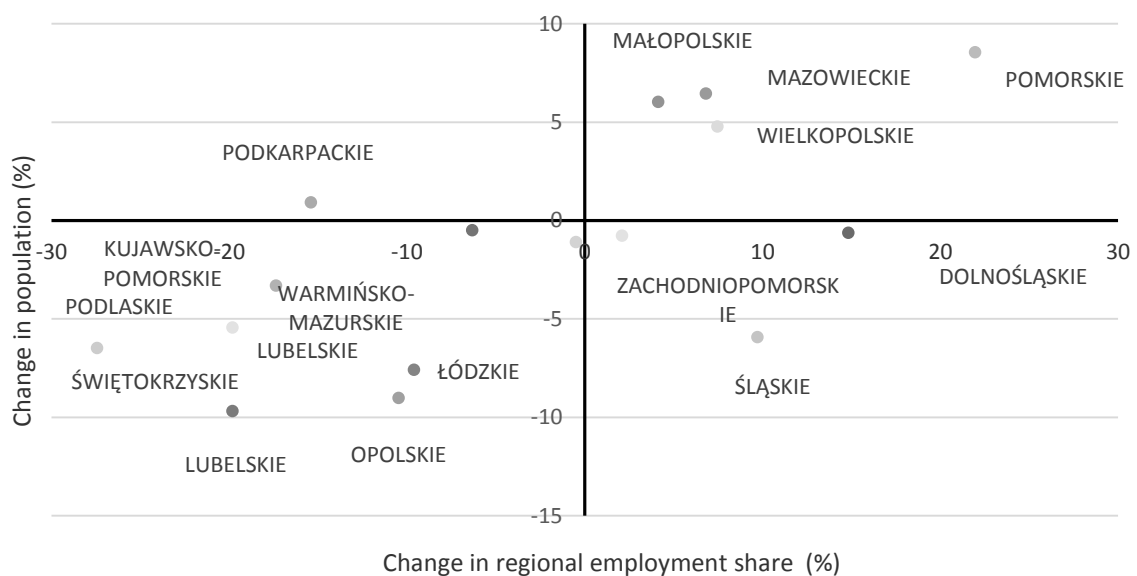


Figure 6. Changes in regional employment share in total employment in Poland in relation to changes in population within 2000-2020.

Source: own elaboration based on statistical data of the Central Statistical Office of Poland.

The changes in share in productivity in relation to the changes in share in GDP is presented in Figure 7.

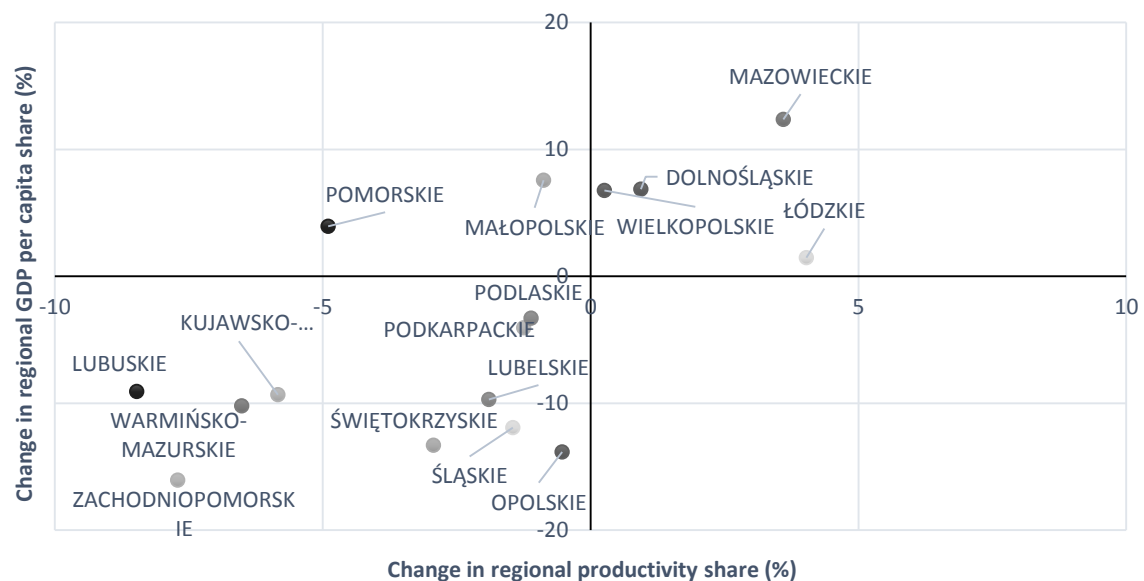


Figure 7. Changes in regional productivity share in total productivity in Poland in relation to changes in population within 2000-2020.

Source: own elaboration based on statistical data of the Central Statistical Office of Poland.

This figure shows the voivodeships characterized by positive productivity increase, besides Dolnośląskie, include: Łódzkie (with the highest positive change of more than 4%), Małopolskie, Mazowieckie, Pomorskie and Wielkopolskie. Three of the above-mentioned voivodeships (Dolnośląskie, Mazowieckie and Pomorskie) experience the productivity higher than the national average throughout the entire analyzed period (Table 1). To the group of such voivodeships, Zachodniopomorskie (but only by 2016) and Lubuskie (by 2007) could be included. Those changes are positive and directly proportional only in four voivodeships, namely Dolnośląskie, Mazowieckie, Łódzkie and Wielkopolskie. In the remaining voivodeships, the negative GDP per capita change of share is accompanied by negative change in productivity. On the one hand, this proves the tendency described in reference works, namely that higher productivity leads to higher increase in production. On the other, however, the increased share of the regional productivity in the total productivity of the Polish economy leads to increased share in national GDP per capita. This regularity does not apply to Małopolskie and Pomorskie, where the increased share of productivity is accompanied by decreased share in GDP per capita. The analysis of the impact of the sectoral specialization on the changes of share in GDP per capita also allows to observe several facts. First, it may be noticed that industrialization processes take place in most regions in the analyzed period which contributes to increased disparities between the regions. Only in Mazowieckie the service sector growth dynamics is the highest. However, in Lubuskie, the highest increase is recorded for the agriculture sector. Figure 8 shows that the share in the value of the GVA in the agriculture and service sector is much higher in Kujawsko-Pomorskie, Podlaskie, Warmińsko-Mazurskie and Wielkopolskie than in the other regions. High share of industrial sector is characteristic for:

Dolnośląskie and Śląskie. However, Śląskie has the highest share in the GVA from the industrial sector, with a very low share of agricultural one. Summing up, the regions with the highest GDP per capita increase have the same direction in sectoral specialization – increase in services sector (Table 1). Figure 8 presents relatively high regional differences with concentration of production in all three distinguished sectors in with the Voivodeships.

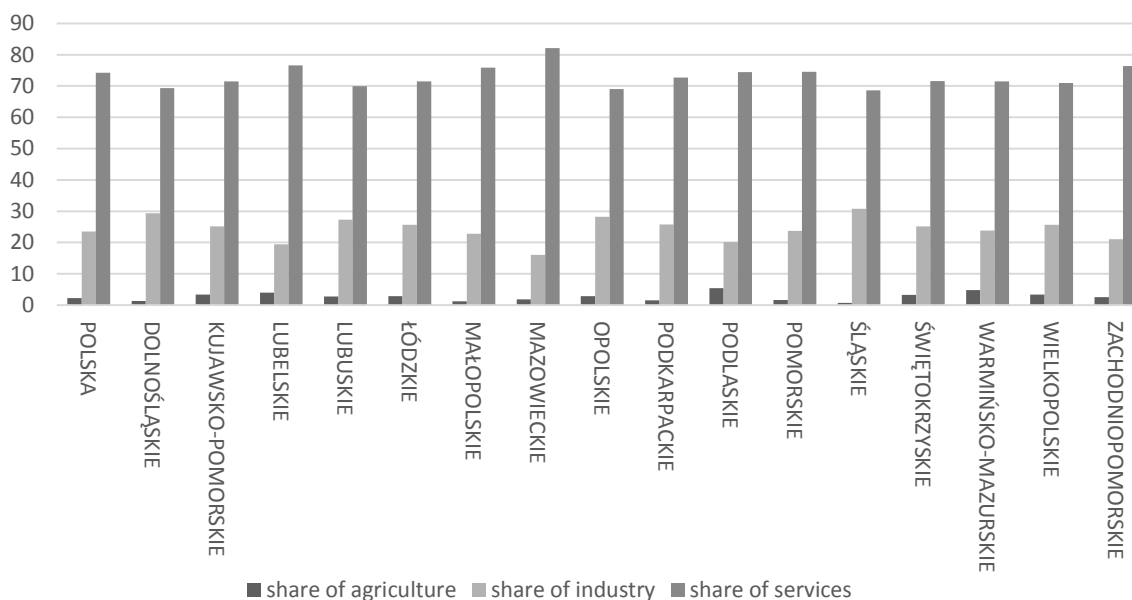


Figure 8. Average shares percentage of three sectors (agriculture, industry and services) in value added of Polish regions in 2000-2020.

Source: own elaboration based on statistical data of the Central Statistical of Poland.

In Figure 8, it can be observed that all regions are characterized by the largest share of the service sector, with a much smaller share of the industrial and agricultural sectors in GVA. This structure is characteristic, according to the three-sector theory, of developed countries. However, such voivodeships as Lubelskie, Lubuskie, Opolskie, Podkarpackie, Podlaskie, Świętokrzyskie and Warmińsko-Mazurskie are characterized by low, about 3% share in the GVA of the Polish economy. Regions with the higher growth in analyzed sectors than these one in total Polish economy are listed in Table 1.

Table 1.

Regions with higher component growth than Poland in 2000-2020

Regions with higher growth than in total Poland of:	
Component	Regions
GDP	Dolnośląskie, Łódzkie, Małopolskie, Mazowieckie, Pomorskie, Wielkopolskie
GDP per capita	Dolnośląskie, Łódzkie, Małopolskie, Mazowieckie, Wielkopolskie
Employment	Dolnośląskie, Lubuskie, Mazowieckie, Pomorskie, Śląskie, Wielkopolskie, Zachodniopomorskie
Productivity	Dolnośląskie, Mazowieckie, Pomorskie, Śląskie, Zachodniopomorskie
Share of agriculture	Lubelskie, Łódzkie, Mazowieckie, Podlaskie, Pomorskie, Świętokrzyskie
Share of industry	Dolnośląskie, Lubuskie, Mazowieckie, Podkarpackie, Podlaskie, Pomorskie, Wielkopolskie
Share of services	Dolnośląskie, Łódzkie, Małopolskie, Mazowieckie Pomorskie, Wielkopolskie

Source: own elaboration.

Figure 9 depicts the change of three sectors shares in Polish GVA. The highest increase in shares referring to agricultural production there is in: Lubelskie, Mazowieckie, Podlaskie and Pomorskie. The increased share value in the industrial sector refers to Dolnośląskie, Lubuskie, Mazowieckie, Podkarpackie, Podlaskie, Pomorskie and Wielkopolskie. However, the changes of the service sector share are small, even if they occur, in such voivodeships as Dolnośląskie, Małopolskie, Łódzkie, Mazowieckie, Pomorskie and Wielkopolskie. In five voivodeships, the share in the GVA for the Polish economy decreases in all three sectors in Kujawsko-Pomorskie, Opolskie, Śląskie, Warmińsko-Mazurskie and Zachodniopomorskie. It is observable that the highest decrease in share is recorded for Śląskie despite a relatively high initial position.

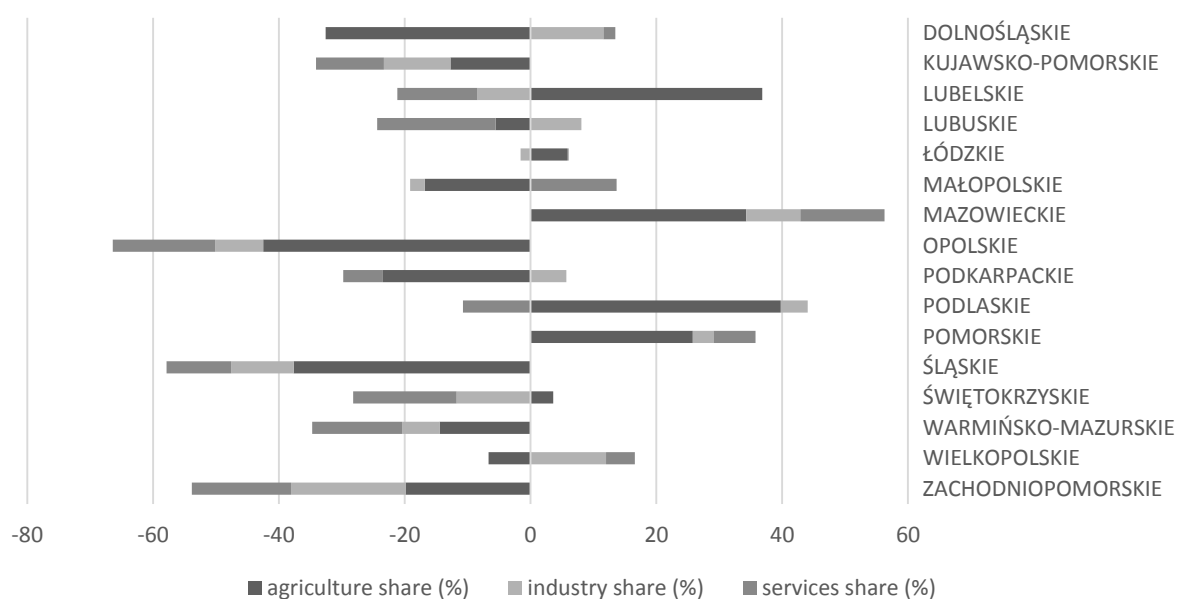


Figure 9. Changes in regional shares of three economic sectors (agriculture, industry, and services) in total value added in Poland in 2000-2020.

Source: own elaboration based on statistical data of the Central Statistical Office of Poland.

Significant share increase is recorded by Małopolskie in the service sector and Dolnośląskie and Podlaskie in the industrial one.

The calculated correlation coefficient between the GDP per capita values for Poland and the changes in shares of GVA for regions is the highest for the service sector. The coefficient is 0.94 which indicates very high correlation between those variables. The correlation between the regions' shares in GDP and the GVA for industrial sector is slightly lower (0.77), but still significant.

Figure 10 summarizes the analysis of changes of selected GDP components for analyzing regions. It reveals that the share of all components in total national GDP increased in two voivodeships: Mazowieckie and Wielkopolskie. Three voivodeships, on the other hand, record the decrease in those shares, namely Kujawsko-Pomorskie, Opolskie and Warmińsko-Mazurskie. In such voivodeships as Śląskie and Lubelskie, the increase occurs solely in the share of employment, with the decreasing share of the other components. However,

in voivodeships such as Małopolskie and Pomorskie, the share of the productivity is the only one to decrease. What is more, structural changes and changes in employment rate have the highest share in total Polish GDP in 2000–2020. If compared these results presented in this article with the results provided by the other authors for the previous period, certain similarities and differences could be noticed. The lower share of population and productivity changes is noticeable in the analyzed years, and the directly proportional relationship between the productivity and economic growth is confirmed. However, still a characteristic phenomenon for the Polish economy is a visible regional differentiation and lack of improvement of the analyzed components in the regions with the lowest GDP growth along with their low share in the national GDP.

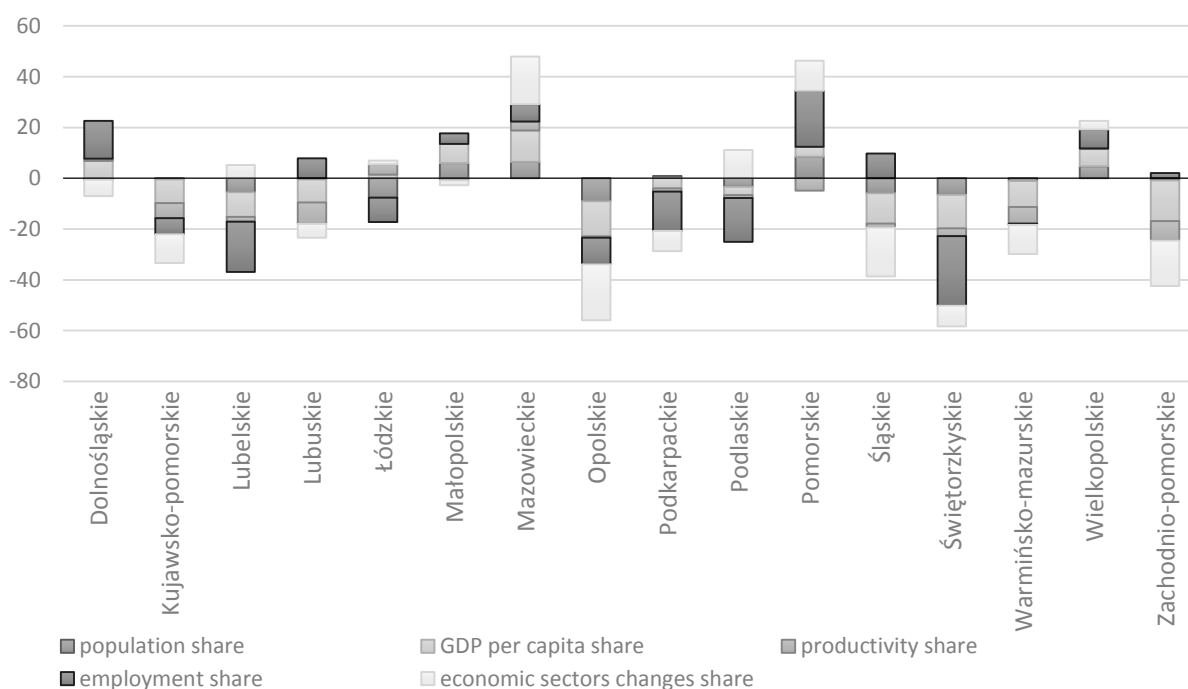


Figure 10. Changes in regional contribution to the total GDP in Poland in 2000-2020.

Source: own elaboration based on statistical data of the Central Statistical Office of Poland.

5. Summary

This article attempts to analyze the regional contribution to economic growth on the example of the Polish economy in the period 2000-2020. Through the literature and statistical analysis, sources of economic growth at regional and national level are identified. The research, based on the GDP decomposition method, indicated regional differences between 16 Polish voivodeships, which is in line with the conclusions of researchers from earlier periods. The shares of regions in the national and European GDP vary both in time and across regions. 90% of regions which record the increase in the share of productivity record the increase of

GDP per capita as well. The inverse relationship of change in the share of employment to the change of productivity occurs in close to 40% voivodeships. The interchangeability of these processes was also confirmed in studies by Spiezia and Weiler (Spiezia, Weiler, 2007), and other authors, while indicating that it is not inevitable. In the remaining 60% of Polish regions, the change in the share of employment was always higher than share of productivity, with the increase both variables in 4 regions. The same 4 regions also note increase their regional GDP per capita higher than Polish. This observation is consistent with the conclusions of the above-mentioned researcher. The directions of structural changes also has significant impact on the regional and national economic performance. Most voivodeships owe their good results to changes in that component values. 4 out of 16 regions are characterized by the increased share of the service sector in GVA with the high economic growth rate and positive change in the share of productivity and employment in national growth. However, still in line with previous studies, e.g. by E. Łaźniewska (Łaźniewska, 2013), the characteristic phenomenon for the Polish economy is the lack of improvement of the analyzed components in regional growth with their low share in the national GDP, especially in the regions of eastern Poland. The study results may constitute a starting point for further, in-depth analysis of key factors shaping the economic results of individual regions.

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Appendix

Formulas for decomposition of regional growth method:

1. GDP share of region i in the GDP of EU:

$$(GDPshareinUE) = \left(\frac{GDP_j}{GDP_{EU}} \right) * \left(\frac{GDP_i}{GDP_j} \right) \text{ GDP share of region } i \text{ in the GDP of EU} \quad (1)$$

2. GDP share of region i in the total GDP of Poland:

$$(GDPshareinPL) = \left(\frac{GDP_i/P_i}{GDP_{PL}/P_{PL}} \right) * \left(\frac{P_i}{P_{PL}} \right) \quad (2)$$

3. Employment rate share of region i in employment rate of Poland:

$$(EMPshareinPL) = \left(\frac{GDP_i/E_i}{GDP_{PL}/E_{PL}} \right) * \left(\frac{P_i/E_i}{P_{PL}/E_{PL}} \right) \quad (3)$$

4. Average productivity share of region i in total average productivity in Poland:

$$(PRDshareinPL) = \left(\frac{GVA_i/E_i}{GVA_{PL}/E_{PL}} \right) * \left(\frac{P_i/E_i}{P_{PL}/E_{PL}} \right) \quad (4)$$

where:

GDP_i – gross domestic product of i region,

GDP_{PL} – gross domestic product of Poland,

GDP_{EU} – gross domestic product of European Union,

P_i – population in i region,

P_{PL} – population in Poland,

E_i – employment in i region,

E_{PL} – employment in Poland,

GVA_i – productivity in i region,

GVA_{PL} – productivity in Poland.

5. Correlation coefficient:

$$(r) = \frac{\sum (x_i - x_{mean})}{\sum (y_i - x_{mean})} \quad (5)$$

where:

x_i – values of the x-variable in a sample,

x_{mean} – values of the x-variable in a sample,

y_i – values of the y-variable in a sample,

y_{mean} – values of the y-variable in a sample.

DECENTRALIZATION IN MULTI-ENTITY ORGANIZATIONS AS A CONTEMPORARY CHALLENGE FOR PARENT COMPANY

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Purpose: The purpose of the study is to identify the degree of centralization - decentralization of management in multi-entity organizations. Around the main objective thus formulated, the following specific objectives were established: (1) to recognize the degree of centralization -decentralization of management in multi-entity organizations in light of the literature on the subject (2) to identify the changes directly implemented in the subsidiaries of German concerns during the Covid-19 pandemic, (3) to recognize the directions of changes in the distribution of functions in the subsidiaries of German concerns.

Design/methodology/approach: The method used was content analysis of source materials and the interview method. The director of the production plant (subsidiary) was interviewed systematically (once a year). Interviews were conducted from 2019 to 2022.

Findings: The research shows that during the Covid-19 pandemic period, the scope of functions and decision-making powers were increased for subsidiaries. This is because the idea was to equip them with the necessary competencies to make many important decisions on the spot from time to time.

Research limitations/implications: The research was limited to four subsidiaries belonging to different automotive concerns. The results presented should serve as a starting point for research on a larger research sample.

Practical implications: Coronavirus influenced the acceleration of decentralization processes in concerns. The results of the study showed the changes that the companies implemented in terms of functions and decisions in order to cope with the new challenges (threats) coming from the environment. The results presented in the article can be used by other multi-entiti organizations to redesign the structures of their subsidiaries into more flexible and more resilient to hard-to-predict phenomena arising in the organization's environment. As a result, increasing their decision-making independence.

Originality/value: Demonstrate the trend toward decentralization of management, detailing the functions covered by the changes. The material can be used by practitioners to redesign existing arrangements for functions (tasks) and decision-making powers in subsidiaries.

Keywords: Parent company, subsidiary, centralization, decentralization.

Category of the paper: Research paper.

1. Introduction

A multi-entity organization consists of an overarching unit (parent company) and subordinate units (daughter companies). The parent entity acts as a decision-making and management center. It imposes objectives, strategy, rules of operation on subordinate entities and enforces their implementation. The role of subordinate units is to implement the decisions made (strategy) and generate value for the entire multi-entity organization. As a rule, they are strongly dependent on the company's headquarters in their operations.

Observations of business practice, as well as management theory, indicate that efficiency, quality, flexibility and innovation are becoming categories that determine the development of organizations in the 21st century. The importance of competent employees, information systems, including information and communication technologies, automation and robotics (Industry 4.0), artificial intelligence (Birkinshaw, 2018; Iansiti, Lakhani, 2020) and also organizational culture is increasing. The political and legal situation in the world is changing (Kunisch, Menz, Collis, 2020, p. 4), cultural conditions (Baum, Haveman, 2020, pp. 268-272), global competition is constantly growing and so are the demands on organizations. Global value chains have emerged (Strange, Humphrey, 2019, pp. 1401-1413; Hernandez, Pedersen, 2017, pp. 137-150). There are also phenomena that are difficult to predict and have not occurred before, such as the Covid-19 pandemic. The pandemic is treated as a completely new phenomenon relying on the fact that organizations did not have time to analyze upcoming changes and adopt defensive strategies, but were almost immediately confronted with the consequences of events over which they had no control (Flieger, 2020). The pandemic showed that most B2B companies and society in general were unprepared to deal with a crisis of this scale and nature (Mora, 2020). The pandemic influenced faster-than-ever decision-making in various functional areas of the organization, the processes implemented, accelerated the introduction or modernization of information systems. It has reduced the importance of just-in-time in the supply chain, and has led many companies to reorganize their purchasing policies toward local (continental) purchases instead of global (from regions geographically far from the company's headquarters). Today, organizations are facing a new challenge - the energy crisis.

The ongoing changes in the operating environment of the organization, especially caused by the Covid-19 pandemic and now the energy crisis, are forcing headquarters managers to take a new look at the existing division of functions, power, decisions between the superior unit and subordinate units. The problem of centralization and decentralization of management is one of the most difficult problems, both in organization and management theory and in economic practice. It acquires a deeper meaning and complexity in multi-entity structures (Kreft, 2004, p. 83), in which superior units have the right to interfere in the functional spheres of subsidiaries decomposing the hitherto established distribution of functions and decision-making powers in

the direction of centralization or decentralization of management. Both solutions have their peculiar advantages and disadvantages, which are revealed in different circumstances. The issues addressed in the study are complex and rarely explored in the literature today.

The purpose of the study is to identify the degree of centralization - decentralization of management in multi-entity organizations. Around the main objective thus formulated, the following specific objectives were established: (1) to recognize the degree of centralization - decentralization of management in multi-entity organizations in the light of the literature on the subject (2) to identify changes directly implemented in subsidiaries of German corporations during the Covid -19 pandemic, (3) to recognize the directions of changes in the distribution of functions in subsidiaries of German corporations. The realization of the first specific objective was carried out in the theoretical part of the study. While the realization of the second and third objectives in the empirical part of the study.

2. The problem of centralization - decentralization of management in multi-entity organizations

The problem of centralization and decentralization of management should be considered at the level of the distribution of corporate functions and decision-making powers between the parent company and daughter companies. Between the parent company and subordinate companies there are so-called hierarchical relationships (Werr, Blomberg, Löwstedt, 2009, p. 451) showing the distribution of authority and responsibility. Corporate functions include production, sales, marketing, R&D, IT, HR, finance, among others (Goold, Campbell, 2003; Neilson, Wulf, 2012; Kunisch, Menz, Collis, 2020). Changes in the organization's environment are conducive to the separation of new functions. While certain corporate functions such as IT, marketing, HR, and finance exist at most firms, new functions, in areas such as risk management and compliance are emerging (Kunisch, Menz, Collis, 2020, p. 15).

The centralization of decision-making functions and powers in multi-entity organizations means shifting them vertically upward, to the level of the superior unit. In traditional functional arrangements, the decision-making autonomy of the managers of individual organizational units, distinguished on the basis of the criterion of function, is controlled to a greater extent by the top management of enterprises. As a rule, this means that they can more or less limit it or, to put it another way, interfere with its scope without violating the "actual" architecture of the enterprise.

Decentralization, on the other hand, is the reverse process, favoring the movement of functions and powers downward to subordinate units. Regardless of the final location of the function, special care should be taken to equip the entity receiving the function with the necessary human, material, financial and information resources. As a result, this will allow the

efficient and effective performance of the tasks that make up the content of the function. In the context of the above statement, two extreme opposite choices can be said. In the case of centralization of functions, the parent unit interferes with the scope of functions of subordinate units, taking them away and locating them in the company headquarters. The corporate headquarters provides centralized services to the company's operating units, such as: HR, IT or media purchasing (Menz, Kunisch, Collis, 2015, p. 645). In turn, the decentralization of functions is accompanied by a process of enrichment of the functions performed at the level of subsidiaries as a result of locating new functions there. As a result, this leads to the implementation of new tasks, stimulating the activity of local personnel, increasing their involvement in business processes. Decentralization of functions is conducive to increasing the position of the unit in the corporation. It can be assumed that the more corporate functions and with them decision-making powers are localized in the company-daughter company then there will be a tendency to decentralize management. If the parent company takes away functions and decision-making powers from the daughter companies there will be a tendency to centralize management. Decentralization is a trade-off between the superior knowledge of local managers and the loss of control at company headquarters (Acemoglu et al., 2007, pp. 1759-1799).

The literature has attempted to empirically verify the degree of centralization/ decentralization of management in multi-stakeholder organizations. The results of studies in this regard are shown in Table 1.

Table 1.

Selected research on centralization / decentralization of management in multi-entity organizations

Author/year	Description	Research conclusions
Kunisch S., Müller-Stewens G., Campbell A., 2014	A study of corporate functions among the 761 largest corporations in North America and Europe.	Companies with business units or divisions have become more capable of standardizing and centralizing their operations, and traditional headquarters functions such as finance, HR, IT, marketing and strategy have grown in size and impact. In the meantime, new features emerge in areas such as risk management. Almost a third of companies reported an increase in corporate functions - and less than 10% reported a reduction - from 2007 to 2010. Leaders in three out of four companies believed that the impact of their corporate functions had increased.
Kraśniak J., 2012, p. 138	Study of the decision-making autonomy of foreign subsidiaries located in Poland. Research functions: sales and marketing, IT, production, finance, human resources. The research covered 60 subsidiaries operating in Poland.	The level of autonomy of subsidiaries was placed at the level of 1.3 on a three-point scale, where 3 was the highest value, meaning a very high level of autonomy of subsidiaries and 1 - a low level of autonomy. The greatest autonomy was noted in terms of human resources (2.3) in all sizes of the surveyed companies. The smallest in the sphere of production and finance (average result was 0.6).

Cont. table 1.

Zajac Cz., 2012, p.167	Research on social aspects of human resource management in subsidiaries of international capital groups located in Poland. The research was conducted in the years 2002-2010 in the same 10 companies.	<ul style="list-style-type: none"> - loss of managerial and operational independence, resulting in limiting the decision-making powers of the management and limiting innovation and creativity, - elimination or strong limitation of many functions in subsidiaries, - interference of the parent company in strategic and operational management in the subordinated companies, - limiting production (the scope of services provided) and specialization, - centralization and outsourcing of many functions, - numerous organizational changes as a result of slimming, flattening and making organizational structures more flexible.
Stępień B., 2009, p. 318	Research on the autonomy of subsidiaries. The study covered 35 production branches of international companies operating in Poland.	<ul style="list-style-type: none"> - the most centralized area is investments in real estate and machinery, - moderate level of centralization and supervision applies to commercial, marketing, supply and distribution activities, - the least centralized area of decisions is the area of shaping the employment policy. However, taking into account the industries, it was noted that Polish branches enjoy the greatest autonomy in the food industry (compared to the machinery and plastic industry) in making decisions in the sphere of trade and supply. There was also a slight increase in the discretionary power with the age of the subsidiaries.
Broszkiewicz A., 2008, pp. 27-29	Assessment of the impact of industrial groups on the functional spheres of subsidiaries with foreign capital. The research covered 50 subsidiaries located in Poland.	The group is strongly influenced by production and technology (3.84) as well as procurement and sales (3.46). The research showed that in terms of financial management, groups exert an extremely strong influence on subsidiaries (average result 4.58). On the other hand, the greatest interference by groups was recorded in the sphere of investment and development (4.64). A five-point scale with 5 being the group's greatest influence. Only in the area of the personnel function, local managers have greater freedom in making decisions (2.18). The degree of group interference in this case turned out to be the lowest.
Listwan T., Stor M., 2008, p. 286	Research on management problems of managerial staff in subsidiaries of international organizations. The research was conducted in 2008 among 35 subsidiaries.	On the basis of the research, the authors indicated the postulates of rationalizing the personnel function, including in terms of reducing the degree of centralization of functions and extending the scope of autonomy in subsidiaries.
Sobotkiewicz D., 2005, pp. 150-153	Autonomy study in terms of the marketing function among 30 subsidiaries of foreign concerns located in Poland.	All decisions in the field of marketing research, product research, prices and promotion are made in the parent company of international concerns. Only in the case of distribution, subsidiaries had greater decision-making independence. Moreover, it was found that subsidiaries mainly perform the executive elements of the marketing function and the mother company - planning and control. Managers, on the other hand, have limited decision-making independence in the field of marketing.

Source: own study.

The results of the research presented here indicate that the greatest interference by the parent in the functions of subsidiaries was in production, finance, procurement, sales, development and marketing, and investment, and the least in the personnel function. The interference of the parent company in the functions and powers of subsidiaries promotes the centralization of management. So it is worth asking at this point, what factors have fostered the centralization of management? The answer to this question is not simple, but an attempt can be made to identify several factors that have triggered the tendency to centralize management, these are:

- the dynamic development of information technology and information programs that facilitate the transfer of information within the organizational structure, as well as programs that support decision-making at various levels of the organizational structure,
- almost in the area of all functions of the enterprise applied computer programs to facilitate the collection, processing and transmission of data,
- the concept of Industry 4.0,
- the tendency to concentrate many functions previously carried out at the level of subsidiaries in the company's headquarters or in spin-off Shared Service Centers, treated as business strategies in the 21st century,
- limiting the role of subsidiaries to the implementation of core functions (e.g., production) with extensive support for auxiliary functions carried out by the company's headquarters or shared service centers.

3. Research methodology

The purpose of the study was to identify the degree of centralization of management in subsidiaries of German automotive concerns during 2020-2021. The following specific objectives were established around the main objective thus formulated: (1) to identify changes directly implemented in subsidiaries of German corporations during the Covid-19 pandemic, (2) to recognize the directions of changes in the distribution of functions in subsidiaries of German corporations. The research was conducted at four subsidiaries of German automotive concerns located in Poland. Each of the companies involved in the study belonged to a different automotive company. At the time the research began, there were no processes of mergers, acquisitions, demergers or divestments of business entities in the concern. The essence of this assumption was to make the results of the research independent of the influence of various disturbing variables that could arise in the case of the above indicated processes. This was a dynamic research focusing attention on processes occurring over time. The research was conducted from 2019 to 2022 and boiled down to monitoring the changes taking place in the area of, among other functions, decisions at the level of subordinate units. The research was

based on a case study procedure. Systematically (once a year) the director of a production plant (subsidiary) was interviewed.

The subsidiaries participating in the survey produce for internal and external markets. The main criterion for selecting units for the sample was the scope of functions performed. The sample included companies that performed a wide range of auxiliary functions. It was assumed that the more functions a parent unit performs, the greater the degree of centralization, and locating these functions in subordinate units may increase the degree of management decentralization.

4. Results and discussion

The first research task was to obtain information for the objective: to identify the changes directly implemented in the subsidiaries of German corporations during the Covid-19 pandemic. During the Covid-19 pandemic, many changes were implemented in the subsidiaries (Table 2) to reduce the negative impact of the coronavirus on the companies' operations. Interviews with plant directors revealed that:

- cost concern (cost containment) has become the biggest challenge for all managers participating in the survey,
- all surveyed companies experienced a significant decrease in sales in the periods IV-VI 2020 and IV-VII 2021 (in one company, the decrease in sales reached 70% in July 2021),
- all of the surveyed companies reduced their employment of primarily production workers. Temporary agency workers were dropped to protect their parent staff (mostly production) from layoffs. However, decisions to reduce employment were made cautiously because there are labor shortages in the labor market and, after the pandemic, there may be high demand for automotive parts and accessories and meeting demand will be tied to the production staff in place,
- problems with movement between countries, the lockdowns introduced have limited (even stopped) the ability of headquarters managers to reach subsidiaries. Problems arose with the implementation of new joint automotive projects, among other things, due to limited support from headquarters for R&D functions at subsidiaries' headquarters. Although long-distance (online) communication tools were used, not all matters could be handled this way. Hence the headquarters decisions to increase the decision-making independence of subsidiary managers,
- problems in the supply chain have emerged. It should be noted here that the automotive industry (including the production of automotive parts and accessories) is highly internationalized and there are strong supply chain linkages. Closing borders between

countries, increasing border controls, and lengthening transportation times for materials have resulted in an almost complete disruption of the supply chain. In turn, the lack of timely delivery of raw materials for production, where the vast majority of companies operating in the automotive industry operate according to just in time, has affected the interruption of ongoing production,

- increased the number of function implementers able to use remote work. It is worth noting at this point that before the pandemic, the automotive industry allowed its employees to work remotely. The companies surveyed were prepared in terms of infrastructure (access to portable computers) to delegate employees to work from home,
- two companies temporarily reduced the pay of their employees,
- energy crisis next to broken supply chains is becoming the biggest challenge for plant (company) directors.

It is worth noting that the introduction of these changes has resulted in a reduction in the size of the organizational structure on the one hand, including as a result of far-reaching changes in the sphere of production through downsizing on the other hand in the gaining of greater decision-making autonomy by managers of subsidiaries as a result of reduced visits by managers of parent units. To some extent, the organizational structures have become more independent of the companies' headquarters.

Table 2.

Changes implemented in subsidiaries during Covid-19 pandemic

Changes implemented in subsidiaries during the Covid-19 pandemic	Number of subsidiaries in which implemented changes
The employment of executive (production) staff was reduced	4
Decision-making authority was increased for subsidiary directors	4
Virtual task forces were established	3
Tasks previously performed outside the organization were integrated into the organization's structure	3
Digitalization of production processes was accelerated	1
Employees were transferred to other organizational departments of the subsidiary	1
Increased employment in sales departments	1

Source: own elaboration based on research.

The second research task was to obtain information for the purpose of: To identify the directions of changes in the distribution of functions in subsidiaries of German corporations. In accordance with the assumption that the more functions a parent unit performs, the greater the degree of centralization and the location of these functions in subordinate units may increase the degree of decentralization of management, changes in the distribution of functions were identified (Table 2).

From the interviews, it was found that:

- interrupted supply chains, problems with access to raw materials led to the equipping of the subsidiary with new purchasing tasks. All companies reported an increase in their participation in the search for new suppliers, including strategic raw materials (the main raw materials used in production processes). As a result, this has led to the expansion of local purchasing departments and the expansion of their scope of authority. One of the directions of changes in purchasing is its diversification. Companies will seek and cooperate with local - European suppliers that are geographically closer to the subsidiary,
- the involvement of local R&D, technology departments in the development of new automotive projects (individual components as well as final products assembled in cars) has increased. Also in this function, there was an increase in employment and a greater level of independence for the companies as before the pandemic,
- with regard to the personnel function, there was greater influence by the companies in making decisions on personnel changes, including downsizing, without consulting corporate headquarters,
- in two companies, Product Management departments were given greater decision-making authority to seek new markets outside the group's home market. In the other two, processes have begun to divide this function in order to strengthen subsidiaries in their independent search for new customers,
- the smallest changes across all the surveyed entities were recognized in the risk management function. In one of the surveyed companies, the involvement of the local management in updating the risk management system for the entire organization was increased. The remaining surveyed companies are supported in this function by headquarters.

Table 2.

Strengthen functions at subsidiary level (decentralization of functions, decisions)

Changes in the location of functions and decisions	I	II	III	IV
Purchasing	+	+	+	+
R&D	+	+	+	+
Personnel	+	+	+	+
Product management	+	Project of division between parent company and subsidiary company	Project of division between parent company and subsidiary company	+
Risk management	+	-	-	-

+ increase in the scope of tasks and decision-making authority over functions.

- no change.

Source: own elaboration based on research.

The delegation of new elements of functions (tasks) and additional decision-making powers to subsidiaries for implementation indicates an increase in their decision-making independence, thereby strengthening the companies' position in the entire multi-entity organization. As a result, they become more independent in their decisions within the various functions of the organization. There are no optimal solutions for functions and decisions. There are only temporary solutions that work for a specific time and circumstance. In the automotive sector, there is a strong internationalization of the supply chain, just-in-time deliveries, heavy dependence of factories producing finished cars on automotive parts suppliers (including non-group companies). The pandemic has had a negative impact on the entire sector. The effects of the coronavirus will have many complex consequences for corporations, for subsidiaries, even in the event of a rapid return to pre-pandemic conditions.

5. Conclusion

There was a tendency in the surveyed organizations to decentralize management (to increase the scope of functions and decisions carried out to subsidiaries). Increasing the level of decision-making autonomy of local companies was influenced by the degree of trust in local management and their ability to manage costs. It is trust and cost optimization that are the main drivers for delegating new functions and powers to the level of subsidiaries during Covid-19. While the constraints on the functioning of the organization, caused by the pandemic, became the main reason for making changes in the organizational structures of subsidiary companies, the increase in their power was influenced by the factors indicated. Major changes observed within the purchasing function as a result of broken supply chains and the ineffective just-in-time method. There is now a trend toward local purchasing - within a given continent. Today, there will be an increasing role and importance of purchasing at the subsidiary level. Also, the product management function will play an increasingly important role in subsidiaries. Searching for new markets, making offers, and providing customer service will be more locally based as before. The challenge for headquarters is to take a new look at the arrangement of functions and decisions throughout the multi-entity organization due to the increase in the cost of operating the organization as a result of the energy crisis and the possibility of another pandemic. The decision to change the location of functions, decisions, changing the current state of centralization/decentralization of the management of the corporation should be preceded by a comprehensive analysis of the places that guarantee the best conditions conducive to the implementation of functions. This is not an easy task, fraught with great risk, but necessary due to the major changes (their continuity) occurring in the environment of the operation of multi-entity organizations.

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OUTSOURCING MANAGEMENT CONCEPT AS A DISTINCT LEGAL CONSTRUCTION

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Purpose: The aim of the article is to analyse the legal structure of outsourcing as a management concept. Outsourcing is a contemporary phenomenon that is at the development stage. There are no precise legal regulations in this regard. Due to the dynamically developing tendency of entrepreneurial activities in the form of outsourcing, it is necessary to analyse and research outsourcing activities, clarify and systematize the regulations concerning such a broad and complex form of activity of economic entities.

Design/methodology/approach: In this case, the subject of application is the analysis of judicial decisions, doctrine studies and legal practice.

Findings: The boundaries between the concept of outsourcing of services and the concept of transferring the work establishment or part thereof to another employer have been defined with the application of article 23(1) of the Labor Code.

Originality/value: Detailed analysis of outsourcing in the field of labor law. Isolation of the outsourcing structure in comparison with the takeover of the work establishment pursuant to Article 23(1) of the Labor Code.

Keywords: outsourcing, qualification, economic entity, management.

Category of the paper: Research paper.

1. Introduction

Outsourcing is a long-term assignment to perform specific functions necessary for the efficient operation of the organization, to a specialized external company, which allows the organization to focus on its core activities.

The aim of the article is to thoroughly analyze the structure of outsourcing and show its features as a legal relationship between business entities. However, in order to proceed to

a detailed analysis of outsourcing at the level of civil law, it is first necessary to clearly define the distinctiveness of the concepts of "outsourcing" and "taking over a work establishment or its part by a new employer".

We will draw our detailed attention to the relationship, similarities and difference between outsourcing and the takeover of a work establishment in accordance with article 23(1) of the Labor Code (Svitana, 2021). We will conduct considerations and analysis in the field of labor law issues in order to distinguish and prove the different nature of the legal structures of outsourcing and the transfer of a work establishment or its part to another employer.

2. Outsourcing of services versus taking over the work establishment or its part - separate legal structures

In the literature, we find the statement that "according to the generally accepted terminology, the term" employee outsourcing "is the same as the transfer of a work establishment or part of it to a new employer, made in accordance with article 23(1) of the Labor Code. This solution is aimed at the continued use of the work of a given employee by the current employer, with the simultaneous transfer of the burden related to formal employment to another entity" (Socha, 2018). We will consider and analyze this claim. According to the definition adopted by us, outsourcing is a long-term assignment to a specialized external company to perform specific functions necessary for the efficient operation of the organization, which allows the organization to focus on its core activities (Svitana, 2021). Assuming that the commissioning of specific functions is carried out for a specialized external company, it is obvious that this company already has its own complex and specialized staff. In such a situation, it will not necessarily, or even not at all, need to take over employees along with accepting the outsourced functions/tasks. In this case, it does not take over a part of the work establishment, but only undertakes the obligation to perform a specific order for the company. Therefore, we need to draw a clear distinction between these concepts: taking over a work establishment or part of it, and undertaking a specific task by the outsourcing company - i.e. outsourcing of services.

In a situation where we are to take over the entire work establishment, there is probably no problem with the assessment of the takeover. The entire work establishment is then taken over as a set of material, functional and organizational elements. Then also article 23(1) of the Labor Code concerning the takeover of the work establishment along with human resources is applied. Here, the construction of outsourcing as a commissioning of specific tasks to an external entity is not the case too, because we are dealing with a general succession of rights and obligations between business entities.

On the other hand, the takeover of a part of the work establishment within the meaning of article 23(1) of the Labour Code needs to be considered more widely.

The provision of article 23(1) of the Labour Code does not define the concept of a part of the work establishment or the concept of a work establishment. To clarify the meaning of these terms, we refer to the provisions of the Council Directive 2001/23/EC of 12 March 2001 on the approximation of the laws of the Member States relating to the protection of workers' rights in the event of transfer of enterprises, plants or parts of enterprises. Article 1 of the Directive indicates that this Directive applies to any takeover of an enterprise, plant or part of an enterprise by another employer as a result of a legal transfer or merger. A transfer within the meaning of this Directive takes place when an acquired enterprise retains its identity, that is to say, an organized pool of resources the purpose of which is to conduct an economic activity, whether it is a principal activity or an ancillary activity (Council Directive 2001/23/EC of 12 March 2001). Thus, the key concept in the application of article 23(1) of the Labour Code is the concept of "an economic unit that retains its identity".

The Supreme Court of the Republic of Poland in many judgments adopted the definition of a part of the work establishment corresponding to the EU concept of an economic unit, indicating that it is a certain organized whole, which consists of specific material and property elements, an organizational system and management structure that allow for further work performance by its employees (Judgment of the Supreme Court of the Republic of Poland of April 13, 2010, I PK 210/09, OSNP 2011 No. 19-20, item 249 and the judgments cited therein). The concept of an economic unit was introduced into Community law by Council Directive 98/50/EC of June 29, 1998 amending Directive 77/187 / EEC. This change was made in response to the evolution of the jurisprudence of the Court of Justice of the European Union, leading to the recognition that the transition may only concern an economically viable unit whose operation is not limited to performing one specific task, such as completing construction work started by a previous employer (Judgment of the Supreme Court of the Republic of Poland of April 18, 2018, II PK 53/17).

The assessment of whether a part of the work establishment (economic unit) has transferred to a new employer requires determining whether the transferred part of the work establishment (economic unit) has retained its identity, and in particular, depending on whether the activity of the economic unit is based mainly on human work or on assets, it is necessary to determine whether the new service provider has taken over some of the employees or property (material equipment) of the acquired entity, which was decisive for its preservation (Judgment of the Supreme Court of the Republic of Poland of 20 April 2017, ref. I PK 153/16).

So let's analyse exactly what is included in the definition of the concept of "identity of a part of the work establishment" and, consequently, what are the reasons for taking over a part of the enterprise on the basis of article 23(1) of the Labor Code. We will separate the following elements of the work establishment:

- 1) material and property components,

- 2) place of work,
- 3) performed tasks/functions,
- 4) management system,
- 5) organizational structure,
- 6) employees.

When assessing the premise for retaining the identity of an economic entity, the function and purpose for which a given economic entity exists cannot be ignored. In order for occurring the take over a part of the work establishment to a new employer, the transfer of an economic unit must take place, which is an amalgamation of at least two elements of the work establishment in conjunction with the transferred task area. This is confirmed by the justification of the judgment of the Supreme Court of the Republic of Poland in which, *inter alia*, it indicated that the Court of Justice of the EU departed from treating the task area itself as an entity to be subject to transfer. The assessment of the nature of an economic unit has fundamental meaning for the correct resolution of transfer cases: is it an entity whose basic resources, values, and its nature and ability to conduct business, are employees and their qualifications, or is it a unit which character is determined by material components. In the case of the former, the transition can take place without the acquisition of material components, if the majority of employees (in terms of numbers and qualifications) have been taken over. This applies to services such as cleaning, home help for residents of the commune who need such help, supervision of facilities, maintenance of parks and gardens. In certain sectors that are mainly labor-based, a pool of workers who are permanently working together can form an economic unit. (Judgment of the Supreme Court of the Republic of Poland of April 18, 2018, II PK 53/17). In this case, the employees and the place of work are decisive.

In the case of entities whom functioning is mainly based on material components, it is decisive to take over material resources, even if most of the labor resources have not been taken over. This applies, for example, to public transport service and catering for hospital patients. The transfer of an economic unit occurs on condition that it retains its identity. Consequently, the transfer of the enterprise, work establishment or part of the enterprise does not manifest itself only in the transfer of its property, but it is first of all necessary to consider whether it has been transferred as a functioning unit or whether its operation is actually continued or resumed by the new employer. In order to assess whether the conditions for takeover have been met, all the facts that characterize the behavior in question should be taken into account, including in particular the type of enterprise or establishment which it is about, the acquisition or not acquisition of assets such as buildings and movable property, the value of the intangible assets at the time of the acquisition, the acquisition or not acquisition of most employees by a new employer, the acquisition or not acquisition of customers, and the degree of similarity in the activities carried out before and after the acquisition, and the time of any suspension of such activities. These elements must always be assessed holistically in the context of a specific case, and none of them alone can be the basis for assuming that an entity

(enterprise, plant or part of a plant) has retained its identity. (Judgment of the Supreme Court of the Republic of Poland of April 18, 2018, II PK 53/17). The Court of Justice of the EU has consistently held that an economic unit (i.e. an enterprise, a permanent establishment, a part of a permanent establishment) that is the subject of a transfer cannot be reduced only to the activity it conducts. Its identity results from the multiplicity of inseparable elements, such as its personnel, management, work organization, methods of operation, or possibly its fixed assets (regarding the evolution of the jurisprudence of the Court of Justice of the European Union on the issues described above, see point 2 of the judgment of the Supreme Court of May 17, 2012, LEX No. 1219491; see the judgments of the Supreme Court of: March 29, 2012, I PK 150/11, LEX No. 1167736; June 14, 2012, I PK 235/11, LEX No. 1250558).

In this matter, it is worthy of noticing the position of the Ministry of Family, Labor and Social Policy of the Republic of Poland expressed in the letter of March 15, 2016, no. in cases of employee outsourcing: "In the practice using the institution of employee outsourcing, a mechanism was used, which was based on offering entrepreneurs a service consisting in HR and payroll services (which is the scope of services usually offered by accounting offices), as well as the payment of salaries to employees to their bank accounts. The last element of the offer was to suggest that the outsourcing companies involved in this practice are actual employers and behave like actual employers. However, in reality, HR and payroll decisions were still left to entrepreneurs (such as the amount of remuneration and its components, vacation dates and the like). It is important that, according to the offer of unfair outsourcing companies, the change of the employer was to take place as a result of the transfer of the work establishment under the procedure provided for in article 23(1) of the Labor Code, but there were no legal grounds to recognize that there was a change of employer at all. This type of relations between the entities did not meet the conditions for taking over a part of the enterprise on the basis of article 23(1) of the Labor Code, and for this reason there were grounds for recognizing the legal actions taken as invalid by operation of law. In connection with the above, the current employers are still burdened with obligations, inter alia, in respect of income tax advances and social insurance contributions (Journal of the Ministry of Family, Labor and Social Policy, 2016). The basis for imposing the obligation to pay advances is the facts established by the tax authorities in a specific case and if, despite the formal conclusion of the contract, the employees did not transfer to a new employer, the original employer would be responsible (Socha, 2018).

The analysis of this situation clearly shows that the role of companies providing employee outsourcing services was limited to taking over only servicing employees in terms of paying them remuneration, the amount of which was de facto decided by the employing entrepreneur, by sending the necessary data on their employment.

It is worth considering this issue, taking into account the judgment of the Supreme Court of the Republic of Poland of 27.01.2016 I PK 21/15, which indicated that the concept of the so-called outsourcing of HR and payroll services does not allow for establishing the transfer of

employees to a new employer within the meaning of article 23(1) of the Labor Code. Agreements concluded between business entities not aimed at the actual takeover of employees, referred to in Article 23(1) of the Labor Code, if, under the concluded agreement, there has been no actual transfer of employees to a new employer, do not result in the "transfer" of the work establishment to another employer. The mere fact that remuneration is paid for work by another entity that maintains appropriate HR and payroll documentation in this respect is not a premise of taking over employees pursuant to Article 23(1) of the Labor Code. Both the activities of signing contracts for the provision of services under the concept of the so-called outsourcing of HR and payroll tasks, as well as agreements on the taking over of employees, are definitely not covered by the provisions of Article 23(1) of the Labor Code and are inconsistent with the applicable standards of employee protection, and, consequently, invalid under Article 58 of the Civil Code. The court shared the view signaled in the judicature that the will of the parties to the contractual relationship (Article 3531 of the Civil Code) in the contact with the institution of transfer of the work establishment (Article 231 of the Labor Code) does not may correct or modify the mandatory provisions of law in this respect (judgment of the Supreme Court of 27.01.2016 I PK 21/15).

In connection with the above analysis, we come to the conclusion that the takeover of the work establishment or its part is a different and separate legal structure from the structure of outsourcing services. It should be noted that these two constructions may occur together in a specific transaction, when an enterprise decides to outsource a certain type of services while transferring part of the work establishment to another employer. However, the transfer of the work establishment will always be carried out on the basis and in accordance with the provisions of article 23(1) of the Labor Code when transferring an economic unit that retains its identity, regardless of the reasons for which it is transferred. Outsourcing of services here may occur as a cause, but will not be a qualifying feature for the takeover of part of the work establishment. The acquisition will have the feature of a transaction that pursues a specific goal and has a logical ending. On the other hand, the outsourcing of services as cooperation between two economic entities will appear as an obligation relationship aimed at long-term cooperation for the conduct of effective business of both parties.

We can even more notice the difference of these legal structures when considering the possibility of classifying a transaction as relating to the sale of individual assets in a situation where one of these components is a work establishment for which certain services are provided under outsourcing. The fact that the services necessary for the conduct of business by a given entity are performed somewhat outside it, does not exclude the possibility of qualifying the sold assets as an enterprise. These services, provided on the basis of civil law contracts, may be transferred as part of a transaction in accordance with the rules relating to the transfer of other contracts concluded within this enterprise (or its organized part), if they concern only a separate unit of the enterprise (Dąbrowska, Szydlik, 2013) . It is in this situation that we can see that outsourcing contracts for the provision of specific services are contractual, civil law and fall

into the overall succession of rights and obligations in case of merge of business entities. On the other hand, outsourcing contracts between business entities are not the basis for the takeover of a work establishment by another employer, but may only be contracts in connection with which the parties decide to transfer a certain economic unit. If this economic unit will have the characteristics of a work establishment, then it will apply the provision of article 23(1) of the Labor Code.

3. Outsourcing of services - civil law relation between business entities

When we talk about the outsourcing of services between business entities, we are dealing only with entrusting the performance of certain tasks to a business client.

When the entrepreneur focuses on the core activity in which he has a competitive advantage, the areas that constitute ancillary or side activity are transferred to the outside world. As a rule, the company's strengths must always remain in it (Kłós, 2009). When the activity is not a primary function and the costs of running it inside the company are high, outsourcing it may be the right solution, while in a situation where the activity is strategically important and results from the company's mission, it is best to present it in structure and lead with own resources and resources (Kopczyński, 2010). Delegating specific functions to external, specialized units is based on a contract, and the result of this cooperation is cost reduction (Kopczyński, 2010).

According to the position of the doctrine, outsourcing is recognized as a mechanism in the field of economics and economic processes, such as: activation of the enterprise, optimal employment strategy, etc. However, it is not defined and is not marked with a specific legal structure. When constructing an outsourcing agreement, various obligation structures are used in order to optimally adjust the legal conditions to economic requirements (Robaczyński, 2010). However, it is believed that due to the progress of economic development and the emergence of various legal relations between economic entities related to outsourcing, it is worth considering and distinguishing outsourcing as an independent legal structure. It is also necessary due to the fact that the legal relationship of outsourcing services is often related to the acquisition of a part of the work establishment, similar to employee leasing, and even used by legal entities in violation of the law, as described in the previous chapters of the article.

Currently, the outsourcing contract belongs to the type of empirical, unnamed contracts, which do not have a legal definition provided in the act. The outsourcing contract, belonging to unnamed contracts, shows individual features, characteristic for named contracts, such as: commission contracts, contracts for the provision of services, contracts for specific work. This contract may have the features of one named contract, as well as of several contracts in total (Malarewicz-Jakubów, and Tanajewska, 2014). A special feature of an outsourcing

contract is the adaptation of its elements to the nature of the customer's relationship with the service provider (Radło, 2005).

Based on the analysis of outsourcing contracts concluded in general circulation economic, one can distinguish the essential elements of this contract, that is: description of the scope of work, agreement on the level of service provided, remuneration, period of validity contracts, process management conditions, intellectual property regulations, sectoral provisions, termination conditions, provisions relating to subcontractors and jurisdiction to settle disputes. From the above elements of the contract, the description of the scope of work and the agreement on the level of the service provided, due to its unique content, require special discussion. Thanks to them, the outsourcing contract has a different character, both in relation to named and unnamed contracts (Malarewicz-Jakubów, Tanajewska, 2014).

According to the authors of the article, an important feature of the scope of work performed under outsourcing, which is the content of the obligation relationship, is the fact that it is to be an activity necessary for the functioning of the enterprise and it is of a continuous nature. The detail that distinguishes an outsourcing contract from, for example, a mandate contract is that when outsourcing services, the performance of tasks is continuous, not periodic as in the case of a mandate contract.

The second, characteristic element of the outsourcing agreement is the service quality agreement, which is a set of activities specified in the description of the scope of work. Appropriate adjustment of quality standards fully allows for effective and optimal quality management of processes (Malarewicz-Jakubów, Tanajewska, 2014).

At this stage, the key feature will be to define the functionality of the outsourcing service in terms of effectiveness and optimization of performance. This feature is characteristic of outsourcing services, although it is necessary for the functioning of the enterprise as a whole of complex processes and is related to the management strategy.

Regardless of the outsourcing methods used, the assessment of effectiveness is a complicated process, taking into account the need to define the boundary between pure outsourcing and services or processes that have been added by the outsourcing provider to improve the implementation of processes or activities.

It is important that the service quality agreement is prepared in a detailed, specific and communicative manner, as it is an element of the contract that should remain unchanged and should guarantee the stability of the level of service provided. Then both parties to the contract will be fully aware of their rights and obligations under the contract (Radło, 2005).

4. Employment of workers by temporary employment agencies in relation to the outsourcing of services

A separate issue that requires detailed consideration in the light of legal provisions is the employment of workers by temporary employment agencies. Let us analyse whether such employment relationships are properly qualified as employee outsourcing and how to treat an employment relationship in which a temporary employment agency is an employer in a contract with an employee, but in fact the work is performed for and under the direction of another economic entity. Such use by an economic entity of the work of employees formally employed by another entity is called external employment. One must agree with the position of the doctrine that in the case of so-called external employment "the traditional paradigm of the employment relationship is disturbed. It consists in separating the functions of the formal employer with whom the employment contract is concluded and who performs legal and factual acts in relation to the employee, from the function of the actual employer for whom the work is performed. External employment does not include typical outsourcing, consisting in separating tasks previously performed independently by entity A and transferring them to an external entity B, specialized in activities including taken over tasks (Miętek, 2015). As a rule, in the case of external employment, the temporary employment enterprise (temporary employment agency) hires an employee to an enterprise conducting business activity. In the case of external employment, the appropriate term will be employee leasing. Pursuant to Article 2 of the Act on the Employment of Temporary Employees, the user employer assigns tasks to the employee referred by the temporary employment agency and controls their performance (Act, 2003). Such cooperation cannot be classified as service outsourcing, also known as employee outsourcing, because:

- a) we cannot state the continuous nature of the cooperation, although the employees are employed by employment agencies temporarily,
- b) the subject of cooperation between the user employer and the temporary employment agency is not the quality of the tasks performed, as in the case of outsourcing services, but only the technical employment of employees,
- c) the user employer is the entity that actually provides the place of work of the temporary employee, and the temporary employment agency is the formal employer.

5. Summary

Outsourcing of services is a separate legal structure, different from the structure of taking over a work establishment by another employer. Outsourcing of services is a construction of civil law as a legal relationship between business entities. Thanks to the outsourcing institution, enterprises reduce the scope of their activities, focusing on the development and promotion of their main activity (Malarewicz-Jakubów, Tanajewska, 2014).

It should be noted that in the event of a decision to outsource the services performed so far by the deciding entity and during the transfer of the assigned functions to another entity, a part of the work establishment may be transferred to another employer. But these will be two separate processes. The transfer of a part of the work establishment, provided that the above-mentioned conditions are met, will be a one-off transaction carried out pursuant to Article 23(1) of the Labor Code, aimed at ensuring continuity of employment and protection of employee rights. Whereas outsourcing of services will be a continuous legal relationship between business entities that establish cooperation for a long-term perspective. So when a certain area of the company's tasks is separated in order to transfer it to another company as part of an outsourcing strategy, and in connection with it part of the work establishment is transferred to another employer, then in this case these two economic entities will have two separate legal relationships. The first is a legal relationship regulated by labor law, where economic entities act as the current and new employer. This legal relationship is limited in time until the effect of the transfer of a part of the work establishment under Article 23(1) of the Labor Code is achieved.

The second legal relationship is an obligation relationship regulated by civil law, where economic entities act as business partners, where they have mutual obligations for long-term periods.

In view of the above, we assume outsourcing as a project consisting in separating from the organizational structure of the parent company the functions already performed by them in order to transfer them to other economic entities or entrusting these functions to other economic entities. In the common trade, such cooperation is often referred to as employee outsourcing, because the tasks for the enterprise are performed by employees who have an employment relationship with a completely separate, different economic entity.

Entrusting external entities with tasks previously performed on employers own may lead to the transfer of a part of the work establishment within the meaning of article 23(1) of the Labor Code if the taken over part of the work establishment (business unit) has retained its identity.

The main feature that distinguishes employee outsourcing from employing own employees is the lack of direct and permanent subordination (both legal and actual) of contractors to the entity (insourcer) at whom place such services or work are performed. If an employee is delegated by an outsourcer to work in another entity, the employee may only be subject to indirect and short-term supervision in the actual place of work (Judgment of the Supreme Court of the Republic of Poland of 27/01/2016).

It is also necessary to distinguish between the notions of outsourcing services, as well as outsourcing of employees, from the provision of work by temporary workers. When using the work of temporary employees, the employer-user assigns tasks to the employee employed and directed by the temporary employment agency and controls their performance.

The role of a temporary employment agency is significantly different from the role of a service outsourcer performing the HR and payroll function. The HR and payroll outsourcer constantly and continuously performs the commissioned area of tasks/functions for the company, the quality of which outsourcer is responsible only to the ordering company. On the other hand, before state supervisory authorities that control a certain area of activities, for example human resources and payroll, the responsibility will be borne not by the outsourcer of services, but by the company commissioning and on behalf of which the outsourcer performs these activities.

The situation is different in the case of employing temporary workers by a temporary employment agency. Here, the temporary employment agency carries out an order for the filling of certain positions of the user enterprise, which becomes the so-called work establishment for the employees of the agency. The temporary employment agency, as a separate entity and formal employer, is responsible for the entire employment process before the supervisory authorities. The employment agency is responsible for the performance of the staffing order in relation to the employer-user. The user company, on the other hand, is only obliged to become a place of work for temporary workers, ensuring safe working conditions and covering the expenses of the employment agency for the employment process, including the remuneration of temporary workers.

Summing up, it should be emphasized once again that the outsourcing of services as a management concept is a complex and multilateral phenomenon. It needs a deep examination, analysis and deserves to be regulated as a separate legal structure.

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CONTEMPORARY CHALLENGES FACING COMPANIES. “OCCUPATIONAL BURNINGOUT” IN THE CONCEPT OF SUSTAINABLE DEVELOPMENT

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Purpose: Nowadays the concept of sustainable development of a company includes job burnout, a new phenomenon which is still poorly recognized and rarely considered in company's activities. Burnout syndrome is a spectrum of symptoms of a physical and emotional nature, resulting from various burdens, including the professional ones, and most often caused by stress. The awareness of the problem should, and already results in preventive measures and a reaction to the existing syndrome of occupational burnout among companies representing sectors especially exposed to this phenomenon. Such sectors include Education, IT and Healthcare, among others. The solution to the growing problem is seen in the complex of well-being activities, comprised in the holistically approached concept of sustainable development. The aim of the paper is to define the basic research categories of the subject of the study and to define the structure of the contemporary model of the concept of sustainable development and the ways of its implementation in the area of "suppressing, preventing and mitigating" the negative effects in the business, environment, and human sub-spheres, with special focus on the latter sphere.

Design/methodology/approach: The research is exploratory in nature. It includes methods of quantitative and qualitative **analysis** for the needs of discussion on the results of secondary research. The conducted primary research is only a pilot study, prior to in-depth explanatory research planned for the near future.

Originality/value: The obtained results show that the necessary condition for the implementation of contemporary models of sustainable development is a holistic approach of companies to the implementation of its sub-areas, especially those aimed at preventing and reducing occupational burnout, which is expressed in a wide spectrum of ways in which it is perceived and experienced by the employer and an employee, and which are different for these two professional groups, and the three surveyed sectors.

Keywords: sustainable development, model of sustainable development, professional burnout, well-being.

Category of the paper: conceptual paper.

1. Introduction

Burnout syndrome is certainly another civilization disease that affects modern society. Burnout was first described in 1974 in the United States. It was associated only with the performance of activities related to providing help and support to others. Today, research shows that the burnout syndrome can be diagnosed in representatives of almost all professions that require high emotional, cognitive, social and physical involvement (Janowska et al., 2005, p. 377).

American psychiatrist H.J. Freudenberg was the first to describe a burnout syndrome characterized by a sense of mental and physical exhaustion, impatience, excessive irritability, cynicism and a sense of chronic boredom, a tendency to isolate and suppress emotions (Kuc et al., 2009, p. 113). Ch. Maslach describes burnout as a syndrome of emotional exhaustion, depreciation, and a lowered sense of personal achievement that can occur in people who collaborate with other people in certain ways. On the other hand, according to E. Aronson, burnout is a physical state, similarly to the above-mentioned definitions of emotional and mental exhaustion caused by long-term involvement in situations that are emotionally burdensome (Bartkowiak, 1999, p. 103).

The WHO European Forum of Medical Associations defines burnout as a syndrome of depletion of emotional, physical and cognitive energy, reflected in exhaustion in these areas, as well as in the lack of efficiency and competence (Bartkowiak, 1999, p. 103). The symptoms of burnout may be so strong that they do not allow for the daily performance of professional duties. The lack of any actions and reactions from the environment may lead to making mistakes by the employee, which may result in serious consequences for the company. Therefore, considering the above, in June 2019, WHO included burnout in the International Statistical Classification of Diseases and Related Health Problems (ICD), which has been in force since January 1, 2022. Statistical data show that the burnout syndrome has recently affected 4.2% of respondents in Poland (5.2% of women and 3.3% of men), most often aged 40-59 (Bezpieczeństwo pracy... [*Work safety*]). At present, September 14 is the International Day for Combating Burnout.

Occupational burnout certainly causes serious psychological damage, which is reflected in the erosion of values, dignity and will. It is a condition that develops gradually, in a continuous and uninterrupted manner, especially in the absence of preventive measures. It can become a clinical syndrome over time. Burnout is an important phenomenon both in individual and social dimension, from the point of view of self-realization and social existence, value building and self-acceptance, as well as the value of the structure (company, institution, society) for which, and in which, the individual functions. Hence, this problem seems to be crucial from the point of view of the effectiveness of a company operations and may constitute a modern way of implementing the concept of sustainable development through the prism of a comprehensive approach to its sub-areas, including the set of well-being activities.

2. Methodology

The research conducted for the purpose of the implementation of the topic of this study is exploratory in nature and includes methods of quantitative and qualitative analysis to discuss the results of secondary research. The study uses the information published on internet portals, e.g., Praca.pl, HR.pl, Eksperci Infor.pl. The results of the research conducted by the Association of Business Service Leaders (ABSL), Kronos Incorporated and Future Workplace, STADA Group and Savanta Inc, The Adecco Group, Gamma Company are quoted and analyzed. The conducted primary research is only a pilot study, prior to the explanatory research. In the study, a pilot categorized interview was addressed at a selected group of typical entities (HR departments of the service sector). The aim of the conducted research was to define the basic research categories as well as to define the structure of contemporary models of the concept of sustainable development and the methods of their implementation, considering the issues of the well-being of the individual and the organization, in the sectoral approach.

Table 1.

Basic information on the survey conducted (data labels)

Specification	Characteristics
secondary information sources	industry journals, websites, sponsored interviews, on-line interviews, expert portals, websites of HR departments of companies
research methods	quantitative and qualitative analysis of secondary sources categorized interview with managers of HR departments, questionnaire survey (electronic questionnaire) among employees of direct customer contact
sample selection	targeted selection of typical units, by the declared concept of sustainable development
sample size	52 managers of HR departments in the service sector 220 companies from the modern services sector (ABSL) 12,347 respondents, professionally active people (SAVANTA Inc.) 18,000 respondents, professionally active people (STADA) 3213 surveys of employees working in 37 organizations (GAMMA) 122 employees of direct customer contact
geographical scope	national and global scale
time scope	2019-2022

Source: own elaboration.

The research, in the form of an on-line interview, was performed on 52 managers of HR departments in service enterprises, the education, IT and healthcare sectors. The electronic questionnaire was also addressed to employees of direct customer contact. In total, 174 opinions of the respondents were analyzed.

3. Burnout as a challenge facing companies; current situation

From the psychological point of view, occupational/professional burnout syndrome is a very serious problem of modern times and generally speaking, concerns work-related fatigue. It should be emphasized that burnout is a process that usually begins with high motivation and "enthusiasm for something". When the work and energy involved do not bring the expected results, we start to burn out.

3.1. Measurement tools

The most frequently used **tools for measuring** the severity of the burnout syndrome include the Burnout Inventory developed by Christina Maslach (Maslach, 1981) (*Maslach Burnout Inventory*, MBI) consisting of 21 statements (Maslach et al., 1996; Leiter et al., 1995)¹ and LBQ (Link Burnout Questionnaire).

Christina Maslach, an American social psychologist, identified three components of professional burnout: emotional exhaustion, depersonalization, and decreased self-esteem, especially if these conditions are observed over a longer period of time. They represent:

- feeling of fatigue or lack of energy,
- depressed mood, negative feelings or indifference manifested by behavior, which is cynical and lacking empathy,
- reduced professional performance, lower assessment of own achievements and the feeling that everything that is done, does not make sense or is not good enough (Sełk, 2020, pp. 13-31; Maslach et al., 1981).

All Maslach MBI items are scored using a 7-level frequency rating from "never" to "daily". MBI has three component scales: emotional exhaustion (9 items), depersonalization (5 items), and personal achievement (8 items). Each scale measures its own unique dimension of burnout. The scales should not be combined into a single burnout scale. It is important that the recommendation to examine the three dimensions of burnout separately suggests that in practice, MBI is a measure of three independent constructs - emotional exhaustion, depersonalization, and personal achievement. On the other hand, LBQ is the Italian version of the Link Burnout Questionnaire by Massimo Santinello (Santinello, 2007). It is designed to measure occupational burnout in people working in professions related to helping other people and teaching. LBQ consists of 24 items describing the feelings of the examined person regarding their professional work. The answers are given on a 6-point scale, the next points of which refer to the frequency with which these feelings occur. LBQ allows for the assessment of four aspects of occupational burnout: psychophysical exhaustion (the dimension related to

¹ Currently, there are five versions of the MBI: Human Services Survey (MBI-HSS), Human Services Survey for Medical Personnel (MBI-HSS (MP)), Educators Survey (MBI-ES), General Survey (MBI-GS), General Survey for Students (MBI-GS [S]).

the assessment of one's own psychophysical resources), the lack of involvement in relationships with clients (the dimension describing the quality of relationships with clients), the sense of professional ineffectiveness (the dimension related to the assessment of one's own professional competences) and disappointment (the dimension of existential expectations).

3.2. Process stages and its causes

Actions taken by the employer depend on the degree and phase of the burnout process (Jaworowska, 2020).

Table 2.

Phases in the burnout process

Phases in the burnout process by The American Psychology Association	Ten levels of occupational burnout by Jörg Fengler	Phases resulting from the observation of the employee by the employer. The results confirmed in a categorized interview among 52 managers of HR departments in the service sector in Poland, January 2022
<ul style="list-style-type: none"> • honeymoon - a period of fascination with work and full satisfaction with professional achievements, energy, enthusiasm and optimism, • awakening - a time when it is noticed that the idealistic assessment of work is inadequate, a period of increased work and efforts to ensure that the idealistic image of work is not disturbed, • roughness - the implementation of professional tasks requires increased effort, problems in social contacts arise, • full-blown burnout - full mental and physical exhaustion, symptoms of depression, feeling of emptiness and loneliness, willingness to be free and escape from work, • regeneration - the time of healing wounds resulting from occupational burnout. 	<ul style="list-style-type: none"> • politeness and idealism • overwork • decreasing politeness • feeling guilty about it • increased efforts to be polite and dependable • lack of success • helplessness • loss of hope • exhaustion, aversion to people, apathy, anger • burnout. 	<ul style="list-style-type: none"> • burnout as a feeling of gradual exhaustion and increasing body fatigue. Weekends are not enough for the employee to rest and start working with new energy; • reduction of activity - withdrawal and apathy appear. The employee does not want to get involved in either company or private affairs; • emotional reactions such as verbal aggression towards colleagues, cynicism, negating the opinion of others; the employee becomes difficult to cooperate with; • decline in condition shown on the level of creativity, motivation to work, commitment and cognitive functions - work begins to take more time and the effects are getting weaker; • degradation of contacts with others, emotional tension is high, mood swings from anger to sadness appear; • psychosomatic reactions, health problems occur, and such disorders include both problems with sleep, more frequent colds or decreased sexual performance, as well as heart and digestive system diseases; • desperation that can lead to the development of reactive depression, addiction and even suicide.

Source: own elaboration (Jaworowska 2020; Fengler, 2001), the results confirmed in a structured interview among 52 managers of HR department service sector, in Poland, January 2022.

The phases of occupational burnout do not have to occur in the composition described above and always in the same sequence. Several phases can occur simultaneously. The return to the previous phases is also possible (Tucholska, 2001).

The reasons for the occurrence of this phenomenon can be divided into at least two groups: individual, i.e., personality-related, and those resulting from improper functioning of the organization. The causes also include the interpersonal sphere. Hence the following reasons are distinguished (Tucholska, 2001; Sęk, 2007):

- **individual** - personality traits such as passivity, oversensitivity, defensiveness and low self-esteem predispose to burnout; on the other hand, also ambitious people who think unrealistically about what they can do at work, perfectionists with an excessive need for control and workaholics who identify themselves with their own work, as well as lonely people are more likely to develop this syndrome,
- **interpersonal (interhuman)** - excessive emotional involvement in the matters of service users (e.g., patients, students, applicants) or other employees, lack of ability to "distance" from work, problems in contacts with superiors and/or colleagues, rivalry, lobbying,
- **organizational** - conflicting expectations, vaguely formulated professional roles, lack of resources to fulfil tasks, lack of development and promotion opportunities, too many duties or their equally destructive shortage, too low pay, lack of adjustment to one's own job position or the company values and culture, lack of time for family life, the need to hurry at work or monotony and work in the evening and at night.

3.3. Current situation

According to a study by Kronos Incorporated and Future Workplace, burnout **is affected by the following** factors (The Future...):

- inadequate remuneration (41%),
- work overload (32%),
- overtime (32%),
- ineffective management in the company (30%),
- no relationship between the role of the employee and the company's strategy (29%),
- low work culture (26%).

Already in December 2018, 62% of Poles experienced the sense of occupational burnout (Fig. 1)².

² STADA Group Health Report "The Future of Your Health" 2019 was prepared on the basis of the results of the opinion poll conducted in November and December 2018 at the request of Kantar Health on behalf of STADA Arzneimittel AG, on a group of respondents from Belgium, France, Germany, Italy, Poland, Russia, Serbia, Spain, Great Britain, n = 18,000.

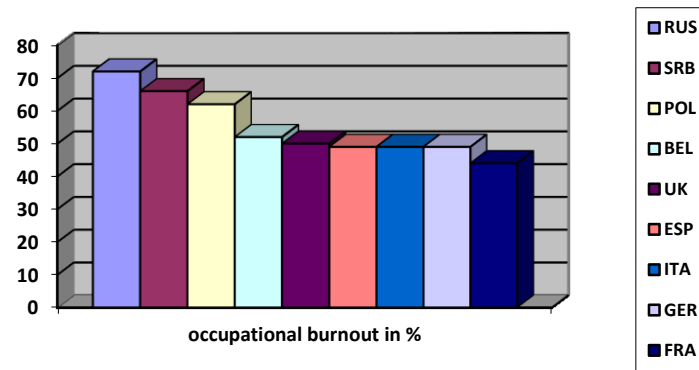


Figure 1. Occupational burnout in selected countries.

Source: (STADA, 2019).

According to Savanta Inc., the COVID pandemic caused the most stressful period ever, and negatively affected the mental health of 78% of employees worldwide in 2019. According to a global study, 82% of employees would be willing to undergo psychotherapy. The pandemic has made people around the world struggle with increasing anxiety and depression at work³. The study especially shows that:

- 70% of respondents assess that this year they experience stress and anxiety at work which are greater than ever before,
- increase in stress and anxiety negatively affects the mental health of 78% of employees worldwide and causes greater stress (38%), imbalance between work and private life (35%), burnout (25%), depression due to lack of social contacts (25%) and loneliness (14%),
- the difficulties caused by the global pandemic overlapped with daily work-related stressors such as pressure to meet performance standards (42%), performing routine and tedious tasks (41%), and an overwhelming amount of work (41%).

The global pandemic has intensified problems with mental health at work, and their consequences are not limited to working life. Therefore:

- 85% of respondents believe that problems with mental health at work (i.e., stress, anxiety and depression) affect their personal life,
- the most common consequences of these problems include insomnia (40%), poor physical health (35%), less satisfaction with personal life (33%), deterioration of family relationships (30%) and isolation from friends (28%),
- remote work made the boundaries between private and professional life started to blur increasingly. 35% of people work more than 40 hours more per month, and 25% suffer from burnout due to overwork,

³ The survey results are based on a survey conducted by Savanta Inc. between July 16 and August 4, 2020. 12,347 respondents from all over the world (United States, United Kingdom, United Arab Emirates, France, Italy, Germany, India, Japan, China, Brazil and Korea) participated in the survey. The study included people aged 22 to 74. (Infor, 2022).

- despite the experienced disadvantages of remote work, 62% of respondents now assess it better than before the pandemic; employees claim they now have more time for their family (51%), for sleep (31%) and for performing their duties (30%).

Workers around the world expect support for their mental health. The research results show that:

- 76% of respondents believe their companies should do more to protect their mental well-being. 51% admitted that their companies introduced mental health services or support in connection with the COVID-19 pandemic,
- 83% of employees would like their employers to provide technologies that would support their mental well-being, such as self-service access to resources related to healthcare (36%), psychological services available on demand (35%), preventive health monitoring tools (35%), access to health and meditation apps (35%), and chatbots answering health-related questions (28%),
- 84% of respondents struggle with difficulties when working remotely, while the most frequently indicated challenges include the lack of boundaries between work and private life (41%) and greater mental health problems, including stress and anxiety (33%),
- 42% of respondents claim that work-related stress, anxiety or depression make them less productive, and 40% indicate that this leads to making wrong decision more frequently. 85% of respondents believe that work-related stress, anxiety and depression have an impact on their private lives.

4. Business model in the concept of sustainable development

Business operation models of enterprises are dynamic by nature - they are subject to continuous modifications, which are a consequence of changes and trends that take place in a given sector, as well as changes and megatrends of non-business sources, exerting pressure on already established business models (Majchrzak, 2019, pp. 79-93). The environment of the organization, both internal and external, is a key source of forces influencing the dynamics of business models. The scope and intensity of changes taking place in the environment determine the nature of changes in business models (Globocnik et al., 2020, pp. 231-243).

Considering business models from a dynamic perspective, two main types of changes can be distinguished (Saebi, 2015, pp. 145-168):

- *Business Model Innovation* – BMI,
- *Business Model Adaptation* – BMA.

In an increasingly complex and dynamic environment, innovations in business models (Giesen et al., 2020, pp. 17-26), which may contribute to the modification of the existing and/or development of new models (Rachinger et al., 2019, pp. 1741-1779) are of vital significance for the success of an organization.

According to the norms and documents of the United Nations: "Sustainable development of the Earth is development that meets the basic needs of all people and preserves, protects and restores the health and integrity of the Earth's ecosystem without threatening the possibility of meeting the needs of future generations and without crossing long-term boundaries of the capacity of Earth's ecosystem". Following the assumption, a modern innovative business model referred to as the 3 XP model (from English), represents a sustainable model that takes into account welfare in three dimensions and strives for a balance between: planet - people - profit. The model of sustainable development of a company, organization or individual represents a number of complementary activities, as well as a way of thinking that assumes sustainable development in many areas and at various levels (Amit, 2010, pp. 1-15; Boons et al., 2013; Sztangret et al., 2017).

Table 3.

Business model in the concept of sustainable development of companies

Pillars of the model	Planet	People	Profit
Focus areas	environment	<ul style="list-style-type: none"> • respect for human rights • employees • social commitment 	compliance and balance
Key stakeholder groups	<ul style="list-style-type: none"> • employees • suppliers • customers 	<ul style="list-style-type: none"> • employees and employees' peers • young talents • consumers • contractors • suppliers • local community • society 	<ul style="list-style-type: none"> • employees • administrative board • shareholders • contractors • consumers
Fields of action	<ul style="list-style-type: none"> • resource management (power consumption, procurement, disposal, travel management) • active participation in eco-ventures • "Green economy" • circular management 	<ul style="list-style-type: none"> • fair, safe, health working conditions • interesting activities and project • transparent development paths • appealing work environment • attractive remuneration • useful software • secure and ethical handling of information technology • digital education • get young people interested in IT • Declaration of Human rights • code of ethics • protecting employee rights • privacy engineering 	<ul style="list-style-type: none"> • legally compliant and ethically correct procedures in business (dependable partner, exemplary investor, industry expert) • Compliance Management System • Sustainable products and services • risk management • data reporting

Source: own elaboration based on the online interview analysis of companies by the declared concept of sustainable development and statements of 52 managers of HR departments in three service sectors.

All of the analyzed cases declared a holistic and systemic approach to sub-areas and operational activities. The implementation of the business model was guided by the idea of well-being in its three dimensions: planet/environment, people and profit, with particular emphasis on humans.

5. Burnout in the concept of sustainable development - discussion in the light of Polish and international circumstances, results of own research

According to the common belief that it is better to prevent than to cure the effects of burnout, more and more companies⁴ delegate this task to professional HR agencies that possess appropriate tools, thanks to which they are able to:

- examine the level of occupational burnout in employees and its causes,
- evaluate communication in the organization,
- design development and career paths for each employee, group and team,
- propose activities facilitating management of multi-person and multicultural, often scattered, teams,
- influence the increase in the satisfaction with the performed tasks, that is, create an environment of well-being in the company.

5.1. Well-being programs

Well-being theories try to define what is necessary for a holistic approach to the concept of well-being. Hedonistic theories equate well-being with a balance of pleasure and pain. Desire theories claim that well-being is about the satisfaction of desires: the more desires are satisfied, the higher the well-being. Objective list theories state that an individual well-being depends on a number of factors that can include both subjective and objective elements. Well-being is the central topic of positive psychology, the aim of which is to identify the factors influencing human well-being (Slade, 2010).

⁴ The results confirmed in a categorized interview among 52 managers of HR departments in the three service sector in Poland, January 2022.

Table 4.*Wellbeing model by chosen authors*

PERMA - wellbeing model, developed by Prof. Martin Seligman	The Swarbrick and Yudof model of well-being
1.1 P: Positive emotions 1.2 E: Engagement 1.3 R: Relationships 1.4 M: Meaning (sense of meaning/importance) 1.5 A: Achievement/Accomplishment (achieving and appreciating what is done).	<ul style="list-style-type: none"> • Physical well-being (energy, form, vitality, power), • Spiritual well-being (sense of meaning in life, life values, spirituality), • Mental/emotional well-being (awareness of emotions and skills in managing them, coping with stress), • Intellectual well-being (open mindedness, willingness to know, learn), • Relationships (building supportive relationships with other people, contacts, belonging), • Finances (sense of financial security, economic management, attitude to money), • Career (consistency between what we do and talents, the sense of creation, value for oneself and others, meaning, development opportunities), • The external environment (surroundings).

Source: own elaboration based on (Seligman, 2011; Swarbrick, 2015).

When the boundaries between home and work are blurring and the pandemic crisis is affecting people around the world, recent months have revealed a critical need for effective “well-being programs⁵” in the workplace (Kulig-Moskwa, 2020). The coronavirus pandemic, physical isolation and uncertain economic situation have contributed to the deterioration of the mental well-being of thousands of workers. In a global study conducted by The Adecco Group (2020), 28% of workers indicated that their mental health had deteriorated during the pandemic, and 80% stated that their employer should be responsible for ensuring proper functioning in the workplace after COVID. The program is especially focused on the *emotional* aspect related to health and *psychological* support, including consultations with professionals, group sessions, using an individual approach tailored to the rhythm of the employee's day. In addition, companies allow employees to work flexible hours so that professional as well as private and family responsibilities can be reconciled. Many companies have adapted development programs for leadership staff, in which specialists train them on how to *recognize* the first symptoms of overload or burnout and depression in employees, what approach to use towards people who experienced psychotic episodes, or how to care for *well-being* in *task forces*. The *physical aspects* of the working environment are also important. The concept of well-being in the context of the work environment includes creating organizational conditions in which employees can fulfill themselves in a safe and healthy way. This comprehensive approach covers physical space, work model, technologies, management culture and managerial practices.

⁵ The Wellbeing Index, an indicator determining the level of employee well-being, developed by the Gallup Institute together with Healthways, includes: *purpose, social, financial, community, physical*.

Table 5.

Elements supporting well-being according to the Swarbrick and Yudof Model, as understood by the respondents, by sector and by professional groups

Elements of the model	evaluation										
	-5	-4	-3	-2	-1	0	1	2	3	4	5
Physical well-being							O I K		Z	HR	
Spiritual well-being								I K		O Z HR	
Mental well-being								I	O K	Z HR	
Intellectual well-being								I K		O Z HR K	
Relations							O	I	Z	HR	K
Finances								K	O Z	I HR	
Career						O	I	K	Z	HR	
External environment					O					I HR	K

Key:

O – Education sector; Z – Health sector; I – IT; HR – HR department; K – direct customer contact workers.

Source: The results of structured interview among 52 managers of HR departments in the service sector in Poland, January 2022 and 122 first contact employees of the IT, Education and Healthcare sectors.

Respondents share the view concerning the importance of the elements supporting well-being according to the Swarbrick and Yudof's Model. HR managers assign equal importance to all factors, while in the case of employees in direct customer contact, the least importance is attached to energy, form, vitality, strength, whereas the greatest importance is attached to human relationships and external factors. Concentration of opinions on all elements of the model in the range of 3-4 is observed among respondents from the healthcare sector. The representatives of the education sector do not notice the influence of the external environment on their well-being. Careers, relationships and physical well-being are of similar importance to the education sector. Career and physical factors also do not determine the well-being of IT employees either.

However, as the research results show, there is a significant dissonance between what the company offers in its wellbeing programs and what employees expect (Table 6).

Table 6.

Well-being dimensions by employer and employee

	HR Departments	Workers
	<i>Assessment of the need to act in a specific dimension of wellbeing in your organization by importance</i>	<i>Dimensions of well-being in employees' view from the worst to the best rated (requiring action in the first place)</i>
1	Intellect and mind	Finances
2	Finances	Physical well-being
3	Relationships with other people	Environment and physical conditions
4	Career and development	Career and development
5	Environment and physical conditions	Mental well-being
6	Spiritual well-being	Relationships with other people
7	Mental well-being	Spiritual well-being
8	Physical well-being	Intellect and mind

Source: (Raport HR, 2018); The results confirmed in a categorized interview among 52 managers of HR departments in the service sector in Poland, January 2022.

It should definitely be noted that the physical dimension, which supports healthy lifestyle habits that are important for the surveyed employees is the underestimated dimension of wellbeing in companies.

5.2. Employees' work-life balance

The idea of work-life balance was created at the turn of the 1970s and 1980s (Raport HR, 2018; Friedman et al., 2019). Work-life balance is a balance between an individual's priorities at work and their priorities in other aspects of life. Due to the positive balance between work and private life, the conflict between work and home is minimized (Fiksenbaum, 2019, pp. 653-672). Work does not interfere with achieving satisfaction in life outside of work, and aspects of personal life do not have a negative impact on work. Maintaining a balance between work and private life is also a contemporary challenge for companies. The imbalance is caused by the development of technology and all-encompassing communication at any place and time. Establishing a time frame for communication via SMS and email is one of the activities in this area. The key aspect influencing job satisfaction is the compliance of personal beliefs with the company's culture and the values it represents. Hence, the selection of candidates should be based not only on their professional competences, but also on the analysis of the represented values and their compatibility with the company's values. According to the research results, Poles like and appreciate what they do professionally (69% of respondents). Respondents believe that work matters and brings value to other people's lives (59%) (Raport HR, 2018). Promoting a healthy lifestyle of employees and taking care of their general mental state is also a way to integrate employees. The time spent together can be fruitful and translate into greater morale and commitment among employees. This area also covers employees' education, including training in counteracting burnout or coping with stress. Employees believe that they are open-minded and like to learn (82%); they are curious and receptive to new knowledge (84%). 55% of respondents believe that they develop in line with their interests and talents, and 63% that they use their capabilities. The flexibility of the employer as regards the participation of remote work in the whole number of hours and time intervals related to the beginning of the working day is a good practice (Kosseck et al., 2011, pp. 289-313).

Sabbatical leave, defined as a form of motivation, in particular for experienced employees, consisting in a long, several weeks' or even several months' leave, while maintaining the current workplace is one of the tools for implementing the concept. Sabbaticals are paid leaves for personal and professional development (Miller et al., 1997, pp. 11-16). According to Zahorski (Zahorski, 1994), a sabbatical leave is meant to provide relief from routine work duties (Sabbatical, 2022). In practice, the long regenerative leave is most often used by employees of international corporations and people occupying the most responsible positions in the organization. The leave is most often associated with the improvement of qualifications or skills in a specific field agreed with the employer. This is confirmed by its nature - a long break at work is to have positive effects not only for the employee, but also for the employer. It happens

that the sabbatical leave is used for voluntary activities, which also plays a vital role in the company's CRS strategy.

Table 7.
Work-life balance in the opinions of the surveyed entities

Balance factors	evaluation										
	-5	-4	-3	-2	-1	0	1	2	3	4	5
Possibility of remote work	Z			O					I HR	K	
Flexible working hours					Z			O	I HR		K
Integration events with the participation of the closest relatives, and family days	Z							O	I	HR	K
Pets allowed to come to the office	Z				O					I HR	K
Promoting physical activity and taking care of employees' health							O	Z		I HR	K
A "home" office in a good location								Z	O	HR	I K
"Satisfaction" surveys and individual meetings with employees								Z		O	I HR K
Organizing and paying for trainings, courses, conferences, etc.										I HR K	O Z
Long leaves, including sabbatical leaves											O Z I HR K

Key:

O – education sector; Z – Health sector; I – IT; HR – HR department; K – direct contact workers.

Source: The results of structured interview among 52 managers of HR departments in the service sector in Poland, January 2022 and 122 first contact employees of the IT, Education and Healthcare sector.

The idea of work-life balance is very important for all groups of respondents, and the ratings are mostly in the 4-5 range. Representatives of the health care sector presented completely different views while totally negating the impact of the possibility of remote work, integration events with the participation of the closest relatives and family days, as well as the possibility of bringing their pets to the office. However, it is a result of the specificity of their profession.

5.3. Digital stress of remote workers

Digital stress is a problem primarily for remote workers. Being constantly online results in overstimulation as well as extra tension and stress, which can lead to burnout and depression. This is the *tension that arises during our interaction with digital technologies, i.e., when reading e-mails or browsing news on social media. In this case, information overload, multitasking or a sense of lack of time become the stressor.* The abuse of digital technology negatively affects the psychophysical condition of employees, thus translating, among others, into deterioration of their mood, weakening of social ties, as well as chronic stress hindering

the performance of daily duties, not only professional, but also the family ones. Digital well-being, i.e., *digital detoxes or online workshops in digital well-being* may be the solution here. Digital well-being (Gui et al., 2017, pp. 155-173) is a state in which subjective feeling is maintained in an environment characterized by an excess of digital communication. In conditions of digital well-being, individuals are able to turn the use of digital media towards a sense of comfort, security, satisfaction and fulfillment. Digital well-being is the subjective, individual experience of the optimal balance between the benefits and drawbacks resulting from mobile communication. This empirical state consists of affective and cognitive assessments of the integration of digital communication and everyday life. People achieve digital well-being when they experience maximum controlled pleasure and functional support, along with minimal loss of control and functional impairment (Vanden, 2021, pp. 932-955). From a business point of view, maintaining a healthy digital balance of employees means⁶:

- functioning in a healthy and sustainable manner, and not operating in emergency mode,
- learning productivity and focused work,
- skillful regeneration of the mind and rest from technology,
- caring about digital hygiene,
- building healthy digital habits that reduce stress and improve well-being.

Table 8.

Healthy digital balance of employees in their opinion

Digital balance factors	scale										
	-5	-4	-3	-2	-1	0	1	2	3	4	5
functioning in a healthy and balanced manner, and not operating in emergency mode								HR	O I		Z K
learning productivity and focused work									I HR	O	Z K
skillful regeneration of the mind and rest from technology										Z HR	O I K
care about digital hygiene								Z HR		K	O I
building healthy digital habits that reduce stress and improve well-being									HR	I K	O Z

Key: O – education sector; Z – Health sector; I – IT; HR – HR department; K – direct contact workers.

Source: The results of structured interview among 52 managers of HR departments in the service sector in Poland, January 2022 and 122 first contact employees of the IT, Education and Healthcare sector.

There is no doubt that all surveyed groups of respondents share the view that there is a need to care for a healthy digital balance of employees. All factors were rated in the range of 2-5. The majority of respondents ranked digital balance as the highest priority.

⁶ The results confirmed in a categorized interview among 52 managers of HR departments in the service sector in Poland, January 2022.

However, as the research results show, employees expect machines to support their mental health. Other challenges for the employer result from the fact that only 18% of the surveyed respondents indicated that it was people, not robots, which provided support for their mental condition. According to the respondents, robots do not judge (34%), are not biased towards people sharing their problems with them (30%) and quickly answer questions about health (29%). 68% of respondents would prefer to talk about stress and anxiety at work with a robot rather than with a supervisor, and 80% of people would be open to using the robot as a therapist or counselor. 75% of respondents believe that artificial intelligence supports their mental health at work. The most important benefits included providing the information needed to do the job more efficiently (31%), automating tasks and reducing workload to prevent burnout (27%), as well as reducing stress by helping to prioritize tasks (27%). Artificial intelligence has also helped most of the employees to shorten the working week (51%) and extend their holiday (51%)⁷.

6. Conclusions

A necessary condition for the implementation of contemporary models of sustainable development is a comprehensive approach of companies to the implementation of its sub-areas (planet, people, profit), in each of the many dimensions, especially those aimed at preventing and reducing occupational burnout, which is one of the factors of social well-being. This well-being is expressed in a wide range of ways of its implementation by the employer (company) and perception by the employee, in terms of their system of values. In the knowledge-based economy, people are the most important capital of an organization, which is why it is so important to create an optimal environment in which employees use their potential. "Well-being", perceived as a set of practices for creating a healthy and engaging work environment is one of such areas. It may become one of the key assumptions of the company's sustainable development concept. The concept of human well-being is undoubtedly important from the point of view of implementing effective concepts of sustainable development of the company, but it is largely an objective category. Its holistic dimension consists of physical, spiritual, emotional, intellectual, relational, financial, career and development-related well-being, as well as the well-being in the living and working environment. Well-being in the company is a continuous and dynamic management of the employee's sense of well-being, by considering their needs in all of the declared dimensions in a comprehensive way, while maintaining a correlation between the company's image of the employee's well-being and their own perception of needs in this area. However, as the research results show, the lack of

⁷ As above.

compatibility between the employer's and employee's perceptions of well-being make the phenomenon even further complicated. Although the study showed different priorities in the field of well-being, there is a clear agreement as to the components of the Model supporting well-being, in its spheres of work-life balance and healthy digital balance of employees, in all surveyed groups of respondents, i.e., HR managers, employees in direct customer contact, education, IT and health sectors. As a result, they bring comprehensive activities including the measurement of the intensity of the phenomenon, identification of the phase of the process and its reasons for building effective well-being programs as a key sub-area of the business model according to the concept of sustainable development.

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CUSTOMER SERVICE IN THE DIGITAL REALITY. CHALLENGES FOR CONTEMPORARY COMPANIES

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Purpose: The article is aimed at indicating the opportunities for and dilemmas of implementing cutting-edge technology in the customer service area, paying particular attention to the operations of customer service departments in companies.

Design/methodology/approach: This article is aimed at answering the question concerning the potential use of cutting-edge technology in the customer service area in confrontation with the digital skills level and expectations of contemporary consumers. The following methods were used: reference works' review, analysis of secondary sources and reasoning based on a critical analysis of studies carried out by international research and consulting agencies.

Findings: Generally speaking, using cutting-edge technology in marketing contributes to reduced costs and improved customer service, but in certain circumstances excessive use of artificial intelligence may have adverse impact on the customers' satisfaction with the service (chatbot anthropomorphism).

Practical implications: Potential advantages, but also threats relating to using the Industry 4.0 tools for marketing, including but not limited to the customer service area, were indicated.

Originality/value: The article provides insights for the discussion concerning chances and hazards of using cutting-edge technology with respect to customer relations, including but not limited to the artificial intelligence.

Keywords: customer service, digital technology, digital consumers.

Category of the paper: Conceptual paper.

1. Introduction

Cutting-edge digital technology and Industry 4.0 tools enter all areas of company operations, including the marketing one, more and more intensely. New solutions are broadly used for marketing activities. First of all, they offer opportunities for multi-channel communication with customers, learning individual consumers' needs better, customization and service facilitation. Customer service is one of the key areas of the company marketing activities as it contributes to the improved customer satisfaction level, builds their loyalty and

improves sale volumes. Results of the global Salesforce Research results of 2020 revealed that for 91% of the surveyed customers experience of the positive service is a factor encouraging them to purchase from the company again (State of the connected customer, 2020). Moreover, it turns out that the customer happy with the customer service is willing to forgive minor mistakes. This attitude was declared by the majority of respondents (78%).

Studies carried out by many authors prove that using cutting-edge technology and digital tools for marketing purposes offers many benefits, including reduction of marketing costs, increased sale volume, improved customer service level, improved customer satisfaction and loyalty, brand awareness building and acquiring new customers (de Haan et al., 2016; de Vries et al., 2017; Hudson et al., 2016; Kumar et al., 2017; Adam et al., 2020; Melović et al., 2020; Yang, 2021).

New technology is used for marketing not only because of its measurable benefits for the company, but also of the customers' competences and preferences which are changing in line with technological progress (Bonaretti et al., 2020; Štefko et al., 2019; Szwajca, 2021a). Consumers, in particular the youngest, more and more often use the Internet, mobile devices and applications for the purchasing process, from looking for offers to buying. Digitization changes not only the purchase methods and habits of consumers, but also their value systems and life style. A consumer who is termed digital represents a slightly different personality type which translates into new, specific requirements and expectations concerning the company offering and the service method (Szwajca, 2020). Using new technology for service to fulfill the requirements of a digital customer is a serious challenge for today's companies (Szwajca, 2021b). Many authors stress that implementing even the most innovative technology does not guarantee success. They suggest that success may result from skillful use of appropriate tools which enable first to learn the customers and understand their needs and growing expectations, and then to prepare and deliver an attractive offer fast, easily and conveniently (Andriole, 2017; Fabrizi et al., 2019; Vial, 2019).

The article is aimed at identifying opportunities and hazards related to using cutting-edge technology and digital tools in the customer service area of today's, mostly Polish, companies. To achieve that objective, it is necessary to answer the following research questions:

- 1) What are the opportunities to use and benefits of using cutting-edge technology for marketing and customer service?
- 2) What are the requirements and expectations of digital customers relating to such service?
- 3) What cutting-edge technology and digital tools are used in the customer service departments of Polish companies in the context of digital customers' expectations?
- 4) Are the investment priorities in the customer service area compatible with the customers' requirements and companies' expectations?

The following research methods were used: critical reference works' review, analysis of secondary sources and deductive reasoning based on a critical analysis of studies carried out by international research and consulting agencies (e.g. KPMG, Deloitte).

The article structure, composed of the following sections, is subordinated to the main objective. Section 2 discusses the opportunities to use cutting-edge technology and digital tools for marketing and customer service. Section 3 presents the personality profile and requirements of digital customers. Section 4 presents using digital technology and tools in the customer service departments in Polish companies. Section 5 contains a discussion and conclusions.

2. Opportunities to use cutting-edge technology for marketing and customer service

The dynamic development of cutting-edge digital technology and Industry 4.0 tools contributes to changing the nature and operation opportunities of the company in all areas. This refers to marketing as well, where a digital transformation has taken place for years (Hendrix, 2014; Sharma, 2015; Kim et al., 2021; Krishen et al., 2021). The Internet, social media, systems and mobile devices offer broad opportunities of contacts and building channels of communication with customers, offer development, product promotion and sales. The solutions are improved all the time and reach new and new digitization levels (Fraccastoro et al., 2021). Hoffman et al. (2022) prove that new technology:

- contributes to the development of new types of interactions between customers and companies,
- enables to acquire new data types and use new analytical methods,
- creates marketing innovations,
- requires new strategic marketing framework.

In the area of broadly-taken customer service, such cutting-edge tools as social media, omnichannel communication, Cloud Computing, artificial intelligence (AI) and chatbots, and augmented reality are of particular importance.

Social media (Facebook, Twitter, Instagram, LinkedIn, Pinterest, Messenger, YouTube etc.) are particularly important for the customer communication, customer service and sales when it comes to the youngest buyers (Hanna et al., 2011; Salo, 2017). Social media enable rapid and ongoing contact with customers, sharing information concerning the offer and also obtaining feedback on the offer approval (number of likes) fast. Using social media, the customers share opinions on products or services, create forums and fan clubs, recommend different offers to one another, all the same ensuring free-of-charge advertising for the company which is more effective than the traditional one. Besides, thanks to their global reach, social media enable the company to get international and acquire foreign customers (Arnone,

Deprince, 2016; Fraccastoro et al., 2021). Thanks to the above properties, social media are most broadly used by companies for the sale process (Lacoste, 2016; Itani et al., 2017; Bill et al., 2020; Müller et al., 2018).

Social media are one of many channels used for customer communication by companies, beside e-mails, hotlines, video messengers, traditional mail and face-to-face contacts. This multichannel approach is being replaced by the omnichannel one at present. The concept entails creation of a smart network of integrated channels, including e.g. brick-and-mortar shops, e-shops, social media and mobile devices which enable the customer to use the same offers or promotions in different channels (Gotwald-Feja, 2017; Kaczorowska-Spychalska, 2017). The company may correct the sale offer on an ongoing bases so that the customer could know if the product they are interested in is available. Thanks to integrating data and messages from all channels, the customer could optimize their purchase path, e.g. order the product in an e-shop and collect it in the brick-and-mortar one or handle complaints switching between channels to the one which is more convenient to them at any given time (Chopra, 2018; Gwiazdziński, 2020).

Another tool is Cloud Computing, with SaaS being its highly advanced level. SaaS is the service consisting in sharing software in a cloud by the provider who develops and maintains cloud applications, ensures their automatic updates and manages the entire hardware and security solutions. The software is shared with the customers online, with a fee conditional on the resource use, i.e. “pay-as-you-go” (Seethamraju, 2015, p. 476). SaaS provides many business applications, including the ones for sale, marketing and customer service (Mohammed, Zeebaree, 2021). Using SaaS enables the company to reduce costs significantly, obtain operating and innovative benefits, which translates into improved financial results as confirmed by research in this area (Rodrigues, 2014; Loukis et al., 2019).

Artificial intelligence (AI) is evidenced in the structure of automatic machines, devices, robots and chatbots displaying aspects of human intelligence and likely to replace humans in doing more and more complex tasks (Rust, Huang, 2014). Chatbot is a computer program which simulates and processes human speech, enabling to communicate with a digital device as if it were a human being. Chatbots are used to talk to customers in real time. They have numerous advantages. They may operate all day long with no limitations and serve the customer online as they find convenient. What is more, they do not get sick or angry and they are very patient. Robots and chatbots are more and more popular in many sectors (Ivanov, Webster, 2017; Crollic et al., 2022). In hotels or restaurants, virtual bots change customer service into self-service (Fluss, 2017; Berezina et al., 2019), social bots replace humans to welcome customers in service outlets, including the SoftBank's Pepper robot “working” in Pizza Hut (Choudhury, 2016).

AI technology and chatbots have high development potential. AI is anticipated to take over not only more and more analytical tasks, but to be able to complete intuitive and emphatic human tasks eventually (Huang, Rust, 2018). When it comes to the market of chatbots and related technology, the value of this market is foreseen to exceed USD 1.34 billion in 2024

(Wiggers, 2018). It should be pointed out that the opinions vary with respect to using chatbots for customer service. Some authors believe that chatbots will make customer service easier and reduce marketing costs (De, 2018). Other perceive certain disadvantages of the situation and hazards for companies (Kaneshige, Hong, 2018). The hazards are connected with the risk of certain cognitive dissonance and frustration for the customer as a result of contacts with the chatbot. Many companies make them excessively human, giving them names and avatars which may confuse the customers a bit. Crolic et al. (2022), having analyzed some international studies and experiments (e.g. in the ICT sector), discovered that the satisfaction level of customers served by chatbots may be extremely different, depending on the customer's mental state. It was found out that when an irritated or angry customer is served by the chatbot, they have a negative opinion on the service and on the company, and do not intend any further purchase. The researchers discovered that this adverse phenomenon is caused by a certain cognitive dissonance of the customer caused by the anthropomorphism of the chatbot which does not fulfill the inflated expectations of the customer concerning their efficiency. This phenomenon does not apply to the response of customers who were not angry or irritated when the interaction was initiated by the chatbot. Miao et al. (2022) conclude that the existing studies of using avatars for marketing strategies and their efficiency (inciting the customer to buy) have brought about different results so far.

Augmented reality (AR) is the technology enabling to combine the actual reality with the virtual world components. Real-world components recorded by a camera are synchronized with computer artwork and 3D animations, thanks to which it is possible to be in two parallel worlds at the same time. Thanks to using AR, a prospective customer may learn and test an unknown product using suitable mobile devices before buying it online (Scholz, Duffy, 2018; Rauschnabel et al., 2019). For example, IKEA uses the augmented reality to enable the customer not only to arrange furniture in their flat, but also to walk round the flat (Smółucha, 2017). Tan et al. (2022) indicate a potential of that technology to improve sales by reducing customer's uncertainty before buying the product.

3. Service-related requirements of digital customers

The ongoing digital transformation contributes not only to the companies' operational methods but also to the consumers' behavior and decisions. The omnipresent digital reality contributes to changing the customer profile. Reference works describe the consumer evolution model, starting from an analogue customer, through a hybrid and digital one, to Homo Cyber Oeconomicus (Fig. 1).

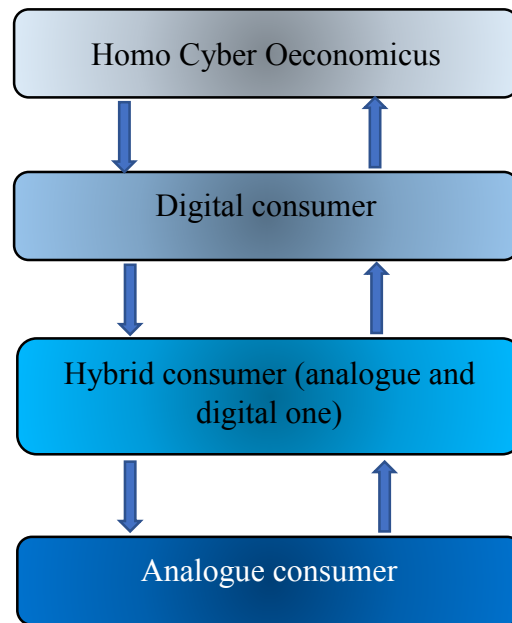


Figure 1. Consumer evolution stages in the context of digital transformation.

Source: Gregor, Kaczorowska-Spychalska, 2018, p. 61.

The analogue consumer is described as a passive recipient of mass-media message sent by the company using traditional media (the press, radio, television). The analogue consumer uses the Internet to a limited degree mainly due to their distrust for this technology and often insufficient computer literacy. The hybrid consumer is characterized by higher digital competence and uses the Internet more eagerly and more consciously. The digital consumer has high digital competence, uses cutting-edge technology, is well informed and conscious of their needs. The Homo Cyber Oeconomicus stage means a consumer who is not only a recipient, but also a co-creator of new technology.

The predominant type at present is the digital consumer who uses digital technology and devices for buying different items and fulfilling their needs. Here, it is worth mentioning that digital competence of Polish consumers, though low when compared to the EU average¹, is getting higher in particular among the youngest consumers from the generation Z. Recently, the pandemic contributed to it (Szwajca, 2022).

The digital consumer not only has high digital competence, but also specific personality traits. The digital consumer is a person (Szwajca, 2020):

- who is well-informed, conscious of their needs and rights and more independent when making decisions,
- who is impatient and strives to achieve comfort,

¹ In terms of Human Capital, one of the components of DESI, Poland ranks 24th among 27 EU countries. 44% of Poles aged 16-74 have at least basic digital skills (the EU average is 56%), and only 21% have secondary digital skills (the EU average is 31%). Source: Poland in the Digital Economy and Society Index. <https://digital-strategy.ec.europa.eu/en/policies/desi-poland>.

- who is curious of the world, open-minded and pragmatic,
- who is demanding, critical, intolerant of any dishonest, errors and mistakes,
- who is open to fashions and new trends, and thus not much loyal,
- independent, active and creative, expressing their individuality by customizing everything.

The personality changes are followed by the changed requirements and expectations concerning the company offer and also the method and level of service. The digital consumer is highly demanding and expects high standards of quality and service ([Cyfrowy] klient nasz pan, 2019). According to the results of studies by KPGM in 2019, the main requirements of digital customers are focused on customizing and error-free, fast service. Due to the need to express their individuality, the digital customer expects the offer perfectly matching their personal needs and preferences. On the other hand, the impatience and wish for comfort generate high requirements concerning fast and effective service.

Comfort and customization are also the major aspects of service according to the results by Salesforce Research. In the fourth edition of the “State of the connected customer” survey of 2020, digital consumers pointed to comfort as the priority aspect of service once again, perceiving it as fast and efficient service in line with individual preferences: “83% of customers expect flexible shipping and fulfillment options such as buy-online-pick-up-in-store” (State of the connected customer, 2020, p. 15). Comfort is particularly important for the youngest customers from the generation Z (Fig. 2).

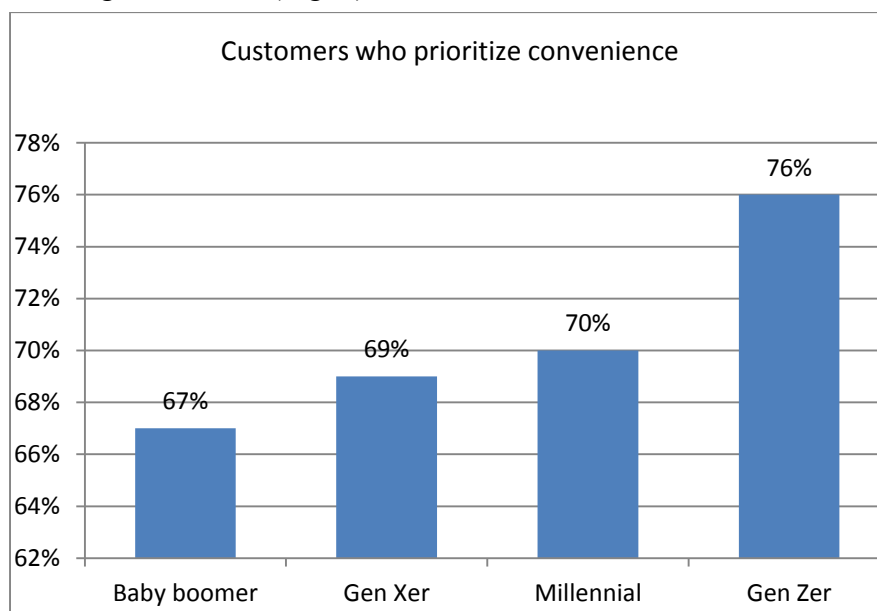


Figure 2. Comfort as a priority aspect of service for different customer generations.

Source: State of the connected customer, 2020, p. 15.

Here, it is worth mentioning the impact of the COVID-19 pandemic on the requirements and expectations of digital customers. Although the pandemic did not change the market habits and behaviors of consumers significantly and permanently (Szwajca, 2022), it changed their preferences to a certain degree. According to the KPMG survey of 2021 (Doświadczenia klientów...), the need to conduct most transactions online caused higher uncertainty and distrust for companies among Polish consumers. Consequently, the consumers indicated that what they appreciate most is the company reliability, easy purchase process and customization.

4. Using cutting-edge technology in the customer service departments of Polish companies as shown in Deloitte surveys

Using cutting-edge technology and digital tools in Polish companies was studied by Deloitte in 2020. 112 companies participated in the surveys, including 55% of large enterprises, 21% of medium-sized enterprises and 24% of small enterprises. The respondents included leaders of Customer Service Departments (CSD). For 31% of companies, CSD was an independent department (mostly in large enterprises). In the other cases, it was a part of another company department (Sales, Marketing or Operations) or was located elsewhere than the company. The surveyed companies represented mostly the following sectors: insurance, professional services for business, banking, technology, retail sales, automotive, ICT as well as transport and logistics. The major objective of the studies was to assess the effect of activities and solutions used by the service for customer satisfaction, with the satisfaction level assessed by the customer service leaders using the score from 1 to 5. The average score of customer satisfaction relating to CSD operations was 3.83 and it differed significantly based on the number of the communication channels operated. Figure 3 presents the communication channels operated by the surveyed CSD. As can be seen, the traditional channels (e-mail, phone, contact form) are still predominant.

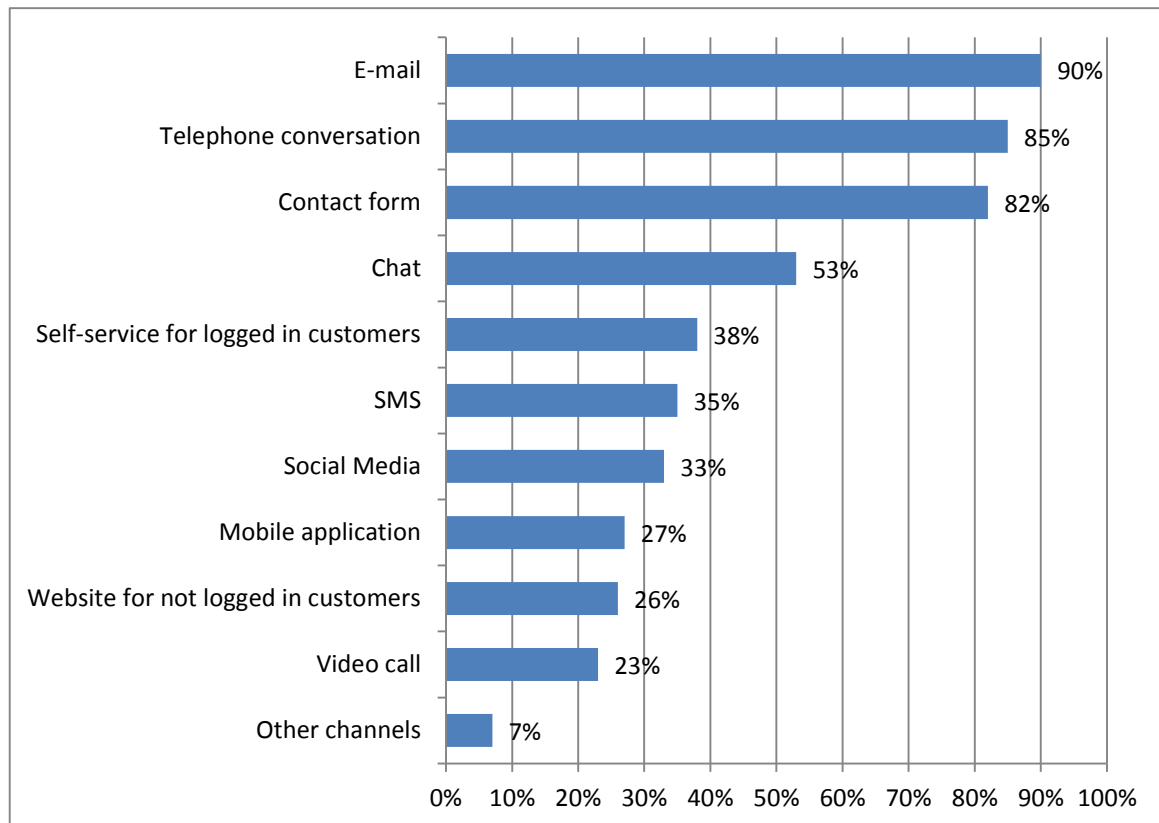


Figure 3. Communication channels operated by the surveyed Customer Service Departments.

Source: Report called Customer Service Excellence 2021 (2021). Study of Customer Service Departments in Poland. Deloitte Digital, p. 8.

It turns out that the customer service departments using more channels obtained higher customer satisfaction score, with the average score for CSDs operating fewer than 6 channels being 3.59, while for CSDs operating at least 6 channels 4.23. This indicates that the customers appreciate the possibility to use different channels to communicate with the company. As mentioned above, contemporary digital customers are more demanding and impatient. They expect immediate, effective service any time. Higher number of communication channels using cutting-edge methods (including self-service, SMS, mobile application) offers improved opportunities to meet those requirements and to establish more lasting and closer relationships with customers. As observed by M. Rakoniewska, head of the Customer Service Centre in Komputronik S.A., the customers want to be given choice with respect to the type of contacts with the company relating to different concerns (Report called Customer Service Excellence 2021, 2021, p. 13). When making a guarantee claim or a complaint, the customers prefer e-mail or the phone as they want to talk to a competent person, an expert, personally. However, when they want to get some information concerning the offer, extra services or promotions, they prefer to use chats and social media. According to M. Rakoniewska, thanks to the availability of different channels and possible customers' migration between them, it is possible to manage customers' traffic and experience more efficiently.

Respondents indicated that one of the most serious obstacles to efficient customer service is the system distribution and absence of an integrated, 360° view of the customer. The notifications from different channels are collected in a single system only in 30% of companies, in 61% of companies they are collected in several systems and in the remaining 9% of companies they are collected in every channel separately. Solving the problem requires using more than 3 systems in 44% of the surveyed companies. Such an approach affects customer satisfaction. As shown in Table 1, the higher number of systems required to solve the problem, the lower the customer satisfaction assessment.

Table 1.

Number of systems versus customer satisfaction

Number of systems	Percentage of companies	Satisfaction level
1-3	56%	3.94
4-6	33%	3.89
7 and over	11%	3.14

Source: Own study based on: Report called Customer Service Excellence 2021, 2021, p. 15.

One of the most serious challenges of CSD is the system of passing customers' concerns to relevant teams and agents. Three methods were identified here, i.e. referring concerns via other people (30%), referring concerns automatically (30%) and independent decision-making by agents (39%). According to the studies, the first method, i.e. referring concerns by other people is the least effective one (the customer satisfaction level scored 3.62). A bit higher score was awarded to referring concerns automatically (satisfaction level 3.82). It turns out, however, that the highest satisfaction level (3.98) was indicated for the independent decision-making by agents. This customer service aspect may be largely improved thanks to using artificial intelligence (AI). Using keywords and natural language processing (NLP) would enable to allocate cases to the most competent people in the given area. Using AI for customer service is one of the trends mentioned for the nearest future by many authors (Kannan, Bernoff, 2019; Fountaine et al., 2019; Guszczka, Schwartz, 2019). AI can not only automate processes which have been carried out by humans so far, but also help to create super-stations operated by robots and super-teams based on human-machine cooperation (McIlvaine, 2019; Malone, 2018).

The studied companies plan investments in solutions facilitating the course of repeatable processes and solving the most frequent problems for the year to come. Figure 4 depicts priority investments mentioned by the respondents for the following year.

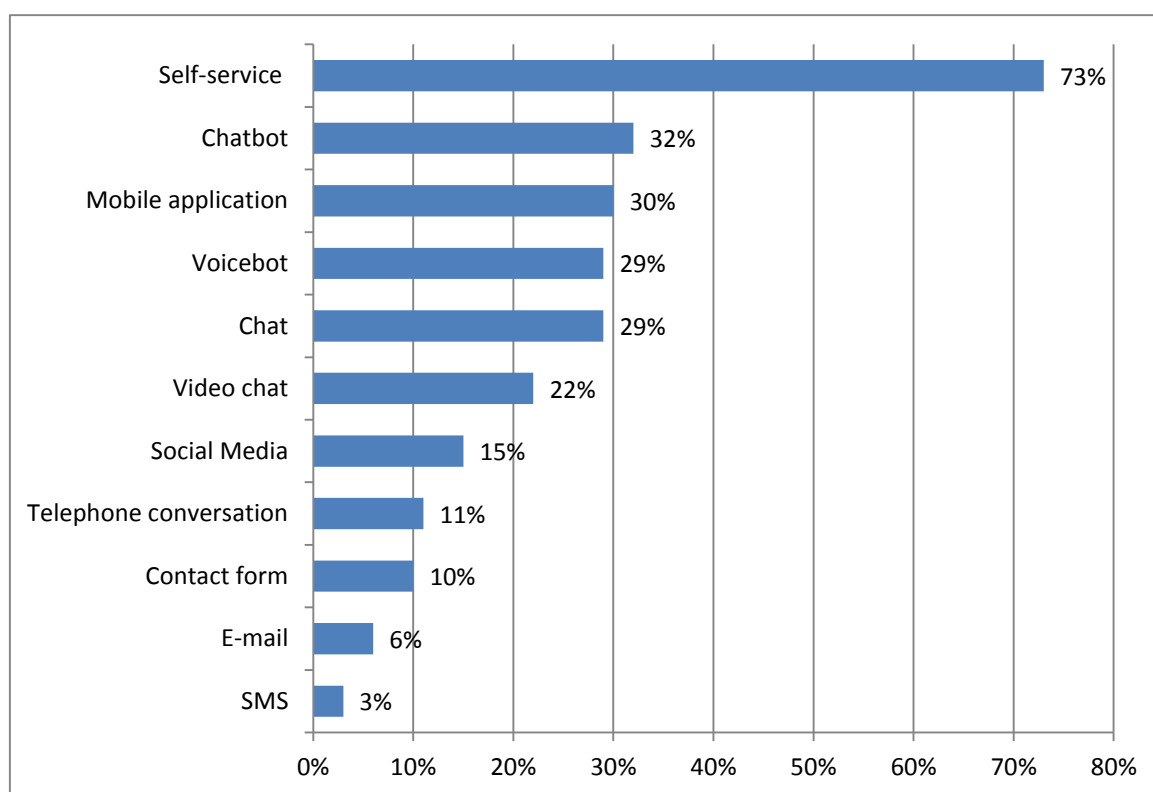


Figure 4. Priority investments in the customer service area.

Source: Report called Customer Service Excellence 2021 (2021). Study of Customer Service Departments in Poland. Deloitte Digital, p. 23.

As shown in Figure 4, self-service is the priority investment for most studied companies (73%). This service method not requiring any contact enables to submit requests and inquiries, order a product or a service, download documents (e.g. invoices, instructions, guarantees), carry out activities concerning personal data and look for products independently. The highest customer satisfaction indexes are connected with the second functionality (product ordering — 4.05) and with the last one (independent product searching — 4.0), although the latter is offered just by 25% of the analyzed companies. More than one third of the studied companies plan to invest in multichannel development, meaning mobile applications, chatbots, voicebots and video chats. Just 15% of companies intend to invest in social media. The traditional channels (telephone conversation, contact form, e-mail, SMS) were indicated as priority investment areas by the lowest percentage of respondents.

Thanks to those investments, the following effects are expected:

- shortened customers' waiting time for response (59%),
- increased customer satisfaction indexes (50%),
- reduced number of issues thanks to self-service (50%),
- reduced number of issues thanks to automation (41%),
- increased sales share (36%),
- increased number of issues solved daily (23%),
- increased number of issues started (12%).

It should be stressed that the pandemic had a major influence on the customer service method. From CSD perspective, the pandemic changed the work method from the on-site to the remote or hybrid one, and also increased demand for new digital technology. According to the surveys, before the pandemic (in 2020) 71% of customer service employees worked solely on-site, while during the pandemic (in 2021) this percentage was just 7%. More than one half of respondents (56%) indicates that the frequency of using the self-service solution by the customers increased as well.

It turns out that the customers intend to use cutting-edge channels to communicate with the company also after the pandemic. According to the surveys by Salesforce Research 2020 (State of the connected customer, 2020, p. 18), more than one half of consumers (58%) declare that after the pandemic they are going to do more shopping online, and 80% of business customers declare continued online transactions after the pandemic.

5. Discussion and conclusions

The progressing digital transformation in companies affects the marketing activities as it generates new opportunities and forms of contact with customers, enables to obtain new data types and use improved analytical methods, and creates marketing innovations. Cutting-edge digital technology and Industry 4.0 tools, including social media, omnichannel, cloud computing, artificial intelligence or augmented reality are of particular use in the customer service area. Thanks to using them, it is possible to facilitate service, improve satisfaction and loyalty of digital customers, which translates into measurable benefits of reduced marketing costs and increased sales. Digital consumers, conscious of their needs, well informed and educated, have high requirements and expect fast, efficient and customized service. The priority aspect of service for digital consumers, especially for the youngest from the generation Z, is comfort.

Implementation of cutting-edge technology and digital tools in the customer-service area is a serious challenge for today's companies as, on the one hand, it is an indispensable investment requiring significant financial expenditure, and on the other entails high risk of a misguided investment. Many authors point to a potential risk, stressing the importance of selecting the appropriate technology and solutions of Industry 4.0. This refers e.g. to contacts with customers. The studies carried out in this respect proved that using artificial intelligence (chatbots), though having immense developmental potential, has also serious limitations due to chatbot anthropomorphism.

Most Polish companies are aware of the need to invest in cutting-edge technology in customer service to satisfy the requirements of subsequent generations of digital consumers and the growing competition. Studies concerning using new technology and digital tools in the

customer service departments of Polish companies in the context of customer satisfaction level revealed that what the customers expect most is the fast and efficient service using many integrated communication channels. Unfortunately, the traditional channels, including e-mail, telephone conversation and contact forms are still predominant in most studied companies. Consequently, for most respondents the priority investment in the customer service area was the development of meta channels, i.e. self-service and mobile applications which enable to solve the issues independently and ensure easy contact with CSD using a chat and forms. More than one half of respondents plan investments in cutting-edge conversations based on artificial intelligence (chatbot, voicehot) and video. Thanks to such investments, the studied companies expect many benefits, including reduced service time, increased number of issues started and solved a day, improved customer satisfaction index and sales growth.

The analyses and conclusions presented in this article provide insights for the discussion concerning digital transformation of Polish companies in the marketing area in the context of competence and requirements of digital consumers. They have management implications as well, as they indicate advantages and limitations of using cutting-edge digital technology and tools in the customer service area.

A limitation of the studies is restricting the analysis to Polish companies and basing on secondary data without any empirical studies. However, the article may provide basis for international comparisons and inspiration to carry out further studies in this field. The studies of efficiency and effectiveness of using cutting-edge technology and digital tools in the customer service area seem particularly important from the perspective of the changing needs and digital requirements of consumers.

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PATENT AND OTHER INTELLECTUAL PROPERTY IN A COMPANY: CHALLENGES AND OPPORTUNITIES

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Purpose: Intellectual capital is a company's most valuable asset, enabling its constant development and affecting its competitiveness. The aim of this article is to present the basic rules of protecting inventions and secrets of entrepreneurships and entrepreneurs within the Polish legal system, and to indicate their value as instruments impacting on the development of a company's innovativeness.

Design/methodology/approach: The deliberations are based on the related subject literature and an analysis of the legal provisions applicable in the area under discussion.

Findings: Adequate protection of intellectual property in a company can be invaluable for obtaining market advantage by using one's own patents in the business activity, while at the same time contributing to the scientific-technological advance of the entire economy. Financial gains related to granting licences to other parties and collecting remuneration for such are also not insignificant. In this context, knowledge of the legal regulations concerning patent protection becomes crucial.

Practical implications: The challenges entrepreneurs face include the ability to use knowledge and intellectual capital in the company, implementation of innovative solutions, and knowledge transfer. For a modern company to grow while also maintaining its presence in the market, it needs to constantly improve its offer, in particular by raising its technological and quality standards. For these reasons, the importance of knowledge about the protection of intellectual property, and in particular the obtaining of patent protection, has been increasing in value in terms of reinforcing the competitiveness of economic entities.

Originality/value: The article raises the issue of managing intellectual property laws in an organisation, which is an important aspect from the entrepreneur's perspective, and has become crucial in a knowledge-based economy.

Keywords: patent, entrepreneur's secret, company secret.

Category of the paper: viewpoint, literature review.

1. Introduction

In the modern world, intellectual property rights affect the prevailing scope of a company's operations. Not only entrepreneurs, but also their employees, contractors and competitors have such rights. This article focuses on the protection of economic activity-based inventions and the company's and entrepreneur's secrets by protecting property not subject to industrial property laws.

Appropriate intellectual property in a company can have an invaluable impact on the organisation's achieving of market advantage through using its own patents in its business activity, while at the same time contributing to the scientific and technological development of the entire economy. Companies have many opportunities to use their own patents and other intellectual property. This can be done by placing new goods, processes, or services on the market, which can help to achieve competitive advantage on the market. Entrepreneurs often make their technologies available to other economic entities by granting licences, the fees from which are a source of financial gain.

It is worth emphasising that it is not always possible to protect a given good with a patent, not even by copyright. These are items of information that are not formally protected by intellectual property law but are relevant from the perspective of the entrepreneur, and whose economic value is undisputable. The possibility of protecting such data depends on the institutions of a company and the entrepreneur's secrets. In this context, knowledge of legal regulations concerning patent protection for a given solution becomes essential.

The aim of this article is to present the basic rules of protecting the inventions and secrets of companies and entrepreneurs within the Polish legal system and to indicate their value as instruments impacting on the development of a company's innovativeness.

The article is based on an analysis of legal regulations in the above-mentioned context, while taking into account the doctrine of law and case law.

2. An invention and its protection in the company

According to the definition adopted by the World Intellectual Property Organization, intellectual property is a set of laws concerning, among others, literary, artistic and scientific works; interpretations of interpreting artists and performances of performing artists; phonograms and radio and TV programmes; inventions in all areas of human activity, scientific discoveries and industrial designs; trademarks, services marks, trade names and commercial designations; protection against unfair competition; and any other laws concerning intellectual

activity in the areas of industry, science, literature and art (Convention Establishing the World Intellectual Property Organization, 1967, Article 2 (viii)).

Intellectual property rights are mostly exclusive rights to intangible property. They function in a company alongside tangible goods, and can similarly be the subject of a legal relationship and play a role in operating a business.

Among intellectual property rights, inventions and their legal protection have a special place. In accordance with Article 24 of the Industrial Property Law, patents are granted – regardless of the field of technology – to innovations that are new, exhibit a high level of innovativeness, and are fit for industrial application (The Act, 2021, Item 324).

The Polish legislature has not yet introduced a legal definition of a patent. According to the doctrine, a patent can be a state law granting the owner the right to exclude other entities from using the invention protected by such title. A patent owner can, therefore, in accordance with the law, use their own exclusive rights in order to prevent other entities from using the patented goods or innovative technological solutions (Kabat-Rudnicka, 2012).

An entrepreneur with a patent has the right to prevent any third party not having the entrepreneur's consent from exploiting their invention for profit or for professional purposes by way of performing the acts consisting of making, using, offering, or putting on the market a product that is the subject matter of the invention, or employing a process that is the subject matter of the invention, as well as using, offering, putting on the market or importing for such purposes the product directly obtained by the process (Act, 2021, Item 324, Article 66(1)).

According to Article 24 of the industrial property law, a patent for a given invention can be obtained when three prerequisites are met: It has to be new as far as the current state of the art is concerned, it has to be inventive, and it has to be susceptible to industrial application. The above prerequisites should be met jointly (VI SA/Wa 832/17).

In order for the given solution to be granted patent protection, it is necessary to ascertain whether it has a technological character. This analysis is crucial and precludes the examination of novelty, innovativeness, and industrial applicability (Turczak, 2010). “The legislator uses in Article 24 of the Industrial Property Act the phrase ‘regardless of the field of technology’, which means that the patent protection can cover inventions in all fields of technology, and the patentable invention has to have a technological character. Therefore, a constitutive feature of patentable solutions is their ‘technological character’, implicitly contained in the term invention itself” (II GSK 487/11). The determination as to whether the given solution is technological is of particular importance with respect to computer-related inventions.

The novelty prerequisite is met if an invention does not fit into the state of the art. The state of the art is everything that before obtaining priority right to patent (i.e., before the submission of the application to the Patent Office) has been made available to the public by means of a written or oral description, and also by the use, displaying or disclosure in any other way (The Act, 2021, Item 324, Article 25).

In view of the above, an entrepreneur who wishes to patent a solution sometimes faces a difficult-to-fulfil obligation to keep the nature of the solution secret, as any public presentation of the solution precludes it from falling under patent protection.

“Inventiveness means innovative significance, non-obviousness of the submitted solution. An expert means a professional from the given field, a specialist, a person working in a particular field of technology in a professional manner. If a solution is within the area of the expert, there is no inventiveness to it. Inventive creations are about overcoming technical difficulty that wouldn't be overcome otherwise” (VI SA/Wa 1327/16). It is notable that the prerequisite will not be met in the case of unremarkable small differences between the submitted solution and the state of the art. Such differences should be special, and the expert from the given field of technology who reviews the innovativeness of the solution should not be able to obtain the result submitted for protection (Mordwiłko-Osajda, 2010). The above prerequisite (as with the remaining ones) is evaluative. “Differently than in evaluation of novelty, arguments against non-obviousness of an invention can be found not only by presenting specific known solutions but also by considering the entire state of the art” (VI SA/Wa 1558/16). An established opinion in case law is that “it is sufficient for the invention to be something more than a routine knowledge of an engineer or a mechanic” (VI SA/Wa 1558/16).

An invention has industrial applicability if it is possible to use it in practice, while ensuring the safety and stability of the results (Król, 2010).

Unlike copyright protection, patent protection is formal in character. The invention becomes protected based on the decision of the Patent Office. By receiving a patent, one has the exclusive right to exploit the invention, for profit or for professional purposes, throughout the territory of the Republic of Poland (The Act, 2021, item 324, Article 63).

The right under the patent is *erga omnes*. As such, it limits the rights of the competition to use the invention within the scope determined by the patent restrictions. To use somebody else's invention, one needs to obtain the permission of the entity holding exclusive rights by entering a licence agreement.

What is important from the entrepreneur's point of view is that the very act of submitting an application for covering the given solution with patent protection results in the inclusion of information in the patent description (from the moment it is announced) to the state of the art. This gives the applicant a guarantee that no third party will be able to reserve the exclusive rights to the submitted solution.

According to the principle of territoriality, an invention for which a patent has been obtained in Poland is not protected outside the territory of this country, although the party owning the patent rights (including an entrepreneur) can extend the scope of patent protection to other countries. Such an extension can be made by using the procedures of such countries in which the party wishes to use the protection. As this requires the submission of an application in the patent offices of the given countries, such a solution will be beneficial if the entrepreneur wishes to protect the invention in a small number of countries. Otherwise, the procedure will be

complicated (as the proceedings in each office will take place based on the legal provisions in that country), time-consuming, and costly (e.g., the obligation to use a patent agent, fees for document translations). Obtaining patent protection abroad is also possible through a European procedure. The application is made directly in the European Patent Office or in the patent office of a country that is signatory to the European Patent Convention; for example, in the Patent Office of the Republic of Poland in one of the official languages (English, German, or French) (The Act, 2004, No. 79, Item 737). One can say that a European patent is a set of country patents, as the individual patents are independent of each other. The patent rights to an invention can be also reserved by the eligible party internationally through the Patent Cooperation Treaty (The Act, 1991, No. 70, Item 303).

The application is submitted at a receiving office (Patent Office of the Republic of Poland) in the official language of the International Searching Authority, which carries out a preliminary examination of patentability. This procedure is beneficial, as by applying for patent protection abroad, the applicant has more time to decide than in the countries in which the applicant wishes to obtain protection (30 months from receiving priority for submitting an application in the patent offices of individual countries).

Irrespective of the protection mode chosen by the eligible party, patent protection is always limited in time. Patent protection is valid for 20 years but can be shortened; for example, if the patent scope does not yield the expected profit. It is worth emphasising that even if the invention meets the prerequisites for patent protection, it is not always worth patenting it.

The very act of obtaining a patent does not guarantee the market success of the given solution, and the patenting procedure has to be paid for. The costs may vary between several to tens of thousands of Polish zloty, with many factors contributing to the amount, from the amount of documentation to the number of countries in which the invention is to be protected. The very process of maintaining patent protection also costs (with adequate amounts expected to be paid annually).

An entrepreneur's decision to invest in intellectual property protection should be preceded by a preliminary analysis of the benefits versus the costs incurred. One should take into consideration not only the probability of reaching the expected income, but also the aforementioned costs of obtaining, maintaining and exercising the exclusive rights protected by a patent. However, in practice, such calculation entails a high risk (Michalczuk, 2011).

3. Company's secret vs entrepreneur's secret

The term of the secret of an entrepreneur is used in Article 5(2) of the Act of 6 September 2001 on the Access to Public Information (Act, item 902, 2022), which states that the right to public information is subject to limitation based in view of the privacy of a natural person or an entrepreneur's secret. However, the Act does not introduce a legal definition of this term.

In accordance with Article 18(3) of the Public Procurement Law of 11 September 2019, information constituting a company's secret within the meaning of the provisions of the Act of 16 April 1993 on Combating Unfair Competition (The Act, Item 1129, 2021) is not disclosed if the party, upon provision of such information, states that it cannot be shared and demonstrates that the reserved information is that company's secret. The economic operator may not reserve the information specified in Article 222(5), which relates to the obligation on the ordering party to disclose information about the entrepreneur's business, the registered seats or places of business activity and places of residence of the economic operators whose tenders have been opened, as well as prices or costs included in the tenders (Ustawa, Item 1129, 2021, Article 222(5)).

The case law of administrative courts exhibits a level of ambiguity in the interpretation of the term entrepreneur's secret, which is used in the Act on Access to Public Information. One of the opinions is that the term is consistent with the term of a company's secret as defined in Article 11 of the Act on Combating Unfair Competition (I OSK 2950/14, II SA/WA 43/17). A different approach, which assumes that the secret of an entrepreneur is derived from the company's secret, as defined in the Article 11 of the Act on Combating Unfair Competition, seems to be valid. These terms, although similar but with partly overlapping scopes, cannot be considered synonymous. It is emphasised that the concept of an entrepreneur's secret should as a rule be understood more broadly. "Information becomes 'a secret' when the entrepreneur exhibits a wish to make it unknowable by the third parties. It does not, however, lose its character by the fact that a limited number of people, bound to maintain confidentiality (e.g., company employees) know it. Maintaining certain information confidential makes the entrepreneur undertake actions to eliminate the possibility of accessing it by third parties in a normal course of events, without the need to make a special effort" (I OSK 192/13). The supporters of this opinion claim that in order to consider given information an entrepreneur's secret, there is no need for a condition of the economic value of such information, as is the case for the company's secret (I OSK 511/13). It is worth mentioning, however, that in the case of the company's secret, information should have objective economic value, which does not have to be "significant, but can also be current or potential" (II GSK 3485/15). The entrepreneur's secret can be, among others, a trade secret, a formula, new substances and materials, device descriptions, or technologies that are not under patent protection (Stec, 2017).

It can be assumed from the above that the term of entrepreneur's secret is entailed in the legal definition of the "company's secret", which is included in Article 1(2) of the Act on Combating Unfair Competition (Act, Item 1913, 2020).

An entrepreneur's secret can be invoked if two prerequisites are met: a formal and a material one. The first is the obligation of the entrepreneur to undertake actions aimed at making the given information secret. Furthermore, it is accepted that the entrepreneur's secret can include only such information the publication of which could negatively affect the market position of the entrepreneur (the material prerequisite).

When an application for providing information that is an entrepreneur's secret is submitted, it is rejected by the president of the Office of Competition and Consumer Protection, based on Article 5(2) of the Act on Access to Public Information (Jabłoński, Jarosz-Żukowska, 2012). It is assumed that in the case of an entrepreneur securing confidentiality of data for which an application to provide information may be submitted in the future, such data is an entrepreneur's secret. The problem arises when the actions aimed at making information secret were undertaken at a later time; e.g., when the information became the subject of the application for their disclosure. It can be assumed that the entity receiving the application for information disclosure should determine whether such information is subject to disclosure and examine the position of the entrepreneur on that matter. The entrepreneur cannot be limited by time in the process of making information secret and may do it at a later stage of the proceedings of their disclosure (Szustakiewicz, 2021).

A "company's secret" is the technical, technological, or organisational information of a company, or other information with economic value that as a whole or in a particular set of their elements is not known publicly to people who usually handle this sort of information, or is not easily accessible to such people, as long as the entity entitled to use such information or manage it has undertaken, with due diligence, actions in order to keep it confidential (The Act, Item 1913, 2020).

As mentioned above, in order to consider information a company's secret, it has to have economic value. The information has economic value when its use by another entrepreneur will reduce financial expenditure related to the production of the goods or provision of the services, will increase profit, or will bring new customers (II SA/Wa 2406/130).

Technical or technological information is that concerning the method of manufacturing, chemical formulae, templates, and ways of operation. Information is organisational if it relates generally to the services and information with significance to the operation of the company, but is not related directly to the manufacturing cycle (Andała-Sępkowska, 2021).

In the case of a company's secret, the entrepreneur's wish to make the information secret is also necessary. The entrepreneur should undertake such efforts that make this intention clear to third parties (e.g., competitors). It is worth emphasising, however, that the entrepreneur does not have an obligation to make specific efforts in that respect. For example, it is sufficient to notify the employee about the confidential nature of the knowledge, technology, or device.

It should be emphasised that a person who has come into possession of information that is a company's secret is exempt from the obligation to maintain confidentiality (IV CKN 211/01). Whether or not the entrepreneur has met the obligation of undertaking the necessary actions in order to maintain the confidentiality of the information is assessed considering all the circumstances of the case. One should consider, among other things, the organisation of work, the people carrying out specific tasks, or their qualifications (I CKN 1159/00).

Making data a company's secret limits the right to public information and protects the right of the entity that owns it before it is made public. Such information is economically significant for the operation of a specified entrepreneurship, and therefore, the entrepreneur may wish to maintain its confidentiality. The entrepreneur can, however, at any time waive their right to protection of information that is important for the company. Therefore, in order for the protection of the entrepreneur's rights to be successful, the restricted information cannot be shared publicly (Zdunek, 2016). In accordance with Article 11(4) of the Act on Combating Unfair Competition, one cannot restrict information that is publicly available; for example, data disclosed in the KRS or CEIDG registers or in such a way that every interested party can legally possess knowledge (I CKN 1159/00).

“Registering information as a secret is an exception from the rule of transparency, and for this reason a public sector entity cannot rely solely on an entrepreneur's statement about its existence, but should independently perform an assessment of the application submitted by the entrepreneur, verifying the existence of a company's secret within the meaning of the provision of the Act on Combating Unfair Competition” (II SA/Wa 1483/12). The entity bound to disclose information can include restricting that information after verifying whether the restricted information meets the prerequisites of the company secret within the meaning of Article 11(4) of the Act on Combating Unfair Competition. “If, as a result of verification, it turns out that the restricted information does not constitute a company secret, then the declared restriction becomes invalid” (II SA/Wa 1483/12). In order to consider the given information a company secret, it is thus necessary to separate out from the data set the data to be made confidential (Szustakiewicz, 2021).

In summary, a company secret is a broader term than the entrepreneur's secret. As a rule, every secret of an entrepreneur is a company secret, but not every company secret is an entrepreneur's secret.

Undoubtedly, the advantage of the discussed measures is the fact that, unlike patent protection, keeping information confidential is not limited by time. There is also no rule of territoriality, and the entrepreneur obtains an exclusive right to use the classified information not only in the territory of the Republic of Poland.

On the other hand, however, there is always the risk of disclosure of the classified information, irrespective of the entrepreneur's will. This can result in unlimited access to information that is valuable from the perspective of the organisation. This is the risk the entrepreneur has to cope with if they obtain a patent for the invention. Although the nature of

the invention is obligatorily disclosed, the right to exclusive use of the patented solution belongs only to the patent holder (Turczak, 2010).

4. Conclusion

In a knowledge-based economy, intellectual goods play a crucial role in the market success of an organisation. One cannot agree with opinions that diminish their value with respect to the innovative advantage of companies (Szewc, 2014). Proper intellectual property protection allows entrepreneurs to gain a strong position in the market, thus gaining advantage over the competition. Patent protection ensures additional profit from granted licences and transfer of rights. It ensures certainty of turnover, providing the subject with exclusive rights to tools allowing them to undertake actions against infringements of protected goods regulations.

A challenge lies in creating a system of intellectual property law protection that is optimal for the development of a business entity. It is undisputable that the most beneficial is the medium level of protection, and any deviations (too weak or too strong protection) are detrimental from the perspective of innovativeness (Chęcińska-Zaucha, Gródek-Szostak, Kajrunajtys, 2017).

The basic form of intellectual property protection is formal protection (among other things, obtaining a patent for an invention). It should be emphasised that proceedings at the Patent Office are time-consuming and costly and are not risk-free, as the act of obtaining a protective title for the given solution does not always guarantee its commercial success. Moreover, not every creation meets the requirements for patent protection.

One should also consider the value of other possibilities for the protection of exclusive rights in a company, including especially the company secret and the entrepreneur's secret. They allow for ensuring confidentiality of, among others, technical, technological or organisational solutions, without the need to go through complicated legal procedures and without additional financial expenditure.

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RESEARCH ISSUES IN PROGRAMME MANAGEMENT: A SYSTEMATIC REVIEW OF LITERATURE

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Purpose: The aim of this article is to provide a systematic review of empirical research in the area of programme management, to recognise research patterns relating to the methods and techniques used and to identify current research issues.

Design/methodology/approach: A systematic review of 39 selected articles published in project management journals was used to achieve this objective. The research potential was classified under three areas, including context, knowledge management and competencies and processes initiated in the programme life cycle.

Findings: The authors acknowledge the shortcomings of the research process conducted, which are mainly due to the decisions made regarding the methodological approach. Firstly, the research focused only on empirical articles directly related to the programme. There may be studies using other terminology for the word "programme". Secondly, the analysis focused only on articles published in prominent project management journals. Thirdly, the scope of the selection of publications was limited both to the word "programme" in different variations and to the assumption regarding the timeliness of publications (not earlier than 2010).

Research limitations/implications: The needs of current research issues in the area of programme management were defined, identifying 21 potential knowledge gaps that could serve as a starting point for further in-depth research.

Originality/value: The article is addressed to scientists and practitioners, presenting the current research issues in program management.

Keywords: Program management, program context, program value, competences, program integration.

Category of the paper: Literature review.

1. Introduction

Over the past 30 years, programmes have evolved from extensions of projects or unmanaged entities into mechanisms for integrating and coordinating strategic activities to drive transformation and change targeted by business benefits. Standards have also emerged

(PMI, 2017; PSP, 2014) distinguishing programme management from portfolio and project management. Current literature shows that project management is a widely known and understood area (Ozmen, 2019), although it is still subject to development resulting from the adaptation of organisations to changes in the environment and new trends in management. On the other hand, the notion of programme is still ambiguous (Pellegrinelli, 2011; McGrath, et al., 2019) and in business practice it is most often used interchangeably with the notion of project, especially strategic project (Lycett et al., 2004). As a consequence, organisations manage programmes like projects, which usually leads to a failure to meet the required expectations (Shao et al., 2012).

By reviewing the literature in terms of the characteristics that a programme should have, it can be assumed that it is a group of interrelated projects (Shao et al., 2011) that share a common pool of resources (Martinsuo et al., 2018; Frederiksen et al., 2021), aim to achieve business benefits in a coordinated way (Breese et al., 2015; Fernandes et al., 2021) and are managed by the programme organisation to achieve one or a set of strategic objectives (Angus, Kittler, 2012; Miterev et al., 2020). The purpose of a programme is to deliver outcomes and benefits related to the strategic objectives of the organisation (Sanchez et al., 2009). From a programme management perspective, the outcomes delivered by projects are only a pathway to what the programme manages. The programme "looks" from the perspective of achieving a certain state, a benefit, through the use of projects results (Levin, 2016). The programme's orientation is to realise benefits through the outcome achieved, not to deliver the outcomes themselves (PMI, 2017; PSP, 2014). It should be emphasized that programme management does not replace project management, which should be effectively implemented at its own level (Martinsuo, Hoverfält, 2018). The authors define the result as the effect of change, having an impact on the real situation and/or circumstances occurring in the company or its environment. The result, on the other hand, is a tangible or intangible product created as a result of a planned activity.

Programme management encompasses activities undertaken to coordinate the organisation, direction and implementation of a set of projects that together lead to strategically important outcomes and benefits. Ritson et al. (2012) highlight that successful programme implementation will in practice be an elusive concept that requires flexibility in terms of strategic and environmental adaptation, thus drawing attention to aspects of developing strategic plans for their approval and management. Van Buuren et al. (2010) and Görög (2011) emphasise that identifying the most problematic areas in programme management leads to the identification of those interrelationships that link a group of projects as one programme during implementation. Programmes deal with outputs and projects deal with outcomes. Programme management and project management are complementary approaches. During the programme life cycle, projects are initiated, implemented and closed. The programme provides an umbrella under which projects can be coordinated.

The aim of this article is to provide a systematic review of empirical research in the area of programme management, to recognise research patterns relating to the methods and techniques used and to identify current research issues. The authors aim to identify current trends by revealing research opportunities for the future direction of programme management research. Given that programmes come in different forms and involve different contexts (Boppel et al., 2013; Martinsuo, Hoverfält, 2018), the analysis conducted focuses attention only on empirical articles.

2. Method and overview

The study involves a systematic literature review of published empirical research on programme management practice. Unlike traditional reviews, a characteristic of the systematic review method is that the entire process of literature acquisition, assessment and synthesis is carefully documented and follows strict standards (Tranfield et al., 2003).

First, a list of scientific journals in the field of project management was compiled. Subsequently, using the keyword "programme" defined by the title, abstract or keywords and an assumption regarding the timeliness of the publication (not earlier than 2010), a preliminary literature of a total of 261 articles was retrieved for further analysis. The titles and abstracts of the publications were then reviewed in a full search. Only those articles that directly addressed programme management issues (56 in total) were considered for further analysis. However, some of the articles rejected at this stage were taken into account in developing the conceptual framework for this article. In addition, articles that dealt with programming or a specific programme (development, training, government, research programmes) or that appeared comma-delimited in a general nature were deliberately excluded.

In line with the process of systematic literature analysis (Booth et al., 2012), following a search that was full within the stated assumptions, additional steps were taken to complete the list of programme management studies. For this purpose, other publications that would discuss the use of programme management were analysed. The search additionally identified 39 publications of which 7 met the above criteria.

Following a selection process (analysis of full texts), the actual literature analysis focused on a total of 39 publications, which were grouped into three areas covering programme context, knowledge management and competences, and processes initiated during the programme life cycle.

3. Results and discussion

3.1. Programme context

The literature emphasises the role of programme context. Lycett et al. conducting a critical analysis of the literature stated that "an effective approach to programme management should be dynamic and flexible, adaptable to changing context and relationship-based" (Lycett et al., 2004). Subsequently, Pellegrinelli et al. conducting a study of 6 programmes through interviews and study visits observed that contextual factors often attract a lot of attention and effort from programme managers, causing them to compromise and reshape the programmes they manage (Pellegrinelli et al., 2007). The authors defined programme context as: "the dynamic cultural, political and business environment in which a programme operates" (Pellegrinelli et al., 2007). Shao et al. (2009) then hypothesised a preliminary research model on the relationship between programme manager leadership competencies and programme success. As a result of their interviews, they developed constructs for program context and program success while confirming the validity of the hypothesis. In addition, they also found that the constructs of programme context include its typology, scope and characteristics (Shao, 2018). The above observations were also confirmed by Näsholm and Blomquist (2015) when analysing the 2014 European Capital of Culture Programme in Umeå. Subsequently, Shao et al. proposed four dimensions of programme context, namely: organisational fit, programme flexibility, organisational stability and resource availability (Shao et al., 2012). They also found that programme context does not directly relate to programme success, but there is a more complex relationship between three variables: leadership competencies of programme managers, programme success and programme context.

Table 1.

Summary of empirical research to date in the area of programme context

Author	Research method	Research context	Potential for further research
[30]	Case study: Transition and merger programme of an Australian telecommunications company	Applying programme management practice to the strategic management of initiatives such as mergers and acquisitions	Application of programme management in the context of acquisitions and mergers in the SME sector.
[49]	Survey research: 119 people involved in delivering construction programmes in the UK. Interviews: 7 interviews with people involved in delivering programmes outside the construction industry	Challenges facing the management of the construction programme	Further research into the challenges facing programme management in other industries. Verification of identified challenges in wider international studies.

Cont. table 1.

[17]	Case study: Shanghai urban major infrastructure development programme	Program management organization maturity integrated model for MCPs	Conduct verification of the developed model. Assess the maturity of programme management.
[46]	Interviews with 15 programme managers from different industries and countries	Develop a construction of the programme context and programme success.	Conduct research on a large international sample to develop constructs for the context and success of the programme
[43]	Survey research: 110 programme and project management professionals. Interviews: 6 programme management experts.	The authors have explored the development of a program management alignment theory.	Understand the impact of structural, incremental and contextual learning. Identify effective practices and approaches that support effective programme design.
[47]	Survey of 172 persons involved in project implementation under the programmes	Development of key measures of programme success	Identify measures, areas, models for evaluating programme success in different contexts
[42]	Case study: Flood protection programme in the Netherlands	Opportunities to use programme management for effective planning and implementation of mega-projects	Carry out wider research into the development of appropriate approaches to programme management.
[29]	Case study: European Capital of Culture 2014 programme in Umeå	Exploring co-creation as an alternative strategic approach to programme management	Co-creation as an alternative strategic approach to programme management in different programme contexts.
[18]	Case study: New product development programme in the machinery manufacturing industry	Program impact management in a real-life R&D context.	Are the advanced performance measures and the collective processes of sensemaking - related to them -supplementary or complementary to each other?
[28]	Case study: Spatial change programme at media company Media Inc. Observation of 9 programme board meetings	Define dominant discursive patterns through which context is constructed.	Identify ways of constructing the context of a circumstance-dependent programme especially in the context of a programme group.
[8]	Case study: IT programme "Omega" adapted to Agile methods. 12 interviews with 24 people. 277 pages of reports	Establish coordination mechanisms for teams working with an agile approach	Mechanisms and modes of programme coordination and their adaptation to the context
[52]	Case study of 5 IT programmes implemented by German organisations internationally active in ICT, industry and consumer electronics	Challenges in IT programme management. Development of recommendations for IT programme management.	Management and operation of IT programmes.
[59]	Case study: China National Programme N (hydraulic structures)	Determinants of timely decision-making from the perspective of collaboration network dynamics.	Behavioural dimensions of programme decision-making and the impact of collaborative dynamics on decision-making effectiveness in different programme contexts.
[19]	Case study: Public cultural programme Aarhus 2017	Exploring value creation in cultural programmes	Deeper exploration of the use of logics associated with entrepreneurship in project decision making.

Cont. table 1.

[21]	Case study: Multi Water Works (MWW) programme of the Dutch Ministry of Infrastructure and Environment	Study on stakeholder co-creation of programme value	Research on dynamic, context-dependent value processes in programs, with a special emphasis on transitions between different program phases.
[24]	Interviews with 21 experienced project management practitioners from various industries and disciplines in Australia	Establish appropriate terminology for the duration of the programme and distinguish it from the project and portfolio.	Identify the boundaries between programme and project and portfolio.

Although programme management practice provides the means for strategic management (Nogeste, 2010), the empirical studies presented in Table 1 illustrate the need to adapt approaches, methods, tools, mechanisms to the programme context (McGrath, Whitty, 2019; Teubner, 2018). As highlighted by Rijke et al. (2014) high programme performance is achieved by adapting to contextual changes. Moreover, programme success cannot be attributed to effective programme management alone, but also to the contextual changes that have positively influenced it.

Programmes have both deliberate and emergent strategies that require designing, organising and managing them as complex adaptive systems (Ritson et al., 2012). As the authors Jia et al. (2011) recognise, emerging issues arise from the management of programme organisation and processes. Näsänen and Vanharanta (2016), observing 9 meetings of spatial change programme boards at media company Media Inc. indicated that a temporary organisation whose hierarchical position is ill-defined, and which operates within the established hierarchical structure of a permanent organisation, seems to constantly negotiate the division of labour between permanent and temporary organisations. Consequently, successful programme implementation will require flexibility in strategic and environmental adaptation (Ritson et al., 2012). Whereas in the environmental aspect, it becomes crucial to balance the dilemmas of multiple stakeholders (Näsholm, Blomquist, 2015), which not only enables understanding and extending the impact of the programme (Laine et al., 2016), but also contributes to faster decision-making (Wen et al., 2018). On the other hand, in the strategic nature, there should be a balance regarding performance and strategy that enables adaptation (Rijke et al., 2014) while at the same time a flexible programme organisation with guiding values and criteria for balancing different projects that can be used to achieve programme objectives (Näsholm, Blomquist, 2015).

In the articles analysed, case studies were the predominant research method. Considering the contextual nature of the programme, it seems appropriate to use such a method. However, many studies suggest verification of theses, hypotheses or developed models on a larger sample and in different contexts. The main research gaps identified in this area include:

- Identify the boundaries between programme and project and portfolio.
- Management and operation of IT programmes - development of consistent guidelines for the management of IT programmes.
- Programme coordination mechanisms and modes and their adaptation to the context.
- Identification of ways to construct a programme context depending on circumstances especially in the context of a programme group.
- The application of programme management in the context of acquisitions and mergers in the SME sector.
- Behavioural dimensions of programme decision-making and the impact of collaborative dynamics on decision-making effectiveness in different programme contexts.
- Research on dynamic, context-dependent value processes in programmes, with particular emphasis on transitions between different programme phases.
- Assessment of programme management maturity.
- Understanding the impact of structural, incremental and contextual learning.
- Identify models for evaluating programme success in different contexts.

3.2. Knowledge management and competencies in programme management competencies

Research on programme management competencies has been carried out for many years (Partington et al., 2005; Pellegrinelli, 2002; Thiry, 2002) which concluded that the competencies a programme manager should have are different from those of a project manager. Furthermore, experienced project managers should not perform the role of programme manager. For example, Partington et al. (2005) performing a multi-organisational study of programme management competencies observed that experienced project managers who have been promoted to the programme manager role tend to reproduce project approaches and environments. As Shao and Müller (2011) point out Project management principles can be an obstacle to higher level programme management concepts. Project managers primarily focus on short-term tactical results based on project performance indicators (time, cost, scope, quality). Program managers, on the other hand, focus on long-term business results based on the achievement of the set outcomes and the realization of business benefits. These differences lead to different competency requirements. A comprehensive programme management competency framework was developed by Parington et al. (2005) and Pellegrinelli (2008) and included in the standard "MSP - Managing Successful Programmes" (MSP, 2014).

As Crawford (2005) points out, competence is a broad concept covering not only people's basic personality traits or skills, but also knowledge issues and knowledge management. The study and use of knowledge is needed in a turbulent environment. Where a programme is not just a coordination mechanism for relatively independent projects, but an organisational mechanism for achieving a major strategic goal or change, its component projects need to be managed as much as possible to achieve both adequate performance and the use of existing knowledge (Pellegrinelli et al., 2015).

Table 2.

Summary of empirical research to date in the area of knowledge management and programme management skills

Authors	Research method	Research context	Potential for further research
[16]	Case study: Analysis of 6 different programmes in different sectors	Transfer of knowledge from single project management to programme management	Indicate features that distinguish programme from project and portfolio
[33]	Interviews with 98 programme participants from 38 IT outsourcing providers located in India	Assess the impact of interdependence in the program environment to achieve collective success.	Structuring management competencies to increase programme performance by promoting collaborative behaviour
[12]	Survey of 69 mega-project managers employed by oil and gas companies	Exploring the impact of information sources used by project managers on the strategic value delivered by the programme.	Develop an information management system focusing primarily on supporting the programme manager's decision-making process
[40]	Case study: An organisational change programme for an Australian finance and insurance sector organisation	Knowledge management and organisational change programmes for an ageing workforce.	Matching different project management approaches to different contexts.
[51]	Case study: Panama Canal Expansion Programme (PCEP)	Ways in which programme partners respond to contractually agreed cooperation	Exploring social phenomena in project management in different contexts.
[11]	Case study: 12 telecoms deployment programme managers in a multinational company in the UK	What are the mechanisms for, drivers of, and barriers to programme-based learning	Conduct research on the impact of different cultures and market sectors on programme-based learning.
[14]	Case study: A programme to design and deliver a large-scale integrated information system for the public sector	Its purpose was to investigate whether shared understanding existed amongst those working together to develop the system.	Development of consistent guidelines for IT programme management
[37]	Case study: Business transformation programme. Retail bank	Facilitating organizational ambidexterity through the complementary use of projects and programs.	Understand the limitations and contextual factors involved in their complementary use in change processes.
[26]	Case study: 10 programmes of different size, complexity and phase in the life cycle implemented in a pharmaceutical company	Programme management competence survey	The impact of programme contextual features on competence areas.
[45]	2 survey questionnaires to 79 programme managers	The moderating effect of program context on the relationship between leadership competences of program managers and program success.	Exploring the fit between competencies and different types of programmes and their contexts.
[10]	Case study: Construction programme, 23 people involved from 6 companies	The purpose of this paper is to determine the extent to which service design (SD) is addressed by the client and its supply chain at a program level into one functional capability, knowledge management (KM), to share knowledge across projects and organizational actors.	Research on knowledge management at organisational level.

The empirical studies presented in Table 2 highlight the role of managerial competency models in the context of programme management, which must explicitly include programme characteristics. Moreover, different types of programmes will require different management styles (Pollack, 2012) and competency sets (Miterev et al., 2016). Although, as Fortune et al. point out, strategic awareness cannot be assumed to exist, even at high levels of the organisation (Fortune et al., 2015). It is important to note that the decisions of programme project managers have an impact on the value of the assets delivered by the programme (Eweje et al., 2012), thus generating a kind of area of uncertainty that may affect the long-term success of the programme. Similar observations have been observed by Shao (2018) stating that the relationship between programme manager competencies and programme success is moderated by the programme context. Moreover, a programme manager's intellectual and managerial competencies play a more direct role in success compared to emotional competencies.

Given this and the insights of Duryan and Smyth (2019), senior management needs to develop a holistic approach to implementing knowledge management, which should be seen as a programme management capability that needs investment, leadership and robust human resource management processes. Moreover, the identification of the most decisive problem areas experienced in programme management leads to the identification of those interrelationships that link a group of projects as one programme during implementation (Görög, 2011).

The main research gaps identified in this area, among others, include:

- Structuring management competencies to increase programme performance.
- Development of an information management system focusing primarily on supporting the programme manager's decision-making process.
- Exploring social phenomena in project management in different contexts.
- The relationship between organisational culture and programme benefits management while considering the embedding of business change in organisational culture.
- Understanding the limitations and contextual factors associated with their complementary use in change processes.
- The impact of programme contextual features on competency areas.

3.3. Processes initiated in the programme life cycle

A programme, like a project, has a life cycle, although it is more complex than for a project it still clearly defines the structure and sequence in which the programme should be implemented. The programme life cycle aims not only to meet the needs of corporate governance but also to deliver the expected benefits in a predictable and coordinated way. Corporate governance is understood as the process by which an organisation directs and controls its operational and strategic activities and, by which an organisation responds to the legitimate rights, expectations and desires of its stakeholders (PMI, 2017). If the programme is

to succeed it will require a governance that is understandable and open to change (Ritson et al., 2012), which provides appropriate guidance and tools for the processes initiated within the programme. In this regard, it is important to ensure that appropriate mechanisms are in place to integrate the programme into the normal business operations of an organisation (Vuorinen, Martinsuo, 2018; Turkulainen et al., 2015).

The empirical research presented in Table 3 focused primarily on processes such as managing benefits, risk, integration, value and programme organisation.

Table 3.

Summary of empirical research to date in the area of processes initiated in the programme life cycle

Authors	Research method	Research context	Potential for further research
[57]	Case study: Amsterdam metropolitan region (Defining the programme)	The level of integration on the three aspects of content, organization and processes will be the outcome of a dynamic interplay between project forces and program interventions.	Interaction between programme management and project management as a cooperative way of creating value
[2]	Case study: 5 departments responsible for 80% of public sector capital infrastructure spending in the UK	Identification of risks shared or reinforced by the implementation of the programme	Recognition of typical programme risks independent of its context.
[1]	Case study: 2 information system based change programmes in the UK	Programme structure as a dimension of programme strategy within the context.	Verification of the developed uniformity-authority matrix based on structural contingency theory.
[5]	Case study: Programmes of regeneration of neglected sites in the north of England, mainly funded by the UK government	Determinants underlying benefits management that have practical implications and must be taken into account in the development of BRM theory.	The link between organisational culture and the management of programme benefits while considering how business change is embedded in organisational culture
[50]	Case study: Guangzhou 2010 Asian Games	Verification of the developed approach to assess supply risk	Programme risk management and identification of effective risk measures, typical risk areas found in a given programme context.
[56]	Case study: Operational expansion programme at Neste Oil. Expansion of operations to include 4 new factories	An empirical examination of integration in the context of a global operational expansion programme	Conducting research on external integration across formal organisational boundaries
[58]	Case study: 2 programmes (Local government public sector organisation and Medium sized private sector company)	Investigate the programs actors' use of integration mechanisms and agency in program integration in different change programs.	Further research on programme integration in different programme contexts. Conduct quantitative research on the competencies and knowledge areas of programme managers
[9]	Case study: Infrastructure programme of a large public sector PBO	The purpose of this paper is to address hierarchies in a large program of projects.	Programme knowledge transfer and the impact of cultures and market sectors on programme-based learning.
[27]	Case study: A programme in the Swedish transport sector.	The interplay between organization designs and value processes in the context of programs.	Identification and verification of dimensions of programme organisation in different contexts.

Cont. table 3.

[13]	Case study: Collaboration Programme of collaboration between Large universities and industry (UIC) implemented by the University of Minho and Bosch Car Multimedia Corporation and co-funded by the Portuguese government.	Present a structured framework to support benefits management in university-industry collaborative programmes.	Modelling the benefits management process in different programme contexts. Quality management in programmes and the social impact of programme implementation
[15]	Case study: A building programme involving 40 building projects within a typology of schools and childcare facilities.	The considerations and choices available to a programme organisation when confronted with multiple institutional logics.	Identifying the conditions in which organisational spaces can emerge that protect the actors involved from the dominant institutionalised prescriptions and allow them to move away from conventional ways of doing things.
[55]	Interviews with 21 energy industry experts	Verification of the programme management areas subject to the monitoring and control process and identification of the methods, techniques and tools used in this process	Carry out in-depth research into the methods, techniques and tools used in the programme management process

Benefits management identifies a set of key activities to be performed, with a clear set of controls, inputs, outputs and resources (Fernandes, O'Sullivan, 2021). The more ambiguous and uncertain the benefits are, the more important it should be to focus on them and address the assumptions and risks that may affect their realisation (Breese, 2012). Moreover, one of the elements that distinguish a programme from a project is precisely the process of benefits management, which is carried out in parallel to the process of delivering results by the projects that comprise it. As highlighted by Shi et al. (2014) effective programme management is not possible without effective risk management. Moreover, the competencies required to structure programme risks must be different from those needed to deal with the risks of a single project (Aritua et al., 2011).

Miterev et al. (2020) defined program value as „perceived ability of a product, service or system to meet the target user/stakeholder needs”. The authors also emphasise that as a result of different shapes of programme organisation, different value creation processes are possible. The above considerations are also confirmed by van Buuren et al. (2010) additionally drawing attention to the interactions between the programme and the projects included in it, which also create value creation.

The effective and efficient implementation of a project programme is made possible by making appropriate decisions based on reliable information and a flexible management regime (Trzeciak, Jonek-Kowalska, 2021). Programme organisation represents the key elements of the organisation, understood as a hierarchy of organisational relationships necessary for effective programme management. Appropriate programme organisation means clearly defined and

described roles, unambiguously assigned responsibilities for these roles, and a governance structure that is appropriate to the type, size and complexity. Moreover, the strategic choice of centralising or decentralising the programme structure should depend on the level of authority of the programme sponsor and the level of homogeneity of business processes in the participating organisations (Angus, Kittler, 2012; Duryan, Smyth, 2019).

The main research gaps identified in this area, among others, include:

- Modelling the benefits management process in different programme contexts.
- Programme risk management and identification of effective risk measures, typical risk areas found in a programme context.
- Programme integrity process (internal, external) taking into account competencies and knowledge areas.
- Interaction between programme management and project management as a cooperative way to create value.
- Quality management in programmes and the social impacts resulting from programme implementation.

4. Conclusions

The study presented in this paper, which includes a systematic literature review of 39 selected publications, has a theoretical contribution. The value brought to the literature focuses on two main contributions. Firstly, current research trends relating to context, knowledge and competencies and processes initiated in the programme life cycle were identified. Secondly, the needs of current research issues in the area of programme management were defined, identifying 21 potential knowledge gaps that could serve as a starting point for further in-depth research.

The analysis of the research patterns relating to the methods and techniques used indicated that in the vast majority a single or longitudinal case study is used for the study. Taking into account the characteristics of the operation of the programmes, it seems reasonable to use this method. However, many of the analysed articles simultaneously emphasise the need to conduct large cross-sectional studies using both qualitative and quantitative methods. Moreover, there is also a need to extend the articulated research in different programme contexts.

The authors acknowledge the shortcomings of the research process conducted, which are mainly due to the decisions made regarding the methodological approach.

Firstly, the research focused only on empirical articles directly related to the programme. There may be studies using other terminology for the word "programme".

Secondly, the analysis focused only on articles published in prominent project management journals.

Thirdly, the scope of the selection of publications was limited both to the word "programme" in different variations and to the assumption regarding the timeliness of publications (not earlier than 2010).

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ARTIFICIAL INTELLIGENCE MODELS SUPPORTING ECONOMICAL DECISIONS COMPARED TO TRADITIONAL DECISION MAKING STRATEGIES IN THE EXAMPLE OF STOCK MARKET

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Purpose: Analysis available solutions and artificial intelligence model proposals supporting stock market decisions.

Design/methodology/approach: Analysis of technical and mathematical techniques for stock market investments. Determining the chart movement for the company over the short term.

Findings: Currently, there are many mathematical and technical solutions that effectively help investors with decision-making. The model is able to obtain information about the direction of the stock price (whether it is rising or falling) for a very short period of time.

Research limitations/implications: further development of the Long Short Term Memory model and analysis of the development of existing tools.

Practical implications: Proposing various methods of analyzing the stock exchange, so that they can help in making decisions. Proposing your own model to support stock market investments.

Social implications: Plenty of investors, consequently a large group of recipients.

Originality/value: Stock market analysis, both mathematical and technical. Moreover, a proposal of your own neural network.

Keywords: neural network, stock market prediction, investment management, technical analysis, mathematical analysis.

Category of the paper: Research paper.

1. Introduction

Investing in stock markets is not only a popular and sufficient way of earning money but it is also a determinant of company's prestige. If a company has its stocks in the market it is considered successful. Successful investors on the stock exchange primarily approach the subject of finance with cold blood and distance, and the basic goal of each stock exchange is "to buy cheap and sell dear". Determining the trend line is one thing, the problem arises when you need to know the line patterns in stock charts. Playing on the stock exchange is facilitated by mathematical models developed by experienced brokers, including the RSI indicator, the ROC change indicator, CCI and stochastic oscillators, or the MACD curve (Anghel, 2015). These models, when used properly, are able to facilitate the game on the stock exchange for the average representative of the society, however, they do not guarantee the absence of losses or revenues. In addition, the paper proposes an Long Short-Term Memory (LSTM) model for predicting stock market price. Long Short Term Memory is a specialized RNN. LSTM network can learn long term because this model use of a mechanism called gate. Consequently, this model was proposed to predict stock market prices. the model predicts the direction of the action for a short period. Future work on the project aims to develop the network to the state of predicting very low stock prices.

2. Stock a Market Analysis

The subject of voting is very common with society, we have contact at every stage of life, and at the same time it is related to the progress of its spheres. The basic operations on the accounts are performed by the given operation The world of finance and economics, we introduce ourselves and complexes. Every day new transactions, directions of development and movement in the company. Due to the high complexity of blocking metals on the stock exchange, whether it is to ensure a fairly high, it is possible without the possibility of introducing a broker. The continuous development of technology and the situation on the stock market additionally increases this threshold. Initial investors are terrified of the stock of knowledge that the beginning will be taken after treat only with a treat. Despite the many difficulties and problems they have, it is difficult to find a location on the stock exchange, you will not be discouraged. According to the data from the analysis carried out ("The analysis of stock market investments in the us", 1999-2021) the share of people participating in the session on the US stock exchange in the years 1999-2020 is more than half. The result analysis is showed on the figure 1.

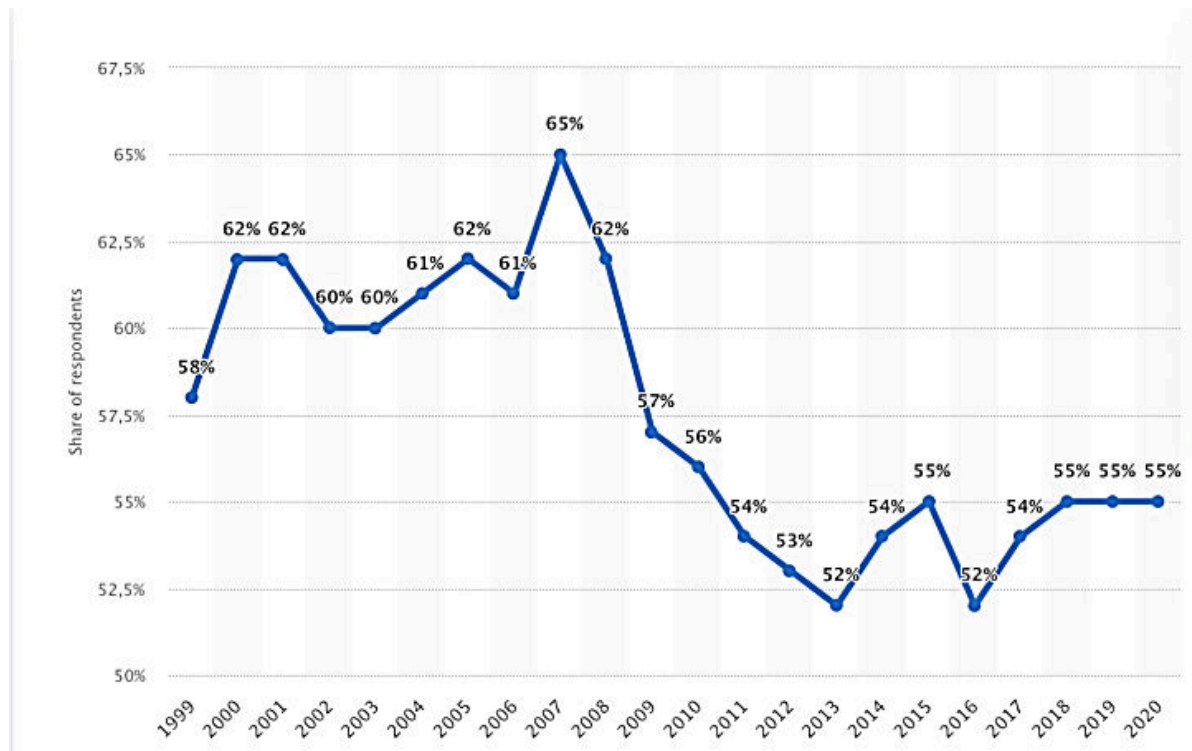


Figure 1. The analysis carried out by Statista.com about the share of people participating in the session on the US stock exchange in the years 1999-2020.

Source: The analysis of stock market investments in the us 1999-2021.

Stock prices are influenced by many factors, so predicting future prices is difficult and investments can be risky, therefore a wide area of research is predicting future stocks in the stock market. Investors must acquire not only basic knowledge about the companies in which the stocks want to invest, but also learn the basics of economics. In addition, they must learn how to draw a trend line and determine whether it is falling, upward or without clear directions of changes, what is the support and resistance point, they must understand the dependence of the price on the trading volume, so as not to make an investment mistake from the very beginning. Successful investors on the stock exchange primarily approach the subject of finance with cold blood and distance, and the basic goal of each stock exchange is "to buy cheap and sell dear". Determining the trend line is one thing, the problem arises when you need to know the line patterns in stock charts. Playing on the stock exchange is facilitated by mathematical models (Nti et al., 2019) developed by experienced brokers, including the Relative Strength Index called RSI indicator (Alhilfi, 2019), the The Price Rate of Change (ROC change indicator), Commodity Channel Index (CCI) and Stochastic Oscillators (Wu et al., 2015), or the Moving Average Convergence Divergence (MACD curve). These models, when used properly, are able to facilitate the game on the stock exchange for the average representative of the society, however, they do not guarantee the absence of losses or revenues.

One of the approaches to investing is so called technical analysis (Graham, 2006; Murphy, 2006). It bases on analyzing candlestick charts or bar Open-high-low-close charts (OHLC chart). Every candle is composed of a body and a knot. The body is either black when the price

is descending and white when its ascending. The color is important because white candles should be read from the bottom to the top whereas black candles should be read from the top. The ends of the candle inform about the opening price. The presence of a knot informs whether the price was above or below the opening value.

The simplest candle formations (Lempart et al., 2013; Bulkowski, 2011) are single figures doji or marubozu. Doji in general is the knot with a thin body. There are four types of doji star, longleg doji, gravestone doji and dragonfly doji (fig. 2). Marubozu is in fact just the body of the candle it can be black when the price is descending or white when it is ascending. Candles occurring one after another are creating a candle formation. The formations are informing whether the current trend is going to continue or is it being reversed. That is why knowledge about candle formations are the key to make an accurate investment (fig. 2).

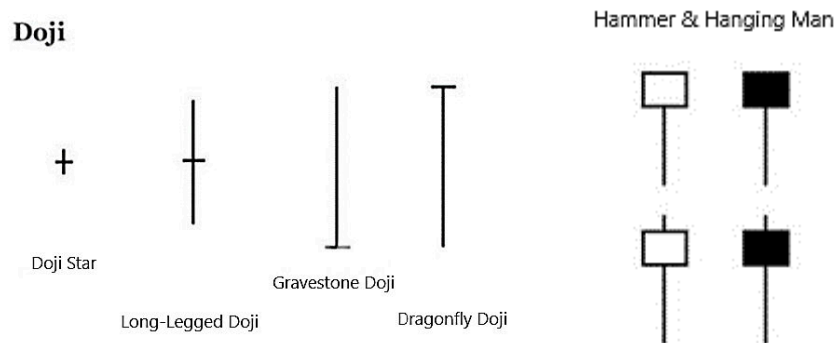


Figure 2. Example of doji and candles.

Source: Measuring and managing market risk.

Doji with a square marubozu is called the hammer when the marubozu is black and the hanging man when marubozu is white. It informs about reversing the trend. An example of more complex formation is the formation of three white soldiers or its opposite the three black crows (fig. 3). It often appears after consolidation period or a correction as three candles with the closing price higher at every candle. This formation informs about continuation of the trend.

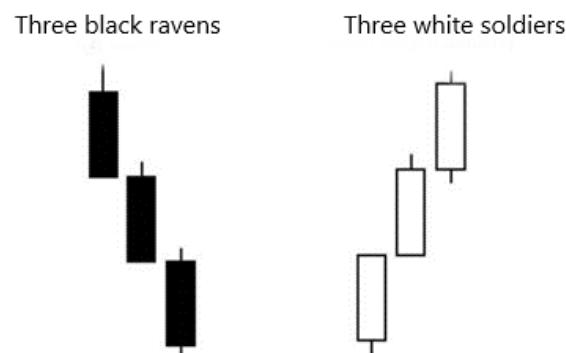


Figure 3. Architecture of Long Short Term Memory.

Source: Edukacja giełdowa.

A formation even more complicated than three white soldiers is the bull market triangle. It consists of five candles. After first white marubozu the correction is made with three smaller black candles with the closure price lower with every following candle. These three have to be in the range of opening and closure of the first. At the end there is an another white marubozu with the closure value higher than the first one. The opposite to this formation is the bear market triangle. On the other hand there is also a more scientific approach which is the mathematical analysis. The mathematical analysis (Han et al., 2021) is using a wide range of mathematical tools and operations. An example of the use of the mathematical approach is multiple regression analysis. It is a statistical technique used to analyze the relationship between a single dependent variable and several independent variables. Using this method it is important to determine these variables:

- all time low and all time high price,
- trading volume,
- market cap,
- circulating supply.

These are considered as the independent variables. Now the dependent variable which is the stock price is modeled using the values of independent variables. The seasonality analysis is another example of investing strategy. By analyzing data from few years back the investor is creating a seasonality plot. Then the statements for example “Bitcoin price reaches the highest value in may” are made. Using the set of statements the investor decides whether he is buy in or selling stocks.

3. Solution

Long Short-Term Memory (Mogbara et al., 2020; Moghar et al., 2020) is a specialized Recurrent neural network (RNN). The general difference between an LSTM unit and a standard RNN unit is that the LSTM unit is more elaborate and sophisticated. A recursive neural network (RNN) is a class of artificial neural networks in which the connections between nodes form a directed or undirected graph along a temporal sequence. This allows him to exhibit dynamic behavior over time. In addition, the LSTM network possesses the gates that regulate better the flow of information inside the network. LSTM networks are useful for predictions based on time series data, also classifying, and processing. LSTM network can learn long term, because this model use of a mechanism called gate (fig. 4). Gate are learned to decide which information in the sequence should be kept and which should be erased. LSTM network has three gates; entrance, forget and exit. The three gates control the flow of information into and out of the cell, and the cell remembers values across arbitrary time periods.

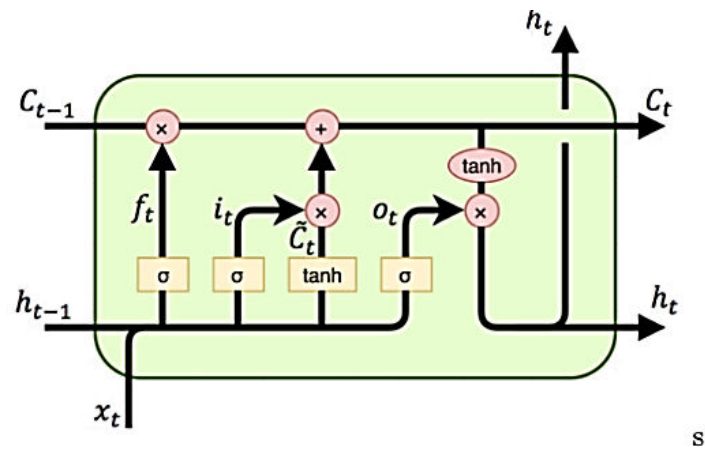


Figure 4. Architecture of Long Sort Term Memory network.

Source: LSTM architecture.

Stock prices are defined by several different values. They are:

- Opening value - the opening price of the stock of the day,
- Closing value - The closing price of the stock of the day,
- High - The highest stock price,
- Low - the lowest stock price for the day,
- Volume - the number of shares of a security traded in a given period.

The 3-layer neural network (fig. 5) based on the Long-Short Term Memory model, calculating the future share price. Input 3D (X, y, time_steps), where:

- X - is a dataset consisting of High, Low, Close,
- y is a dataset consisting of Open,
- time steps - input price prediction period,

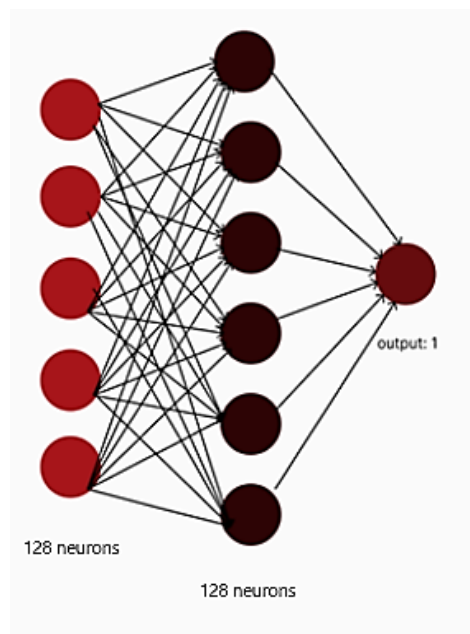


Figure 5. Scheme of the Long Short Term Memory neural network.

Source: own work.

The figure 6 presents the results of the propose neural network for Apple Inc. data. We can notice that both the proposed results and the current results of the Apple company initially drop, then rise and then they drop again.

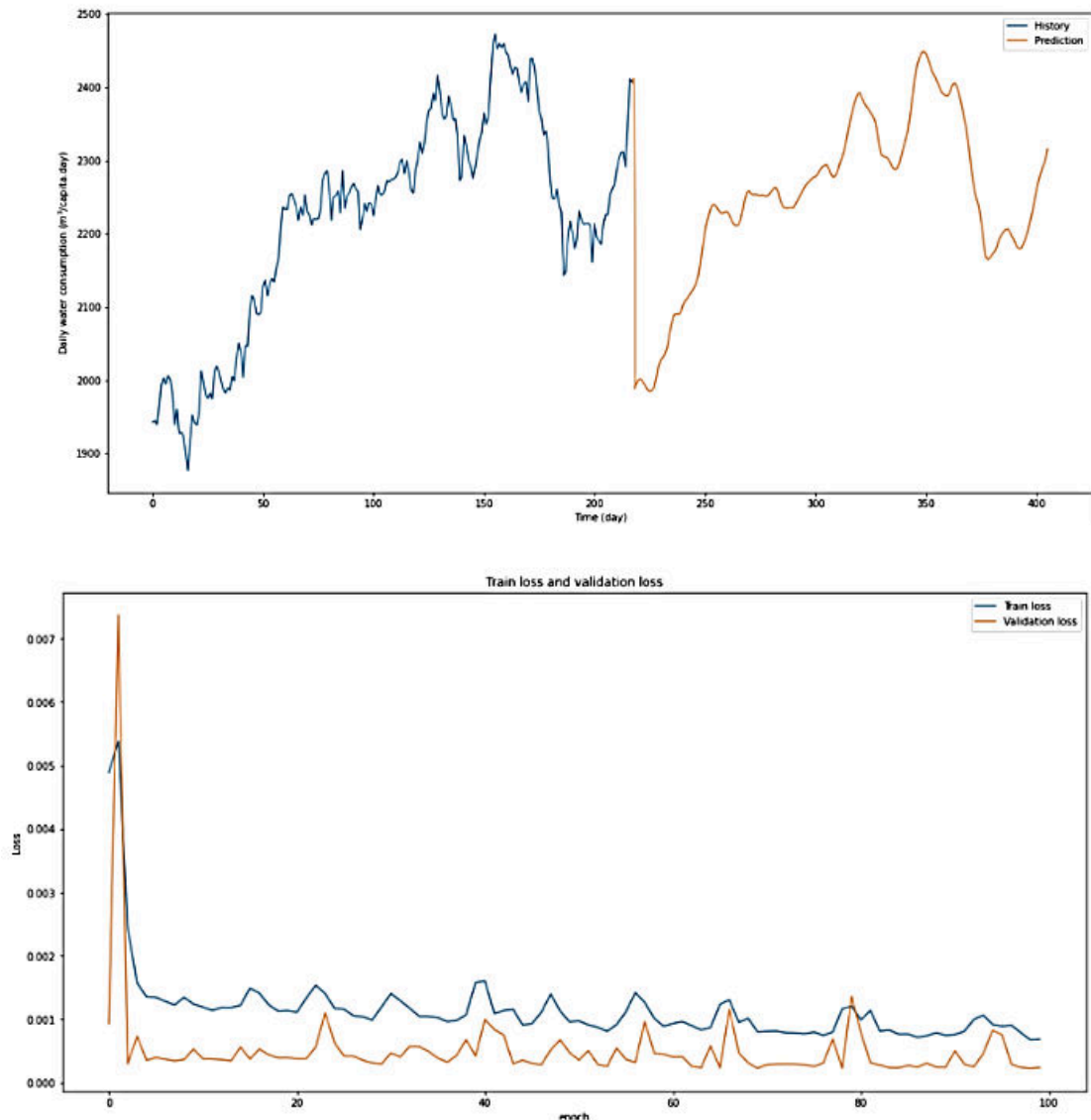


Figure 6. Prediction results for a period of 3 days and result of the accuracy.

Source: own work.

The similar experiments were performed for days 1, 3, 5, 7, 14, 30. The LSTM model achieved the best results for predicting prices three days in advance. During the research, it was noticed that the neural network for the period of which the timely show of the action, the direction of the share price (whether the price will fall and fall).

4. Conclusion

The paper contains an overview of the existing solutions of the mathematical and Isaac technical analysis of the exchange. One of the approaches to investing is so called technical analysis. It bases on analyzing candlestick charts or bar OHLC charts. Determining the trend line is one thing, the problem arises when you need to know the line patterns in stock charts. Playing on the stock exchange is facilitated by mathematical models developed by experienced brokers, including the RSI indicator, the ROC change indicator, CCI and stochastic oscillators, or the MACD curve. These models, when used properly, are able to facilitate the game on the stock exchange for the average representative of the society, however, they do not guarantee the absence of losses or revenues. Additionally, a model of a neural network for stock exchange prediction has been proposed. The LSTM model is good at dealing with data series, therefore it is an ideal choice for the problem of prediction of market prices. The model has a long and short-term memory, thanks to which it produces correlations between the data. The similar experiments were performed for days 1, 3, 5, 7, 14, 30. The LSTM model achieved the best results for predicting prices three days in advance. Future work on the project aims to develop the network to the state of predicting very low stock prices.

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ORGANISATION CONCEPT IN RELATION TO HOSPITALS

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Purpose: analysis of the diversity of organization typologies concerning hospitals.

Design/methodology/approach: to achieve the objective, a critical analysis of the Polish literature was carried out due to the specificity of hospitality in the conditions of the Polish economy. A method of analysis and logical construction was used. The work was divided into four areas, the first relating to praxeology, the second to typology, and the third indicating the possibilities of classifying the hospital according to the chosen typology. Finally, selected aspects of hospitals' activities affecting their uniqueness as organizations and the possibility of classification were detailed.

Findings: It isn't easy to find a clear place for hospitals in some organization classifications. At the same time, the multitude of categories makes it possible to find the right one. The diversity and multifaceted nature of the organization's variety allow research to be carried out from different viewpoints, making hospitals an interesting research object.

Originality/value: a review article, from the primary literature, to refer to the praxeology and typology of organizations.

Keywords: hospital, healthcare, organization.

Category of the paper: a literature review.

1. Introduction

The term organization appears in many, almost all, areas of life and science. The term is used in popular and scientific literature and occurs in an ordinary sense. The great diversity in the word 'organization' has resulted in different meanings being attributed to it. The variation and ambiguity have resulted in many definitions of the term today concerning other aspects of doing business. The organization is derived from the Greek organon or the Latin organum/organisatio (Bielski, 1997). In the former, organization means a tool, an organ, in the latter, it means a system (Krzakiewicz, 1994). The range between the etymologies of the word organization makes it ambiguous and used in various science disciplines, for example,

in management, sociology, and psychology. Given the above, this paper aims to present the problem of typological ambiguity in hospitals.

2. The place of hospitals from praxeology to organizational typology

The popular approach to the organization in Polish literature comes from praxeology, whose founder was Tadeusz Kotarbiński. He stated that an organization is "a certain kind of totality by the relation of its elements to it, namely such a totality, the components of which contribute to the whole" (Kotarbiński, 1969). Formulation organization is the activity of organizing or the complex arrangement of an object developed due to this activity, a system of its internal connections, or an object organized in this way. In praxeology, there are three approaches to the term organization (Ciekanowski et al., 2018; Janus, 2022):

- factual, in which an organization is an entity, a thing made up of interrelated parts or a particular discrete whole with specific characteristics. In this view, the emphasis is on the complex, organized structure that characterizes an organization. The organization is related to the term institution;
- activity-based, in which organization is the process of building or designing a complex thing. This approach depicts a sequence of successive activities that ultimately lead to the realization of a set objective. Attention is drawn here to the process that creates the organization, emphasizing the temporal structure. The concept of organization in the activity-based sense is synonymous with the idea of organizing;
- attributive, in which an organization is a set of typical characteristics for organized things. In this sense, an attribute is a characteristic that gives information about how a composite of many interrelated elements works. A synonym of the attributional view of the organization is organizational structure, and the organization itself is understood here on par with the concept of organization.

The praxeological approach can also be translated into different types of organizations. Many typologies of organizations can be found in the literature, formulated based on different criteria. Examples of criteria for dividing organizations may include (Puchalski, 2008):

- the nature of the organization's environment,
- the technology used,
- characteristics of the organization,
- features of the organizational structure,
- priority of use of the organization.

In classifying organizations by their future role/purpose, six types can be distinguished, i.e. (Puchalski, 2008; Ścibiorek, 2014):

- economic organizations - profit-oriented (e.g., commercial companies),
- public service organizations - nonprofit or quasi-nonprofit organizations (e.g., schools),
- administrative organizations - non-private organizations serving the public (e.g., local government units),
- military and police organizations - serving the security of the state and citizens (e.g., the army),
- social organizations - acting to ensure social order and order (e.g., trade unions),
- religious organizations - acting on behalf of religious communities and cultural formations (e.g., religious associations).

It is assumed that the types of organizations are disjoint in the classification adopted. Concerning hospitals, the above division of organizations do not allow a hospital to be classified into a particular kind of organization. For example, hospitals may provide health services under general health insurance. Thus, the patient does not directly bear the costs associated with the treatment. In that case, the hospital could be considered a nonprofit organization. Another hospital may operate in the medical services market as a commercial company, provide its services on a commercial basis and have a private owner, in which case the hospital would be a business organization. The qualification of a hospital to a specific type of organization is also hampered by the fact that current public hospitals pursue both social and economic objectives (Cholewa-Wiktor et al., 2020), which the "public owner influences", the turnover of public funds and the adopted legal form of operation as a commercial company.

A. Etzioni proposed authority as a criterion for division, defining the type of relationship between people and the organization. Power imposes a certain subordination on the participants in an organization, basing the cohesion of the entity on this (Bielski, 2004). Based on the criterion mentioned above, it is possible to distinguish three types of organization, i.e. (Bielski, 2004; Bąk, 2018):

- coercive organizations - in this organization, power is based on coercion, and its "participants" do not identify with it, often membership in the organization does not depend on human will (e.g., prison),
- utilitarian organizations - power is based on the ability to dispose of resources for rewards, the degree to which participants' needs are met influences commitment to the organization (e.g., industrial enterprises),
- cultural/normative organizations - power derives from people's morals and beliefs (e.g., church).

In the above view, a hospital can be considered a practical organization, assuming that there are incentive mechanisms within it that it can freely dispose of. However, if one believes that a hospital does not have to be profit-oriented (one of the fundamental distinguishing features of

a social economy entity (Hejbudzki, 2018)) and that its founding body can be a church, can it not indirectly be considered as a normative organization?

In the systems view, an organization is considered a collection of interrelated elements that together form a functioning whole (Zankovsky et al., 2019). In the classification according to the economical category D. Katz and R.I. Kahn distinguished four types of organizations, i.e. (Fryca, 2007):

- productive (economic) - responsible for providing goods and services,
- integrative - act to maintain social order, responsible for the transmission of generally accepted social norms and values (e.g., school),
- adaptive - lead to social and economic development as a result of scientific and educational activities (e.g., universities),
- political - are responsible for protecting public interests; the state is cited as an example of a political organization (Kołodziejska, 2018; Prońko et al., 2017), which through the exercise of power, can guide society.

In the above view, a hospital can be classified as both an adaptive organization (clinic) and an integrating organization, among other things, as an organization that cares for the health of society.

It can be said with certainty that public hospitals belong to the group of non-governmental organizations (NGOs) with social and non-distributive profit objectives. NGOs operate based on the principles of the market economy and are now becoming increasingly important. In the literature, the term nonprofit organizations are often used interchangeably with the concept of NGOs. The former draws attention to the relationship between the organization and the public sector, while the latter emphasizes the opposition to the private sector. The translation of the term nonprofit as a not-for-profit is standard in the literature. Nowadays, this understanding of nonprofit organizations is widely criticized because it erroneously indicates that they cannot generate profit (Limański et al., 2007). Here it should be emphasized that nonprofit organizations can make a profit and should be managed like other organizations, i.e., efficiently.

One international classification of NGOs is The National Council for Voluntary Organisations. The area of activity of the organization is taken as the main criterion for the division; concerning hospitals, the classification distinguishes organizations whose area of activity focuses on (Sergeant, 2004):

- education and research - the scope of activities includes administration, programming, service, and support of teaching,
- social service and social services - activities may concern the care of children, young people, the elderly, and the disabled, or material support,
- health care - the organizational activities concern administration, implementation of health services, and ad hoc services in the health area.

The classification presented includes the place of hospitals among other NGOs. Since some hospitals may carry out teaching or research activities, they will do the same activities as organizations focused on education and research.

In Poland, NGOs have been differentiated according to the criterion of activity. The Act of 24 April 2004 divides NGOs according to the areas of action (the last update of the Act took place in 2022). For example, the Act on Public Benefit Activity and Volunteerism distinguishes the area of:

- social assistance,
- charitable activity,
- health protection and promotion,
- activities for the disabled,
- science, higher education, education, upbringing, etc.

The Act lists 33 areas where non-governmental organizations operate, thereby defining the place of hospitals and other healthcare institutions in the system. As in the case of the previously cited typologies, hospitals carrying out teaching, research, or having a treatment and care facility (ZOL) in their organizational structure will operate in several different areas simultaneously.

However, many authors draw attention to other organization characteristics than their area of operation. Mostly they point to the economic aspect. H. Hansmann, an American researcher, classified NGOs according to the criterion of the origin of income and the method of control. According to the first criterion, he distinguished between organizations living from grants and commercial organizations (Hansmann, 1987). The second criterion distinguishes between community-based (self-help) organizations, whose activities are directed at the organization's members, and entrepreneurial organizations, where independent bodies exercise control. As a result, the typology cited above specifies four types of NGOs: grant-making, commercial, community, and entrepreneurial. The first division fully satisfies the capture of hospitals in the health sector, dividing them into public and commercial facilities. In the second view, the division of hospitals is not apparent; it seems more appropriate here to treat hospitals as entrepreneurial organizations since their activities are constantly controlled by internal and external bodies expressly set up for this purpose.

3. Summary

Hospitals are undoubtedly organizations and should be treated as organizations. The diversity and multifaceted nature of the classification of organizations allow research to be carried out from different points of view. However, it should not be forgotten that industrial organizations are distinguished by the specificity of their functioning in the environment and

by the difference in their management. S.M. Shortell and A.D. Kaluzny point to such differences as:

- the difficulty of standardizing and measuring the results of work,
- the complex and highly differentiated nature of the work,
- the immediacy of action,
- the absence or low tolerance of error and ambiguity,
- the independence of the activities performed,
- the high degree of coordination of activities, efforts, and tasks between different groups of experts,
- the increased specialization of staff,
- the fact that the loyalty of the members of the various professional groups to each other is given priority over allegiance to the organization,
- the provision of services and the generation of expenses mainly by medical staff (especially doctors),
- lack of effective control of medical staff in organizational and managerial terms,
- the existence of dual subordination (clinical and administrative).

The above list can immediately be supplemented by the mixing of public and private financial flows (Saryusz-Wolska et al., 2013) or the different legal regulations governing the operation of hospitals (Ziemba et al., 2019).

Another distinguishing feature of hospitals compared to other organizations is the services they provide, for which constant demand affects their availability (Rabiej, 2020). The overriding value with which medical activity is associated is health, which occupies one of the most important places among the matters relevant to society (Zapłata et al., 2003). The product offered to the patient by the hospital is the health services performed, which are part of the health care services. Medical services are a series of activities of an intangible nature and are committed to ensuring health. It should be noted that the patient is not only the service recipient but also its subject which influences the course and outcome of the service process (Krot, 2003). The services offered by the hospital are highly individualized and require the patient's active participation in the treatment (Bukowska-Piastrzyńska, 2007). The unique nature of medical services is linked to the specialized knowledge and, thus, high qualifications of the staff (Stewart, 1998).

The unique nature of medical services is also due to the special role of medical staff who, in performing their duties, determine another person's health and the quality of the services provided (Krot, 2008). The hospital's team can be divided into core business staff, technical, administrative, and economic staff, and economic and service staff (Erfurt, 2002).

Given the above, it can be concluded that hospitals are organizations with broad research potential. The research work carried out in the hospitality field can be differentiated according to the different types of organizations and analyzed through the prism of their characteristics.

Due to the specific nature of their business, which is characterized, among other things, by the need for constant readiness to provide round-the-clock patient care or the unilateral payment of fees by the primary payer (Hass-Symotiuk, 2011), hospitals represent an unlimited potential for research opportunities.

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THE DEVELOPMENT OF E-COMMERCE DURING COVID-19 PANDEMIC

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Purpose: The paper presents the issues related to the development of e-commerce during COVID-19 pandemic.

Design/methodology/approach: The study used world-bank reports from statista portal and own research.

Findings: The aim of the article is to present the development of e-commerce during COVID-19 pandemic. The functioning types of e-business and basic business models used in e-commerce are also presented. Payment methods used in internet sales are shown. An analysis of the online payment methods preferred by consumers during the COVID-19 pandemic was also performed.

Originality/value: The publication presents the results of research conducted on the basis statista international portal.

Keywords: e-commerce, COVID-19 pandemic, e-business.

Category of the paper: research paper.

1. Introduction

The state scientific publishing house dictionary of the Polish language calls e-commerce in one sentence as "trade via the Internet". According to the Organization for Economic Cooperation and Development is a transaction of selling or buying goods or services using computer networks through methods specifically designed to receive and placing orders. These methods provide goods or services, however payment as well delivery, can take place outside the online realm. The participants of the transaction are businesses, households, individuals, governments as well public or private organizations. Orders placed via the Internet, extranet or electronic data systems are considered e-commerce transactions.

The main purpose of the article is to analyze e-commerce in Poland regarding the time of COVID-19 pandemic. The article poses the question: How did the e-commerce sector develop in Poland during the COVID-19 pandemic, what the consumer behavior looked like and what factors influenced it? The problem was analyzed by reviewing the literature, reports and information provided by enterprises.

2. History of e-commerce

The progressive digitization of trade ensures rapid communication between trading partners or between the customer and the organization etc. Organizations today want to have a competitive advantage over their competencies, constantly considering expanding their business to reach different customers in different locations. This is not possible with a normal distribution channel, point of sale, etc. To do this, they use the internet, which can be accessed from anywhere in the world, and modern supply chain management helps them deliver products to customers wherever they want at an affordable price.

The electronic commerce market (so-called e-commerce) is currently the most dynamically developing branch of commerce. The term e-business has been here again first used in 1995 by IBM (International Business Machines Corporation). According to one of the simplest definitions proposed by S. Pangsy-Kania, e-business is a type of business that is run with the use of ICT solutions, including primarily web applications, as well as automatic delivery or exchange of information and business data (Pangsy-Kania, 2012). According to authors such as A. Hartman, J. Sifonis and J. Kadora, electronic business refers to all projects implemented via the Internet, mainly tactical and strategic, which transform business relationships, such as business-to-consumer (business - clients), business-to-business (business - business) or intra-business (business connections). These authors added that e-business is a new source of efficiency, speed, innovation of enterprises and the functioning of new ways to create value in the organization (Hartman, Sifonis, Kador, 2001). The OECD definition indicates that this trade is a business run through the network in the WTO definition that it covers various means of production or marketing, and in the WCO definition that it supports data traffic between computer systems of different enterprises. Among the events immediately preceding the emergence of e-commerce were:

- 1991 lifting in 1991 of commercial restrictions imposed by NSFNET (National Science Foundation NET) regarding for the use of the Internet by individual users and then the creation, with the participation of IBM, Merit Network Inc. and MCI Communication Corp., infrastructure, thanks which made it possible to make commercial internet connections;

- creation in 1993 one of the first web browsers - Mosaic, thanks to which virtually anyone could navigate around network and use its resources;
- finalizing the 1995 contract for the sale of ANS to America Online, thanks to which all Internet infrastructure remains so far only at the disposal of the public sector, passed to the private sector and it was he who began to play the most important role in the further development of the Internet;
- commencing commercial operations on the Internet in 1995 companies such as Amazon (the world's largest online store that offers books, music and movies), Dell (producer computer equipment) or eBay (portal with online auctions), which caused mass development of e-commerce and gradual dissemination of its individual forms and models among more companies (Tian, Stewart, 2006).

The first true online deal came three years after the National Science Foundation lifted its ban on commercial use of the web. In 1994, 21-summer economics graduate Dan Kohn sold the CD to Phil Brandenburger. Brandenburger had to place the order through a device having the XMosaic viewer. Using the new technology, Dan's start-up was the first store to transact online using an encrypted credit card. At first, potential consumers were concerned about sharing their personal data via a global network and exposing them to foreclosure by criminals. These worries decreased when the Secure Socket Layer (SSL) protocol was invented in 1994, which was used to securely encrypt the transmitted information. By the end of 1995, 120,000 domains had already been registered, and in the next three years that number had risen to 2 million.

With information and communication technology, doing business internationally has totally changed. The progressive digitization of trade ensures rapid communication between trading partners or between the customer and the organization etc. Organizations today want to have a competitive advantage over their competencies, constantly considering expanding their business to reach different customers in different locations. This is not possible with a normal distribution channel, point of sale, etc. To do this, they use the internet, which can be accessed from anywhere in the world, and modern supply chain management helps them deliver products to customers wherever they want at an affordable price.

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3. Examples of international electronic commerce

It involves entering into commercial transactions and selling products through various means and devices electronic, such as the Internet, telephone or fax, for example currently the most popular. International e-commerce consists of three basic ones entities: consumers, enterprises and administration. Due to the nature of the relationship between these entities, several types of e-business have developed. The basic relationships between e-commerce entities include (Combe, 2006):

- C2C (customer-to-customer) - refers to transactions between consumers that are carried out, for example, as part of the operation of auction sites,
- C2B (customer-to-business) - includes transactions between consumers and enterprises, with consumers as their initiators, and the goal is, for example, price comparison,

- C2G (customer-to-government) - these are transactions between citizens and public administration that concern, for example, taxes,
- B2B (business to business) - this is "classic" e-business and includes implementation of business processes between two enterprises,
- B2C (business-to-consumer or business-to-client) - this is "classic" e-commerce and includes transactions between businesses and consumers,
- B2G (business-to-government) - covers transactions between enterprises and public administration, such as public procurement or tenders,
- G2C (government-to-citizen) - concerns the flow of administrative information from offices to citizens,
- G2B (government-to-business) - covers the flow of economic information (customs documents, statistical data) from offices to companies,
- G2G (government-to-government) - cooperation between organs public administration, which coordinates internal processes.

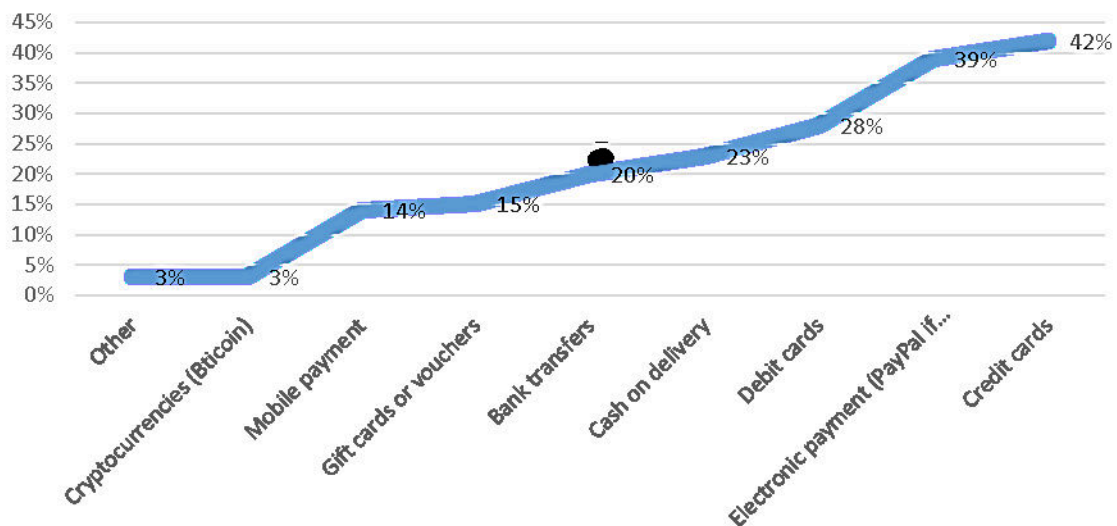


Figure 1. Preferred payment methods of online shoppers of March 2021 in Poland.

Source: own based on <https://www.statista.com/statistics/508988/preferred-payment-methods-of-online-shoppers-worldwide/>, 2021.

In Poland, during the pandemic, consumers are more likely to choose non-cash forms of payment, and less and less use of cash as a means of payment is declared. For the most part, a credit card is used (see Figure 1). Searching for new sales opportunities is one thing, but e-commerce companies also need to be up to date with technical innovations. Payments are certainly such an area. The fact that clients want to execute transactions simply and hassle-free is known to all. However, there are new trends on the market that need to be adapted to.

The factors influencing the development of e-commerce in Poland have been studied over the years, the appearance of the SARS-CoV-2 virus is another stimulus that has influenced the economic activity on the Internet. COVID-19 contributes to growth of e-commerce. The global

coronavirus pandemic is affecting consumer behavior worldwide. In the week ending April 26, online traffic in the supermarket segment increased by 135 percent compared to the reference period in January and February 2020. In general, e-commerce sales have increased in recent years, a trend that was expected to continue through 2024. It is likely that this sector will see further increases due to COVID-19, as many people choose to stay at home and amend their daily routines to avoid catching the airborne virus. As people spend longer stretches at home, consumers are purchasing more nonperishable food-items, cleaning supplies, and home entertainment products (see Figure 2). This is often done through online marketplaces, such as Walmart or Amazon. In contrast, there has been a decrease in spending in clothing and furniture stores, as most of these locations have been temporarily shut down to help contain the spread of coronavirus.

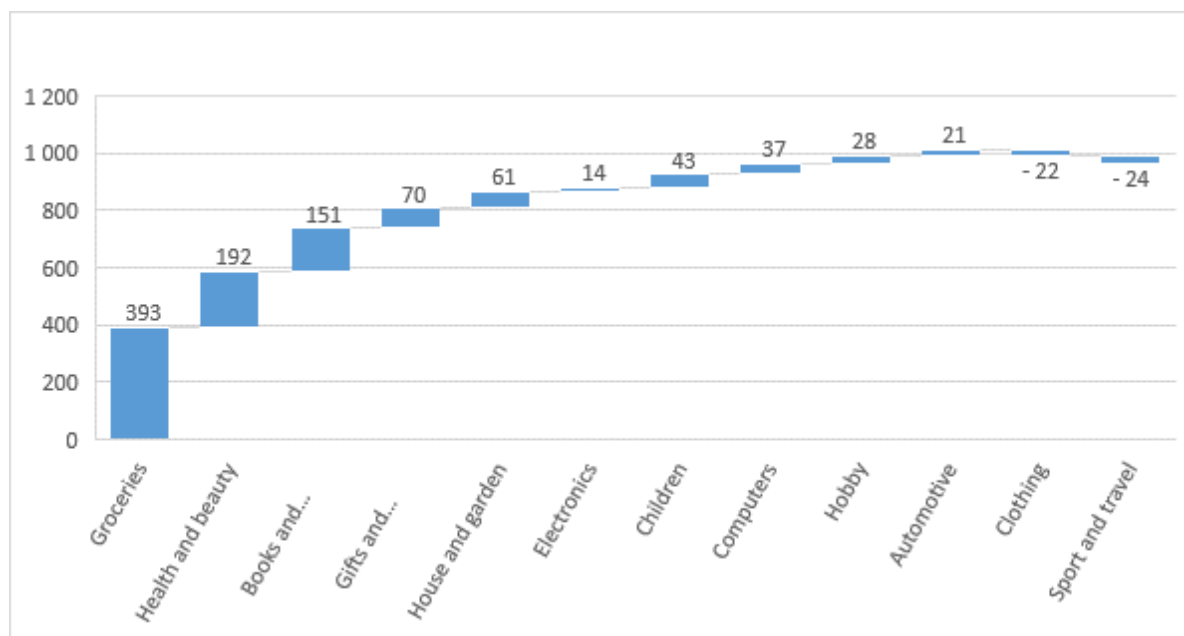


Figure 2. Growth in transactions number and sales value of orders in online stores due to the coronavirus (COVID-19) outbreak in Poland from February to March 2020, by category.

Source: own based on <https://www.statista.com/statistics/508988/preferred-payment-methods-of-online-shoppers-worldwide/>, 2020.

At the turn of 2020 and 2021, a CAWI study presenting the e-commerce situation in Poland was carried out. 100 Internet users aged 15 and over participated in the study. One of the behaviors studied was to check what influences the decision not to use online shopping. It was conducted on a representative sample of 80 people. The results shows the percentage of the population who made online purchases in the last 12 months in particular years. The same as with online stores the numbers are consistently growing both in Poland and in the European Union (see Figure 3). The dynamics of Polish e-commerce is clearly visible here, where in 2019 and 2020 the number of buyers increased by 13% compared to the previous years compared to the European Union, where the increase was only 5% and 3%, respectively. In 2020, the difference between them was only 4 percentage points, where previously it was even 16 points.

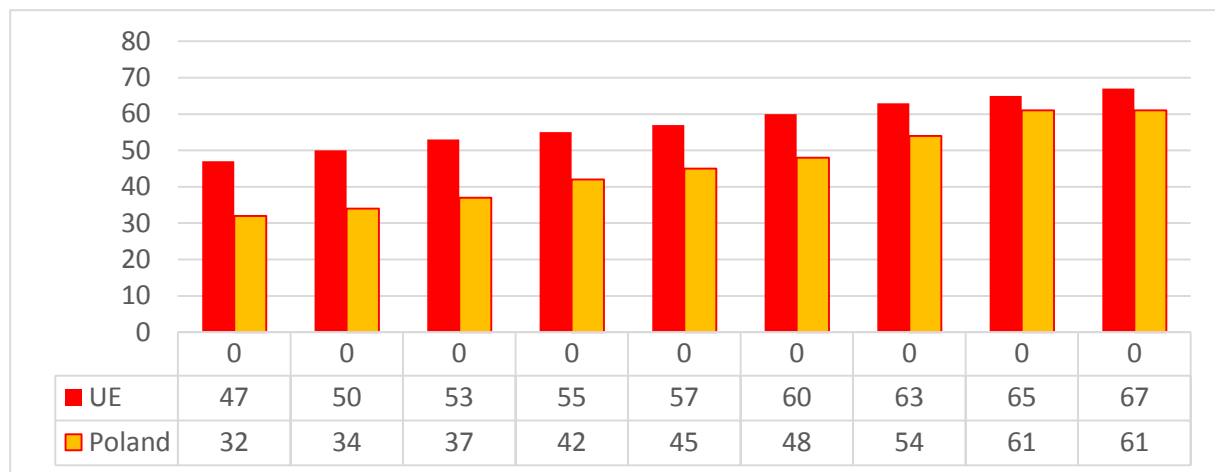


Figure 3. Percentage of the society purchasing online in the last 12 months.

Source: own elaboration based on Eurostat data.

In 2021, the share of households with internet access in Poland increased by two percent since 2020. Therefore, the share of households with internet access in Poland reached a peak in 2021 with 92 percent (see Figure 4). Notably, the share of households with internet access continuously increased over the last years.

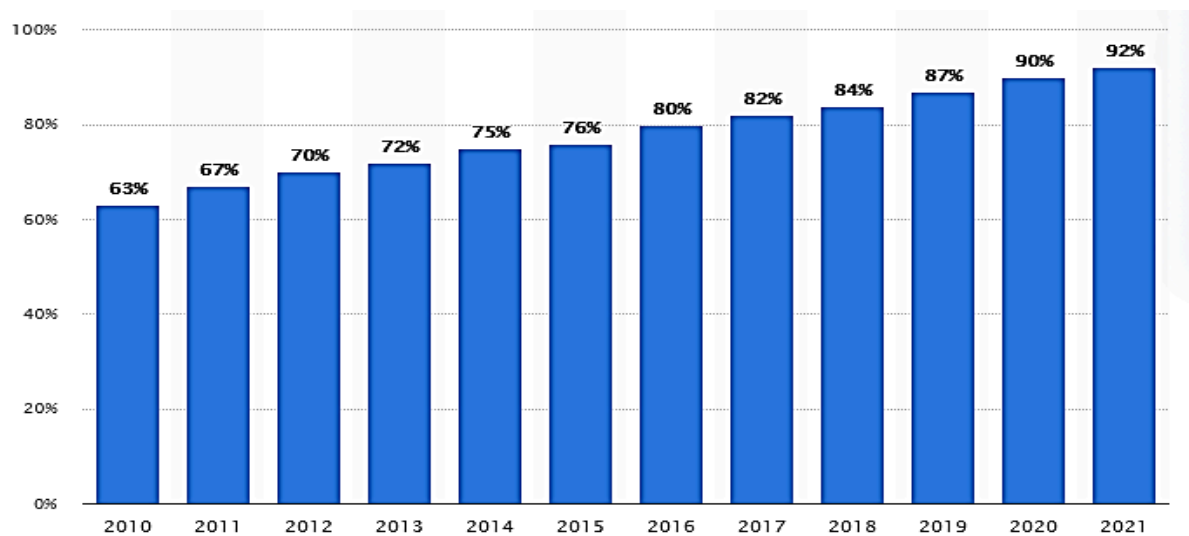


Figure 4. Share of households with internet access in Poland from 2010 to 2021.

Source: <https://www.statista.com>.

The development of information technologies (specially e-commerce) is the foundation for the growth not only of the ICT sector, but also of the entire economy and society. The competitiveness of Polish industries is largely based on the availability and quality of ICT sector solutions. In an era of global change, it is one of the key sectors for future growth (<https://www.gov.pl>, 24.05.2021).

The share of online sales in total sales also increased as shown in figure 3. Particular attention should be paid to the month of March and April 2020. It was then that the first wave of COVID-19 reached Poland and the first lockdowns were introduced. In these two months, online sales almost doubled. April with sales of 11.9% so far is the highest value in recent years (see Figure 5).

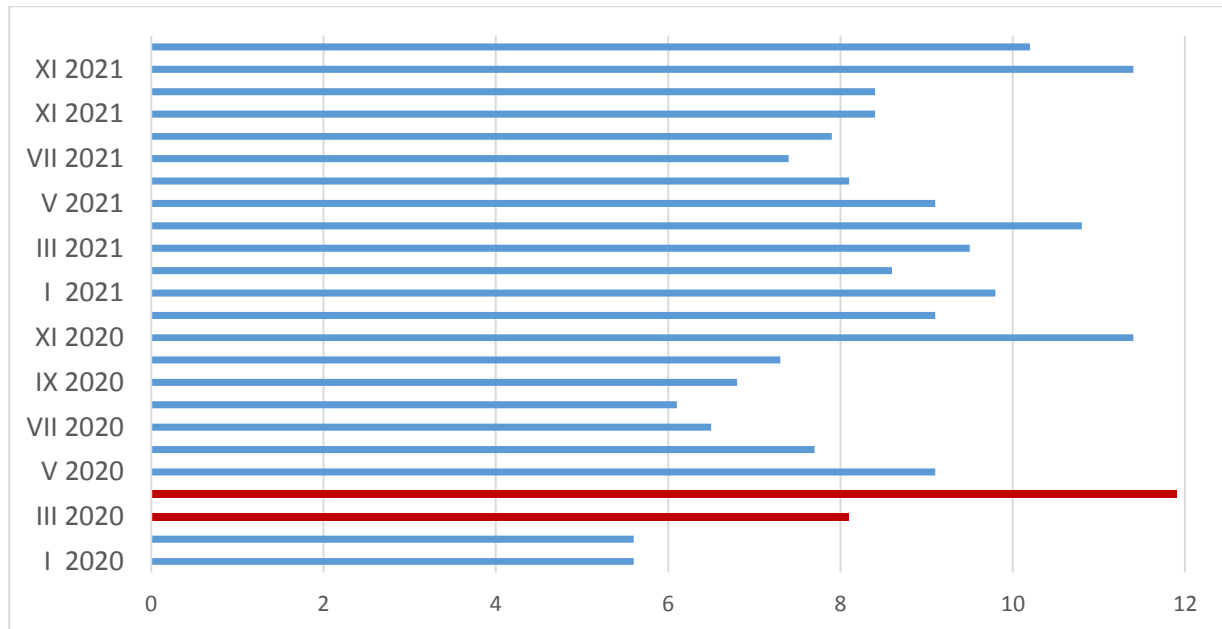


Figure 5. Share of total internet sales in total retail sales in Poland in the period 2020-2021 (%).

Source: Own study based on GUS data.

In December 2021, the value of the share of online sales in the whole retail sales dropped from 11.4% to 10.2%, however, the value of sales increased retail, which means that its value in current prices is really higher than in November. The value of internet sales increased by 3.2% in terms monthly. So the number of transactions in traditional stores increased, but still this e-commerce was still a frequently chosen option.

45% of respondents declare that they prefer to see the product in person before deciding to buy it; 24% of respondents are used to the traditional way of shopping and do not need to change their habits; 23% of respondents complain that delivery costs are too high and are concerned that problems will arise if the product does not meet expectations and cannot be returned; 22% of respondents are worried about the security of internet payments and do not trust this type of transaction; 18% of respondents are concerned about problems with delivery (see Figure 6).

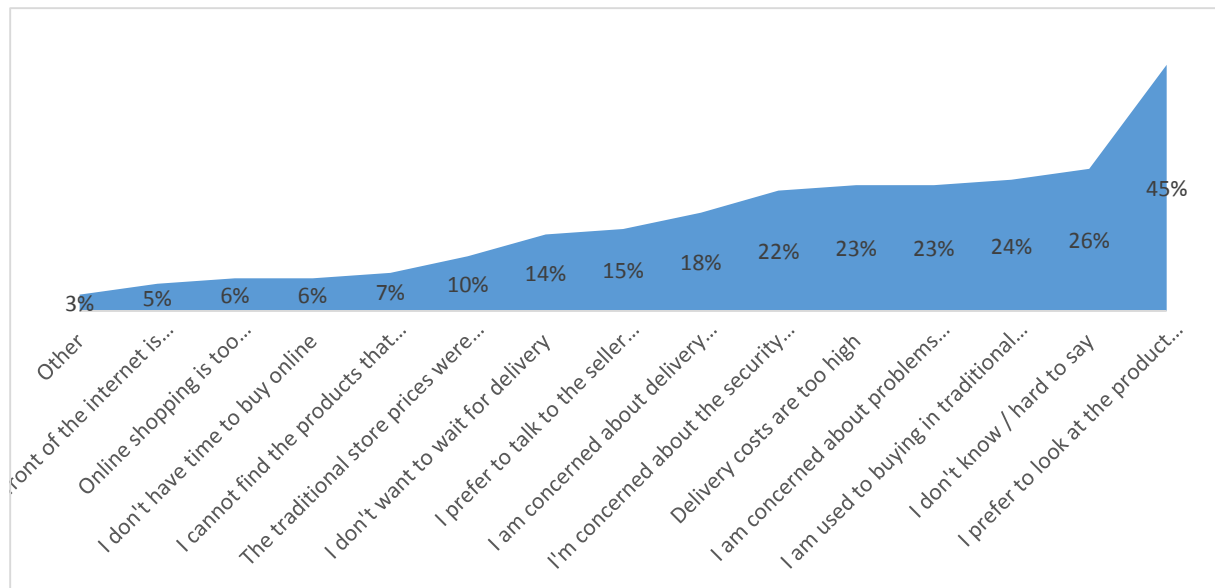


Figure 6. Factors influencing the decision not to use online shopping [%].

Source: own research.

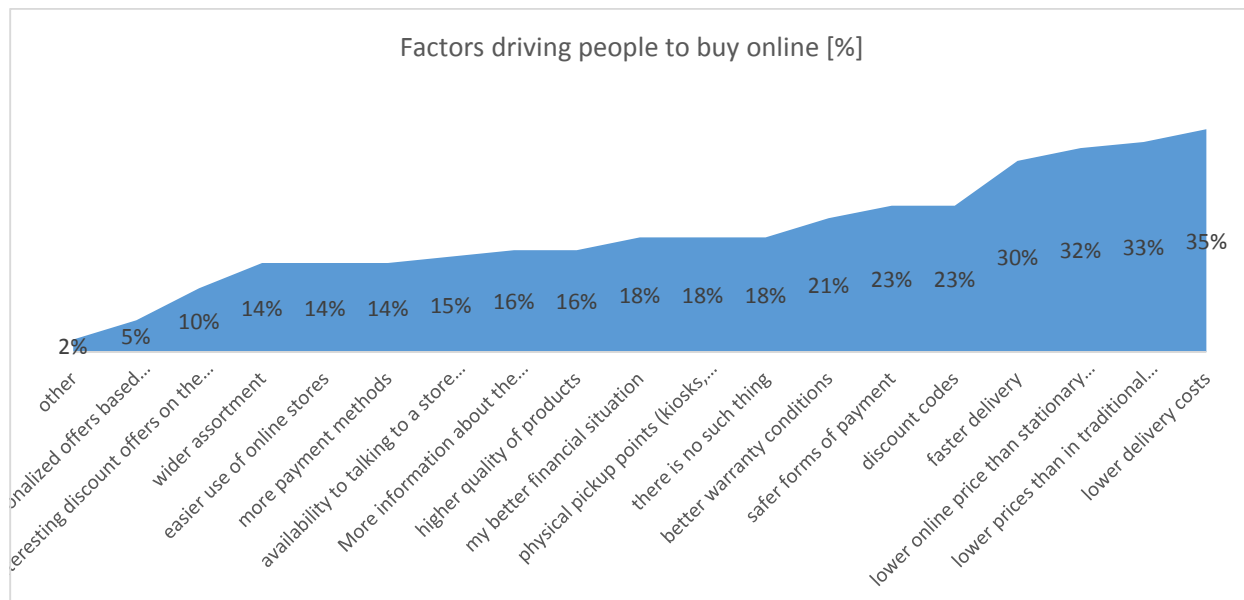


Figure 7. Factors driving people to buy online [%].

Source: own research.

Figure 7 shows that as many as 35% of respondents expressed the willingness to buy online with lower delivery costs; 33% of respondents declared that they would decide to buy products or services online if their prices were lower than in traditional stores, and 32% of respondents if the price was lower than the price in a stationary store of the same brand; 30% of respondents indicate faster delivery as a factor that would convince them to buy online; 23% of respondents would decide to buy online, with safer forms of payment, the same percentage would like to have more discount codes on offer. Other factors influencing the change of decision include Better warranty conditions; physical collection points; access to more information about the product on the websites of stores; offered higher quality products; possibility of talking about

the product with store employees, e.g. via the hotline or chat; a wider range of products on offer, as well as more personalized special offers based on previous purchases.

What made e-commerce so popular during the pandemic? Of course, that is lockdown. It had to be limited leaving home, there were limits in the shops of people who could at the same time stay in it, there were terrible queues and there was a shortage of goods in the shops. Much of the z these problems were solved by the advantages of e-commerce. It is enough for such purchases a computer and access to the Internet and in such a store there is already more choice, lower prices, and most importantly in a pandemic, purchases can be made from home without being huge queues.

4. Conclusion

The e-commerce pandemic has highlighted many of its downsides previously they did not exist or were not that noticeable. These were things like missing access to the internet and equipment in less developed countries, disruption of chains deliveries, changes in inventory management, increased competition or problems with services internet. It would be necessary to analyze what is their cause and what is possible 60 prepare for similar situations in order to avoid them in the future. For example improve transport or buy more servers for your website. The development of e-commerce is important because it makes it easier for people to access shopping globally. This leads to an increase in the number of customers and sellers as well development in other fields of trade which provides new jobs for people like couriers, web designers, internet providers and much more. It should be noted that the frequency of purchases and a large part of the society is still increasing forced to make purchases over the Internet, learning about the advantages of e-commerce even after returning to the pre-2019 state, it will continue to do so in this form.

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PROBLEMS OF COVID-19 INFLUENCE ON SMALL AND MEDIUM ENTERPRISES ACTIVITIES – ORGANIZING FUNCTION

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Purpose: The aim of the paper is to analyze selected aspects of impact of COVID-19 pandemic on small and medium enterprises organizing function in Zimbabwe.

Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic. The analysis on data from questionnaire.

Findings: After analysis of the results of realization of organization function by SME in Zimbabwe during COVID-19 pandemic we can observe that it has the rather bad influence on the teams management. Especially problematic area was connected with coordinating work processes which was not easy and in many SME were problems with this area during COVID-19 pandemic. Also managers have problems with seating up work and too much absence of workers. The management of workers using only remote tools is not an easy one process and need very careful approach and many adjustment of team working organization to the new situation. We can observe the negative impact of CIVID-19 pandemic and full remote working on realization of organizations by SME organizations. Maybe this was because of not enough level of knowledge by workers how to use remote working solution. It would be interesting to conduct training in remote working and management of remote working teams in organization and try to analyze the results after it. Maybe it could influence positively on the results. It is important because in many organization also after the COVID-19 pandemic the remote work will be used more frequently comparing to times after this pandemic conditions.

Originality/value: Detailed analysis of all subjects connected with COVID-19 pandemic impact on the functioning of organization function in SME organizations.

Keywords: small and medium enterprises, management, COVID-19, organization, Industry 4.0.

Category of the paper: literature review, data analysis.

1. Introduction

The COVID-19 pandemic and its consequences have had a devastating impact on the business industry worldwide, particularly in the Small and medium-sized enterprises (SMEs) sector. There are emergent changes in work practices (e.g., working from home, virtual teaming) and (b) emerging changes for employees (e.g., social distancing, stress, and unemployment). COVID-19 lockdowns posed a challenge to existing organizational management functions, of planning, organizing, leading, staffing and controlling. Those changes are especially connected with Industry 4.0 principles – digitalization of the organization processes (Drozd, Wolniak, 2021; Kwiotkowska et al., 2021). This digitalization is a step towards remote working system but it's worth analyzing if for now organization are prepared for the full remote working. The times of COVID-19 pandemic was a good time to analyze it.

The aim of the paper is to present selected aspects of impact of COVID-19 pandemic on small and medium enterprises organizing function in Zimbabwe.

2. Small and medium enterprises

SME stands for Small and medium-sized enterprises (SMEs) and they play an important part in the economy of most countries. The European Commission considers SMEs as key to ensuring economic growth, innovation, job creation, and social integration in the European Union (Eurostat, 2020). The number of employees in SMEs varies from industry to industry. These enterprises are job creators and have created the competitive state of the market which led to better satisfaction of consumer needs. SMEs also contribute in supplying certain activities to help big enterprises in a way of producing goods and services efficiently (Fan, 2003). Another important feature of SMEs is focusing on innovative processes, both in technology and in management. Thus, they help in forming the GDP and increasing the national export and play role in maintaining the social-political stability in a country (Fan, 2003).

A small and medium-sized enterprise is defined as a company that employs under 250 employees. A small business is a company that has fewer than 50 employees and a micro business employs fewer than 10 people. Small and medium-sized enterprises (SMEs) represent 99% of all businesses in the EU. The definition of an SME is important for access to finance and EU support programmes targeted specifically at these enterprises (European Commission, 2021). SMEs play an important role in the economic development of a country (Jonek-Kowalska, Wolniak, 2021). Their role in terms of production, employment generation, contribution to exports and facilitating equitable distribution of income is very critical (Hashi,

2020). The World Bank estimates that 90% of businesses worldwide are SME's. The importance of SME for economic growth, as well as creating the competitive private sector has been proven in many studies. The significance of this group of entities for the economic growth and employment is unquestionable, which is proved by scientific research and numerous reports. Qimiao Fan indicates that SME are not only an engine for the growth but also essential for competitive and efficient market as well as critical for the poverty reduction (Fan, 2003).

Entrepreneurial activities in society were started by the ancient Greeks and it was the philosopher Xenophon (approximately 430-354 BC) who recognised opportunity seeking activities of overseas merchants (Houben, 2005). In modern times, small business development dates as far back as the 1600s, when Americans would trade crops, supplies, and services. As the nation itself was developing, all businesses were small at that time. Machines were not yet available, and automation was unheard of. Transportation was extremely slow, and banks had not yet been established. America was still working out the groundwork for such things, including taxes. In the 1800s, after the nation became independent, small businesses really began to boom. The growing commercialisation of farming, including the involvement of farmers in land speculation in the early 1830's almost all farmers combined some trade with agriculture, most of them make agriculture itself a trade. Small and medium enterprises are privately owned businesses whose capital, workforce, and assets fall below a certain level according to the national guidelines. Local restaurants, grocery stores, garages, etc. that serve a hyperlocal target audience usually fall under the blanket of a small-to-medium-size enterprise as they generate less revenue and operate with less than a certain level of workforce and assets. SMEs usually do not require heavy or sophisticated machinery. Hence, it uses more labour-intensive techniques, they require a smaller number of people as compared to large corporations, due to their small scale of operations (Verma, 2021). In most cases, a single owner or a small group of individuals handle the management of the business. While large corporations pour a lot of money to connect with their customers, SMEs do it easily they operate locally and have a smaller customer base, which makes it possible to maintain close relationships with its customers (Verma, 2021).

While only a few SMEs have managed to exploit the advent of the internet by doing business online, the majority of them still rely on the traditional means of face to face in doing business. Therefore, any situation that disrupts the status quo so much as to threaten to reduce or nullify face-to-face interaction will inevitably pose a perennial threat to the survival of these small businesses. The advent of COVID-19 with its stringent conditions therefore, is likely to have undoubtedly dealt a devastating blow to the SMEs especially in Zimbabwe where e-commerce and e-business are still budding. This study therefore sought to assess the impact of this pandemic.

SME'S are the anchor of most economies as they provide the most jobs and are a great contribute to a nation's Gross domestic Product GDP. In the United States Of America, in 2021, the number of small businesses in the reached 32,5 million making up nearly all (99.9 percent)

US businesses (Lin, 2020). The increase in the number of small businesses in the US in 2021 is representative of the sustained growth as it marks a 2.5 percent increase from the previous year and a growth of 9.8 percent over the four-year period from 2017 to 2021. According to the US Small Business Administration, “small businesses” are defined as “firms with fewer than 500 employees” (Lin, 2020).

While in Asia survey that the Asian Development Bank (Asia SME Finance Monitor (ASM) carried out on 20 countries from 5 ADB regions 1 showed that SMEs accounted for an average of 96% of all enterprises and 62% of the national labour forces across the ASM countries. These countries cover Central Asia, East Asia, South Asia, Southeast Asia, and the Pacific. Meanwhile, the latest data reveal that SMEs contributed an average of 42% of the gross domestic product (GDP) or manufacturing value added in ASM countries.

3. COVID-19 pandemic

Across the world, world leaders have declared health emergencies to combat the COVID 19 epidemic. At the moment, strides have been made to come up with COVID-19 vaccines like Pfizer, Moderna, Astra, Sputnik, Sino-pharm and Sinovak amongst others (WHO, 2022). In addition, authorities have effected lock downs, curfews and made the wearing of masks mandatory and they have ordered people to stay home and travel restrictions have been put in place (Stecula, Wolniak, 2022). Many businesses are closed and only a minimum of shops continue to operate particularly those who provide essential services, such as health care services, banks, media outlets, food industry etc.

There are new regulations for travelers, including quarantine, and most countries like Australia have very strict travel restrictions. According to media reports Australia was one of the few developed countries prohibiting its citizens and permanent residents from exiting the country except in cases where one had a compelling reason or emergencies.

Broughton (2015) denotes that crises can entail: epidemics, natural disasters, technology, poor management, terrorism, warfare and scarcity. There are three elements that are most common for defining crises: threats to organizations, elements of surprise, and short time decisions. COVID-19 meets this criterion, its severity has threatened small and large enterprises, and nonetheless small and medium businesses have been affected the most. Preventive Health Measures encompass a variety of interventions that can be undertaken to prevent or delay the occurrence of disease or reduce further transmission or exposure to (Hayakawa, Mukunoki, 2021) states that in the case of COVID-19, strict preventive measures had to be set in place due to the fact that COVID-19 is easily transmittable. According to the World Health Organisation the virus can spread from an infected person’s mouth or nose in small liquid particles when they cough, sneeze, speak, sing or breathe. One can transmit the

virus by breathing in when near someone who has COVID-19, or by touching a contaminated surface and then your eyes, nose or mouth. The virus spreads more easily indoors and in crowded settings (WHO, 2022).

A case study done by Kabir et al. (2021) shows that Bangladesh experienced a surge in infections from June to August 2020, marking the first wave of the virus. Several containment measures were applied to control the situation, including a countrywide lockdown and travel and social activities restrictions. Risk communication strategies were also developed and deployed in the country as part of the National Pandemic Preparedness and Response Plan.

Misconception on COVID-19 has been another predominant challenge in the risk communication strategies around the world. An exploratory study in Canada revealed that the participants perceived public health messages on COVID-19 as conflicting, with perceptions varying by age-group (Chrisa et al., 2020). The coronavirus outbreak has had a significant impact on the workplace. Many organizations have switched to working remotely to curb the virus's transmission and protect workers. Video communication applications such as Zoom meetings and instant messaging have replaced personal interaction (Gajdzik, Wolniak, 2021). This has both advantages and disadvantages although it may be flexible working from home. Some members of staff who preferred personal interaction with colleagues and also found face-to-face guidance with their manager extremely beneficial in helping them complete tasks and achieve their goals (Businessinfo.uk, 2020).

Working from home may also not fit in with everyone's home-life for example some people may have young children that may be unaware of boundaries and cause interruptions during the working day. Others may not have the physical space required to create a suitable dedicated working area (Businessinfo.uk, 2020). Maurer (2020) says research has shown remote employees are working longer, spending time in more meetings and having to keep up with more communication channels. Employees are struggling to know how to disconnect from work, resulting in longer hours, higher stress, and eventual burnout (Zhikuan, Zhang, 2022).

Despite researchers' changing perspectives on proximity over time, some general guidelines seem evident. It is apparent that increasing proximity among people has positive, but non-monotonic, effects on interpersonal relationships and group functioning. In most cases, humans are highly uncomfortable at close range (Freedman, 1975). Proximity increases social impact, such as obeying someone's request to sing loudly, contribute to a charity, give a large tip, or do a favour or expend effort for the group. Likewise, in a group, free riding (letting others do the work) is minimized when members are proximate and each member's contribution to the group project can be clearly identified (Latane, 1986). While working from home is convenient and has many benefits, it also exposes both individuals and businesses to a range of cyber security risks (Root, 2021).

4. Methodology

The study is designed to understand how COVID-19 induced lockdowns has impacted the organisational management of small businesses. A survey was focus on Zimbabwe example. In Zimbabwe, the biggest number of SME firms is to be found in the in-wholesale trade, retail and food industries, the focus of this research will be on the aforementioned. There were 50 questionnaire conducted in the research on example of Small and medium enterprises functioning in Zimbabwe. The highest percentage of respondents (70%) were SME directors, while the remainder (30%) were SME managers.

5. Effect of COVID-19 pandemic on organizing function

In our research we analyzed the effect of COVID-19 induced lockdowns on organizing in SMEs in Zimbabwe. The effect of COVID-19 pandemic was assessed through the following themes COVID-19 induced lockdowns, due to curfew and standard operating procedures. Respondents were asked to indicate the level at which they agreed with the responses suggested. The study results are presented. in Table 1 below. The effect of COVID-19 on organizing in SMEs was assessed through two themes work teams and organizational structure. Respondents were asked to indicate the level at which they agreed with the suggested responses.

Table 1.

Positive effects of COVID-19 pandemic on organization function

Teams	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree	Total	
						Freq	%
Setting up work teams was easy, with some team players absent	0.00%	58.00%	22.00%	12.00%	8.00%	50	100.00%
Coordinating work-processes was easy	54.00%	16.00%	0.00%	30.00%	0.00%	50	100.00%
Sharing operational work information was easy	10.00%	56.00%	20.00%	14.00%	0.00%	50	100.00%
Organization structures							
Functional reporting structures running	0.00%	8.00%	10.00%	56.00%	26.00%	50	100.00%
Formal reporting structures were easy to adhere to	8.00%	52.00%	12.00%	20.00%	8.00%	50	100.00%

Source: On basis: (Sibanda, 2022).

The primary question for SME directors was: how easy was it to set-work teams during the COVID-19 induced lockdowns when some workers were absent? An analysis of the presented results showed that the majority of respondents (58%) were strongly disagreeing with the assertion that setting up work teams was easy during the COVID-19 induced lockdowns despite the fact that some workers were absent from work. This was followed by 22% of respondents who were not sure whether it was easy or not to set up work teams. Only 8 % of respondents were agreeing that setting up work teams was easy during the COVID-19 induced lockdowns despite the fact that some workers were absent from work. Thus setting up work teams was not easy for SMEs during the COVID-19 induced lockdowns.

The other key question for SME directors was: how easy was it to coordinate work processes during the COVID 19 induced lockdowns? An analysis of results showed that the majority of respondents (54%) were strongly disagreeing with the assertion that coordinating work processes was easy during the COVID-19 induced lockdowns despite the fact that some workers were absent from work. This was followed by 30% of respondents who agreeing that it was easy to coordinate work processes during COVID-19 induced lockdowns. Only 16% of respondents were disagreeing that coordinating work processes was easy during the COVID-19 induced lockdowns despite the fact that some workers were absent from work. Thus coordinating work processes was not easy for SMEs during the COVID-19 induced lockdowns.

Key to the aspect of organizing was the question how easy was it to share operational information during the COVID-19 induced lockdowns? An analysis of results showed that the majority of respondents (56%) were disagreeing with the assertion that sharing operational information was easy during the COVID-19 induced lockdowns despite the fact that some systems were non-functional. This was followed by 20% of respondents who were not sure whether it was easy or not to share operational information during COVID-19 induced lockdowns. Only 14% of respondents were agreeing with the notion that sharing operational information was easy during the COVID-19 induced lockdowns despite the fact that some workers were absent from work. Thus, sharing operational information was not easy for SME managers and directors to share operational information during the COVID-19 induced lockdowns.

6. Conclusion

After analysis of the results of realization of organization function by SME in Zimbabwe during COVID-19 pandemic we can observe that it have the rather bad influence on the teams management. Especially problematic area was connected with coordinating work processes which was not easy and in many SME were problems with this area during COVID-19

pandemic. Also managers have problems with seating up work and too much absence of workers. The management of workers using only remote tools is not an easy one process and need very careful approach and many adjustment of team working organization to the new situation. We can also observe problems connected with sharing operational work and information between teams member. This is problematic in fully remote condition without additional training of workers.

In the case of SME organizational structures we can observe that the organizations don't have a problem with functional reporting – is could be done in times of pandemic even better than in normal condition. Typical, formal reports can be easy prepared using remote working system. But the main problem was in the case of sharing information's in report – it was worst without typical face-to-face meeting.

Summing up we can observe the negative impact of CIVID-19 pandemic and full remote working on realization of organizations by SME organizations. Maybe this was because of not enough level of knowledge by workers how to use remote working solution. It would be interesting to conduct training in remote working and management of remote working teams in organization and try to analyze the results after it. Maybe it could influence positively on the results. It is important because in many organization also after the COVID-19 pandemic the remote work will be used more frequently comparing to times after this pandemic conditions.

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SENTIMENT ANALYSIS CONCERNING HEAT PUMPS - ANALYSIS OF TWEETS PUBLISHED IN POLISH

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Purpose: Identifying thoughts, feelings and opinions on “heat pumps” based on the content of tweets.

Design/methodology/approach: Tweets written in Polish, containing all possible grammatical cases of the terms “heat pump” and “heat pumps”, were automatically downloaded. The content of the tweets has been preprocessed. URLs, hashtags, emojis, usernames, all characters except letters, and phrases used to search for tweets were removed from their content. The sentiment value of the tweets was calculated. Visualisations were prepared to show the percentage of positive, negative and neutral tweets. The most frequently used words in tweets were shown with word clouds.

Findings: The number of tweets concerning heat pumps and the percentage of positive, negative and neutral tweets were determined.

Research limitations/implications: Only the content of tweets written in Polish was analysed. Sentiment analysis was performed automatically by the service “ccl_emo”, without author supervision. Only the opinions of people who posted on Twitter were analysed.

Practical implications: Automatic monitoring of people's feelings about heat pumps.

Originality/value: Information on the attitudes of people from Poland towards heat pumps was obtained. It has been established, based on a growing number of tweets, that interest in heat pumps in Poland is growing all the time.

Keywords: sentiment analysis, Twitter, heat pump.

Category of the paper: research paper, case study.

1. Introduction

As global warming becomes more visible in the environment, society faces several climate-related challenges to significantly reduce greenhouse gas emissions from heating and cooling buildings (Decuyper, Robaeyst, Hudders, Baccarne, de Sompel, 2022). The heating and cooling of buildings cause one-tenth of anthropogenic greenhouse gas (Edenhofer, 2015). These emissions are likely to increase sharply in the coming decades (Ürge-Vorsatz, Cabeza,

Serrano, Barreneche, Petrichenko, 2015). Heating systems need a rapid transition to low-carbon options to meet global climate goals (Martiskainen, Schot, Sovacool, 2021).

Thanks to technological advances, heat pumps now have the potential to reduce emissions from heating and cooling in many settings by half or more (Billimoria, Guccione, Henchen, Louis-Prescott, 2021). Heat pumps are diverse, using renewable energy from the air, water, ground or air exhausted from buildings to provide heating and cooling (Nowak, 2018). Two common types of heat pumps are air-source, which transfers heat to and from the outdoor air, and ground-source, which transfers heat to and from the ground (Kircher, Zhang, 2021). Heat pumps can be used for a variety of purposes, including providing heating and cooling for buildings, generating electricity and providing hot water (Soltani et al., 2019). Heat pump technology has developed significantly in recent years, both in terms of efficiency and heating performance at low temperatures (Chua, Chou, Yang, 2010). Despite their advantages, heat pumps face several obstacles to widespread adoption. Their lifetime costs are not always competitive with existing technologies such as natural gas furnaces (Billimoria et al., 2021). Even when the operating costs of heat pumps are competitive, the initial purchase and installation costs can be prohibitive (Bergman, 2013). Additional barriers to heat pump adoption include finding installers who are familiar with modern heat pumps, choosing the right models and sizes of heat pumps, and finding and applying for rebates, tax credits, and other incentives (Snape, Boait, Rylatt, 2015).

With the rise of the digital age, people often express their opinions and post them on social media. People's thoughts, feelings and judgements can be analysed using a technique called sentiment analysis. Sentiment analysis provides an automated method for analysing sentiment, emotion and opinion in written language (Xu, Chang, Jayne, 2022). It is the process of analyzing, processing, generalizing, and reasoning about subjective texts with emotional overtones, such as valuable commentary information about people, time, products, etc., posted by users on the Internet (Deng, Ergu, Liu, Cai, Ma, 2022).

One of the most popular places 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). They can share their instantaneous thoughts or information on a wide range of topics or interests through short messages (known as "tweets") (Das, Sun, Dutta, 2015). Users have established certain conventions to support more conversational features. They can republish someone else's tweets ("retweeting"), and also use the "@" symbol and/or the "#" symbol when posting tweets. (Boyd, Golder, Lotan, 2010; Panagiotopoulos, Sams, 2012). By using the "@" users can directly address or refer to other users in conversations (Akshay Java Xiaodan Song, Tseng, 2007; Honeycutt, Herring, 2009). Using hashtags marked with the "#" symbol, users can categorize posts about a specific topic or event (Bruns, 2012; Small, 2011).

Twitter can be a source of big data. Downloaded data can be analyzed using various tools. Due to a large amount of data, text mining, data mining, machine learning, topic modelling, sentiment analysis and similar approaches are used. Social media data mining is an emerging field. It is gaining popularity due to its cost-effectiveness, accessibility, and anonymity (Das, Dutta, Medina, Minjares-Kyle, Elgart, 2019; Das et al., 2015; Evans-Cowley, Griffin, 2012). There are many studies in the literature on sentiment analysis based on data obtained from the Internet (Pang, Lee, 2004, 2008; Read, 2005). Many studies deal also with sentiment analysis of tweets (ALQARALEH, 2020; Antypas, Preece, Collados, 2022; Ayan, Kuyumcu, Ciylan, 2019; Çoban, Tümüklü Özyer, 2018; Das et al., 2019; FADEL, Cemil, 2020; Gabarron, Dechsling, Skafle, Nordahl-Hansen et al., 2022; Garcia, Berton, 2021; Go, Huang, Bhayani, 2009; Nezhad, Deihimi, 2022; Sarlan, Nadam, Basri, 2014; Sunitha, Patra, Babu, Suresh, Gupta, 2022; Zavattaro, French, Mohanty, 2015). By examining current or popular topics with sentiment analysis over social network data it is possible to have an idea about the future of these topics (Ağralı, AYDIN, 2021).

2. Research methodology

On 11.05.2022. 20298 tweets were retrieved from Twitter. The snsrape library for Python was used for this. This library contains various functions to collect tweets, user information, profile information, hashtags and comments. It makes these elements available through a Twitter API-free interface. It provides helpful flags that help filter tweets based on conditions such as the number of likes, the number of replies, language, identification number of tweet 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 phrases in Polish: “pomp ciepła”, “pompa ciepła”, “pompach ciepła”, “pompami ciepła”, “pompa ciepła”, “pompe ciepła”, “pompie ciepła”, “pompo ciepła”, “pompom ciepła”, “pompy ciepła”. These phrases are in all possible grammatical cases for the Polish language and are translations of the terms: "heat pump" and "heat pumps".

In the next step author removed:

- tweets, which were written in languages other than Polish,
- duplicated tweets (some tweets were retrieved several times because they contained more than one phrase used during the search e.g. “pompe ciepła” and “pompy ciepła”),
- tweets whose content was identical to the content of other tweets (it was often 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 “==”

In the next step, the content of the tweets was pre-processed. URLs, hashtags, emojis, users' names and all characters except letters were removed from the content of the tweets. The phrases used to search for tweets have also been removed so that they do not take part in the calculation of a tweet's sentiment value. Next, the number of words in the cleaned content of each tweet was checked, not including words considered unhelpful (such as stop words, conjunctions or prepositions). Tweets that had less than 2 words were removed. After these actions, the number of tweets was 11830. These tweets formed the corpus named Corpus_1. This number of tweets was published by 3731 users.

In the next step, the **ccl_emo** (<https://wiki.clarin-pl.eu/...>; <https://clarin-pl.eu/...>) service (developed by CLARIN-PL¹) was used. This service also has the names “Wydźwięk” (in Polish) and “Sentiment” (in English). It is a service for statistical analysis of the overtone and emotions in texts (Grubljesic, Coelho, Jaklic, 2019; Janz, Kocoń, Piasecki, Zaśko-Zielińska, n.d.). It can be used in the Python language². In addition to this service, other CLARIN-PL's services were used. These were:

- Any2txt - service that converts a file containing text (e.g. doc, docx, xlsx) into text.
- Speller2 – a service for checking the spelling of the text. It uses the Autocorrect (<https://languagetool.org/pl/>) tool to correct text.
- Wcrft2 - is a simple morpho-syntactic tagger for Polish.
- WSD - a service for word sense disambiguation. It works for Polish texts and as a source of possible senses using plWordNet (plWordNet 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.).

Sample tweet	Winą nie są domy jednorodzinne, a <i>wysoka</i> [1] cena gazu i pomp ciepła (często też <i>brak</i> [-1] <i>dostępu</i> [1] do sieci gazowej), dopuszczenie na rynek <i>kiepskiej</i> [-1] jakości węgla, <i>śmiesznie</i> [1] <i>niskie</i> [-1] kary za palenie śmieciami, <i>slaba</i> [-1] egzekucja prawa. Bloki też bywają opalane węglem (i byle czym)...
Sentiment calculation	<i>wysoka</i> [1] + <i>dostępu</i> [1] + <i>śmiesznie</i> [1] = 3 <i>brak</i> [-1] + <i>kiepskiej</i> [-1] + <i>niskie</i> [-1] + <i>slaba</i> [-1] = -4 The number of positive words (3) < The number of negative words (4) Sentiment of tweet = negative

Figure 1. Example of calculating sentiment of a tweet.

Sources: original research.

At this stage, the cleaned content of each tweet was saved to a separate text file and processed sequentially by Any2txt, Speller2, Wcrft2, WSD and ccl_emo services. Among others, checking the spelling and word sense disambiguation was performed. For words sense the emotive information (polarity - positive, negative, neutral or ambiguous) was retrieved. This information was saved to separate text files - each tweet to one file. Based on the data from

¹ CLARIN-PL is a Polish scientific consortium, part of the European Research Infrastructure CLARIN (Common Language Resources and Technology Infrastructure) (CLARIN-PL, n.d.).

² This service is also available as a web application at <http://ws.clarin-pl.eu/sentyment.shtml>.

these files, the sentiment for each tweet was calculated. The calculation of the sentiment of a tweet is shown in figure 1. The figure shows one of the tweets downloaded. The square brackets contain information about the polarity of the words in front of them. Words with negative polarity have a value of -1. Words with positive polarity have a value of 1.

If the number of negative words is greater than the number of positive words, the tweet has a negative sentiment. If the number of negative words is less than the number of positive words, the tweet has a positive sentiment. If the number of positive words is equal to the number of negative words tweet has a neutral sentiment.

Table 1.

Number of tweets and users in Corpus_2

Number of		Total number of tweets	Percentage of tweets in Corpus_1
tweets	users		
1	2467	2467	20,9%
2	513	1026	8,7%
3	243	729	6,2%
4	114	456	3,9%
5	95	475	4,0%
6	50	300	2,5%
7	31	217	1,8%
8	26	208	1,8%
Total	3539	5878	49,7%

Source: original research.

Table 2.

Number of tweets and users in Corpus_3

Number of		Total number of tweets	Percentage of tweets in Corpus_1
tweets	users		
606	1	606	5,1%
408	1	408	3,4%
259	1	259	2,2%
218	1	218	1,8%
194	1	194	1,6%
128	1	128	1,1%
115	1	115	1,0%
Total	7	1928	16,3%

Source: original research.

During the analysis, it was noted that there are differences in the number of tweets published by users. Therefore, the author decided to analyse two additional corpora (Corpus_2 and Corpus_3) which were subsets from Corpus_1. Tweets of users who posted between 1 and 8 tweets formed Corpus_2. Table 1 provides information about this corpus. It can be read from it that, 2467 users published one tweet (2467 tweets in total, which is 20.9% of the tweets in Corpus_1), 513 users published 2 tweets (1026 tweets in total, which is 8.7% of the tweets in Corpus_1). Corpus_2 included 49.7% of tweets from Corpus_1. This corpus was formed by the tweets published by 3539 users.

Tweets of users who posted between 115 and 606 tweets formed Corpus_3. Table 2 provides information about this corpus. It can be read from it that, each of the seven users published 606, 406, 259, 218, 194, 128, and 115 tweets respectively. The percentage of tweets from Corpus_3 in Corpus_1 was 16,3%.

3. Results

Figure 2 shows how many tweets from Corpus_1, Corpus_2 and Corpus_3 were published each year. Tweets from Corpus_3 have been published since 2015 and from Corpus_1 and Corpus_2 from 2009. The number of tweets has been increasing since 2016. The number of tweets for 2022 is lower than for 2021, but this is because for 2022 figure only shows tweets published between 01.01.2022 and 11.05.2022. When we compare the number of tweets published in January, February March, and April for 2021 and 2022 we can assume that the number of tweets in 2022 will be higher than in 2021.

Figure 3 shows the percentage of positive, negative and neutral tweets. For all tweets analysed (Corpus_1) 37% had a positive sentiment., 15% negative sentiment and 48% were neutral. Corpus_2 had similar values of 35% positive, 16% negative, 49% neutral respectively. Corps_3 had fewer negative (12%) and neutral tweets (44%) and more positive tweets (44%) than Corps_2 and Corps_1. All corpuses had more positive than negative tweets.

Figure 4 shows the percentage of positive, negative and neutral tweets by year. As we can see, there were no tweets with negative sentiment in Corps_1 and Corps_2 in 2009. Analysing the results, it can be seen that the percentage of negative tweets has increased since 2009 (for Corpus_1, for example, it was 0% in 2009, 5% in 2010, 11% in 2018 and 21% in 2021). At the same time, the share of tweets with a neutral sentiment has decreased. The decreasing share of tweets with a neutral sentiment can be seen especially in Corpus_3. The percentage of tweets with a positive sentiment from 2018 to 2022 ranged between 37% - 41% for corpus_1 and 33% - 42% for corpus_2. From 2018 to 2021, the percentage of negative tweets tended to increase and the percentage of neutral tweets trended downwards.

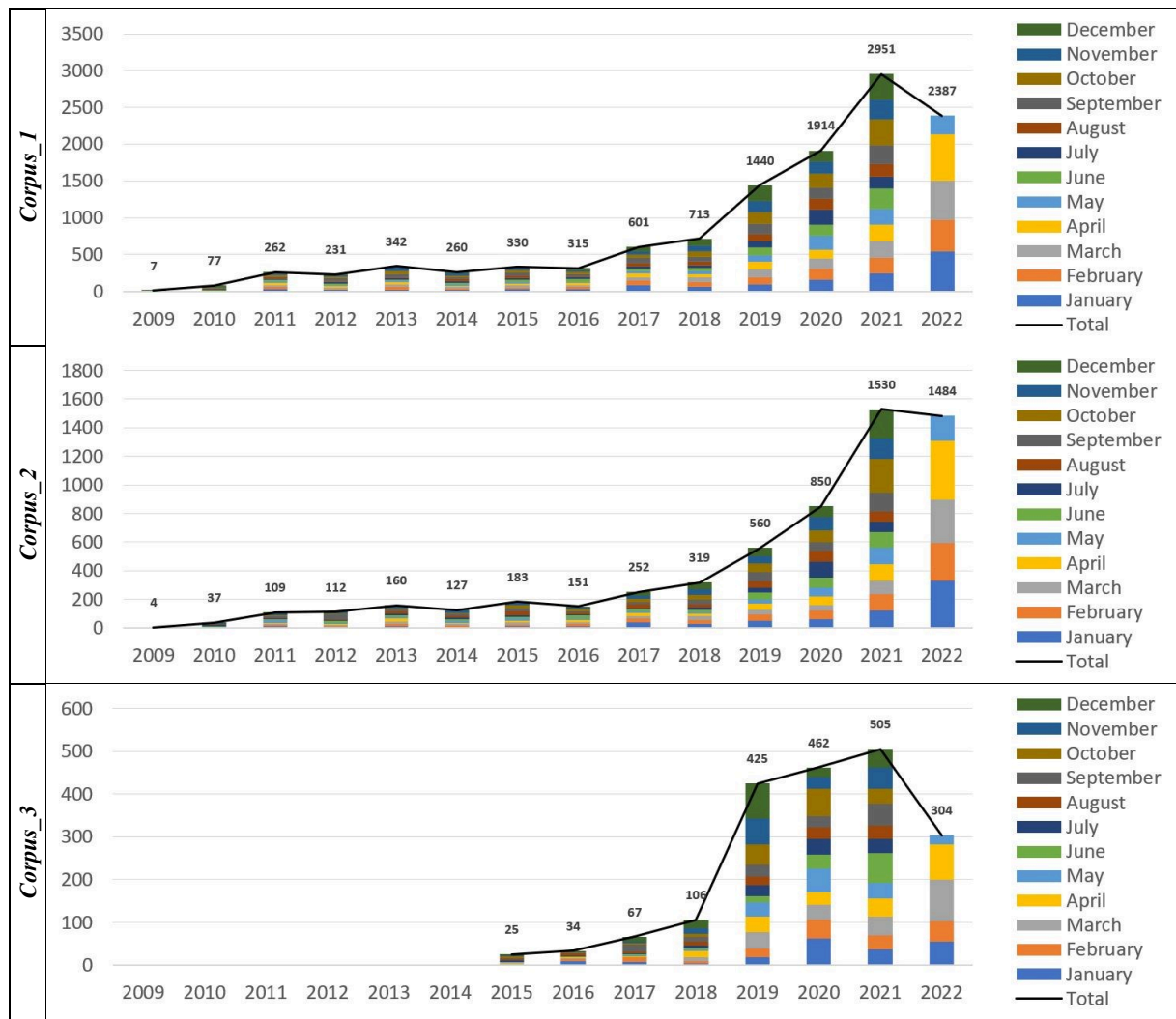


Figure 2. The number of tweets by year.

Sources: original research.

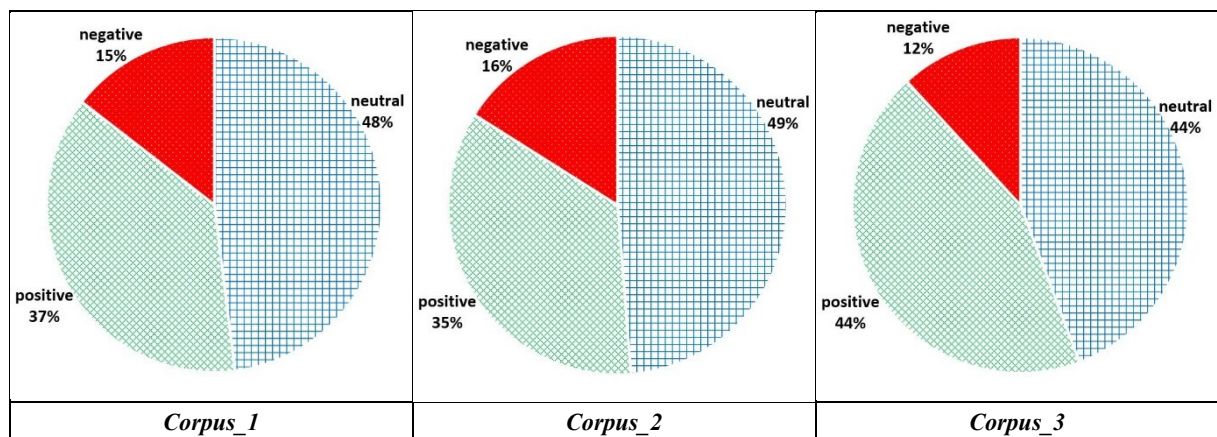


Figure 3. Percentage of positive, negative and neutral tweets.

Sources: original research.

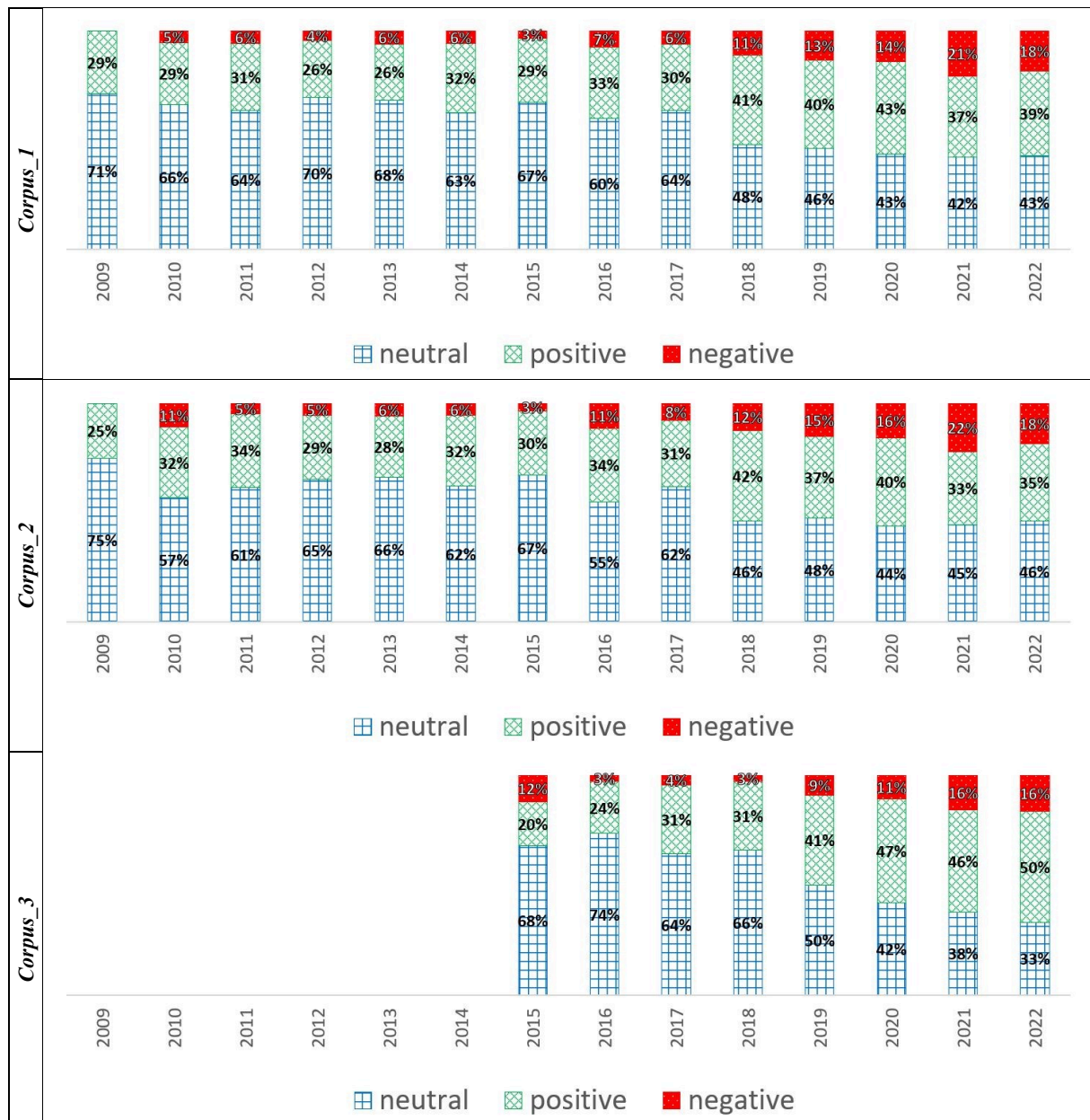


Figure 4. Percentage of positive, negative and neutral tweets by year.

Sources: original research.

Figure 5 shows as a words cloud the most common words in tweets for Corpus_1, Corpus_2 and Corpus_3. These words have been reduced to their base form. The upper part of the figure shows word clouds with the 2-gram “pompa ciepła” (Eng. heat pump). This 2-gram occurred often enough that the other words are much smaller. The lower part of the figure shows word clouds without this 2-gram. By analysing words from this figure is possible to determine what the tweets were about. Words such as “dom” (Eng. house), “budynek” (Eng. building), “ogrzewanie” (Eng. heating), “instalacja” (Eng. installation), “ciepło” (Eng. heat), “pompa” (Eng. pump), “piec” (Eng. heating oven), “woda” (Eng. water), “powietrze” (Eng. air) show that the content related to heating systems for houses and buildings. System for heating water and air. The word “powietrze” (Eng. air) can also indicate the type of heat pump used, and air

translations of the terms: “heat pump” and ”heat pumps” allowed to established the following conclusions:

- an increasing number of tweets show that interest in heat pumps is growing all the time, especially after the year 2016,
- for analysed tweets 37% had a positive sentiment., 15% negative sentiment and 48% were neutral,
- the percentage of negative tweets has increased since 2009 (it was 0% in 2009, 5% in 2010, 11% in 2018 and 21% in 2021),
- analysing the most frequently used words can determine that tweets did not only concern heat pump but also in general:
 - heating systems for houses and buildings, using different equipment and energy carriers,
 - system for heating water and air,
 - the type of heat pump,
 - the air quality,
 - systems for producing electricity from solar energy,
 - the information about solutions encouraging the replacement of non-ecological heat sources with ecological ones.

Research has confirmed that Twitter can be a source of big data. This data can be used for sentiment analysis to find out people's thoughts, feelings and opinions regarding “heat pumps”. This study identified only the opinions of those posting on Twitter in Polish.

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CAUSAL RELATIONSHIPS BETWEEN THE METALS MARKET AND THE STOCK MARKET IN THE FACE OF THE CHANGES TAKING PLACE IN THE MODERN WORLD

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Purpose: The high uncertainty on the industrial metals market that has occurred in recent years is an important premise for looking for methods that will allow for a good predict of the price of these raw materials and their volatility in the future. The detection of causal relationships between the price of metals and the rate of certain financial instruments may improve the quality of forecasts by reducing the variance of the prediction error. The aim of the research is to test of the causality between the rate of the selected metals and the factors influencing their price.

Design/methodology/approach: In order to study the causal relationships between the selected variables, the linear Granger test and the non-parametric Diks-Panchenko test were used. The second test can be used to detect causal relationships that are not necessarily linear.

Findings: In the first phase of the research, the Granger linear causality test of variable pairs was carried out. For this purpose, the equations of the VAR model with the same number of lags for both variables were estimated and the test of the total significance of the delays of a given variable was applied in the equation explaining the second variable. Then, in order to compare the obtained results, the non-parametric Diks-Panchenko test was used for the same variables.

Research limitations/implications: The indications of the Diks-Panchenko test depend on the number delays of variables. At a later stage of the research, one should, inter alia, check in more detail the influence of the delays adopted for the variables in this test.

Practical implications: Application in making investment decisions on the capital market.

Originality/value: The use of information on causal relationships to improve the quality of industrial metal price forecasts.

Keywords: Causality in the Granger sense, Diks-Panchenko test, metals market, the impact of the crisis and the pandemic.

Category of the paper: Research paper.

1. Introduction

Currently, metals are the subject of many market transactions and play a large role in various business strategies, where they are often treated as alternative and safe the investment assets. Therefore, it is important to observe and analyze the reasons that influence the changes in the price of these raw materials. The determinants of metal prices include, among others, the dollar exchange rate, rates of return on stock exchange indices, and crude oil. Research has shown that also demographic, macroeconomic and political factors influence the formation of commodity prices. However, there are many reasons for the volatility of commodity prices, and it is very difficult to determine which of them are the most important.

This article is largely empirical. Its overarching goal is to test the causality between the prices of copper and silver and the prices of specific financial instruments. For this purpose, the linear Granger test and the non-parametric Diks-Panchenko test were used. The literature (Syczewska, 2014) discusses the impact of the financial crisis on changes in the relationship of returns from financial instruments. Therefore, the results of the causality analysis for the crisis and in the pre-crisis period, and the results before and during the coronavirus pandemic were compared. The research used time series composed of the closing prices of selected financial assets obtained from the investment portals stooq.pl and investing.com. The research period covers the years 2005-2022, narrowed down to sub-periods in individual analyzes.

The article consists of two main parts: the first is theoretical (the methodology used in the analysis is briefly discussed and references to the literature are given), and the second is the analysis of financial data and its conclusions. The article ends with a summary.

2. Reasons for changes in copper and silver prices

Many industries today would not work without copper and silver. Copper is essential in the process of production, transmission, distribution and, above all, use of electricity. It is also a very good heat conductor, which is why it is of great importance in obtaining environmentally friendly energy, and therefore its importance for the energy sector is growing. The developments and breakthroughs made in telecommunications over the decades would not have been possible without this metal. Copper has also long played a vital role in the automotive industry. Without copper electrical and electronic components, intelligent motor and drive control would not be possible.

Silver, on the other hand, due to its properties, is used not only in jewelry, but also like copper, mainly in the manufacturing industry. It is an excellent guide and additionally has antibacterial properties. It is used in medicine and dental services, in the production of batteries

and accumulators, LED chips, touch screens, in the construction of nuclear reactors, in photography and water treatment, and many other industries.

Therefore, it can be concluded that the demand of the global industry is the most important factor influencing the prices of copper and silver. The prices of these metals are rising in line with the increase in global industrial production. In good times, their prices rise, and in case of a risk of recession, they drop. As copper is used in almost all electronics and machinery and equipment power applications, its price is one of the better leading indicators showing trends across the economy.

However, the development of technology is not the only factor that affects copper and silver prices. The world prices of these metals are also shaped by the supply and demand game on the world's leading commodity exchanges. In addition, the prices of these metals are given and settled in US dollars, therefore the level of their prices is also affected by the exchange rate, i.e. the relation of the dollar to other currencies. When the dollar depreciates against other currencies, the prices of copper and silver increase, and when the dollar appreciates, the prices of these metals decrease (Figure 1).

It should not be forgotten that the level of inventories also affects the prices of copper and silver in the global markets. The higher the stocks, the slower the prices of metals grow in the context of an economic boom, and their prices fall faster in a downturn.

The price of metals may also be affected by changes in the price of crude oil. This is due to the fact that crude oil, as a popular raw material used in industry, can be regarded as a signal of its future economic situation. An increase in industrial production may lead to an increase in the demand for crude oil and its prices. Taking into account the use of metals in industry, the relationship between the price of crude oil and the prices of metals (e.g. silver and copper - Figure 1) may also result from the fact that an increase in industrial production entails an increase in demand for metals in industrial applications, which may translate into an increase in their prices (Kasprzak-Czelej , 2018).

Copper and silver prices also changing under the speculative behavior of investors, inflation, stock indices, and events of global importance.

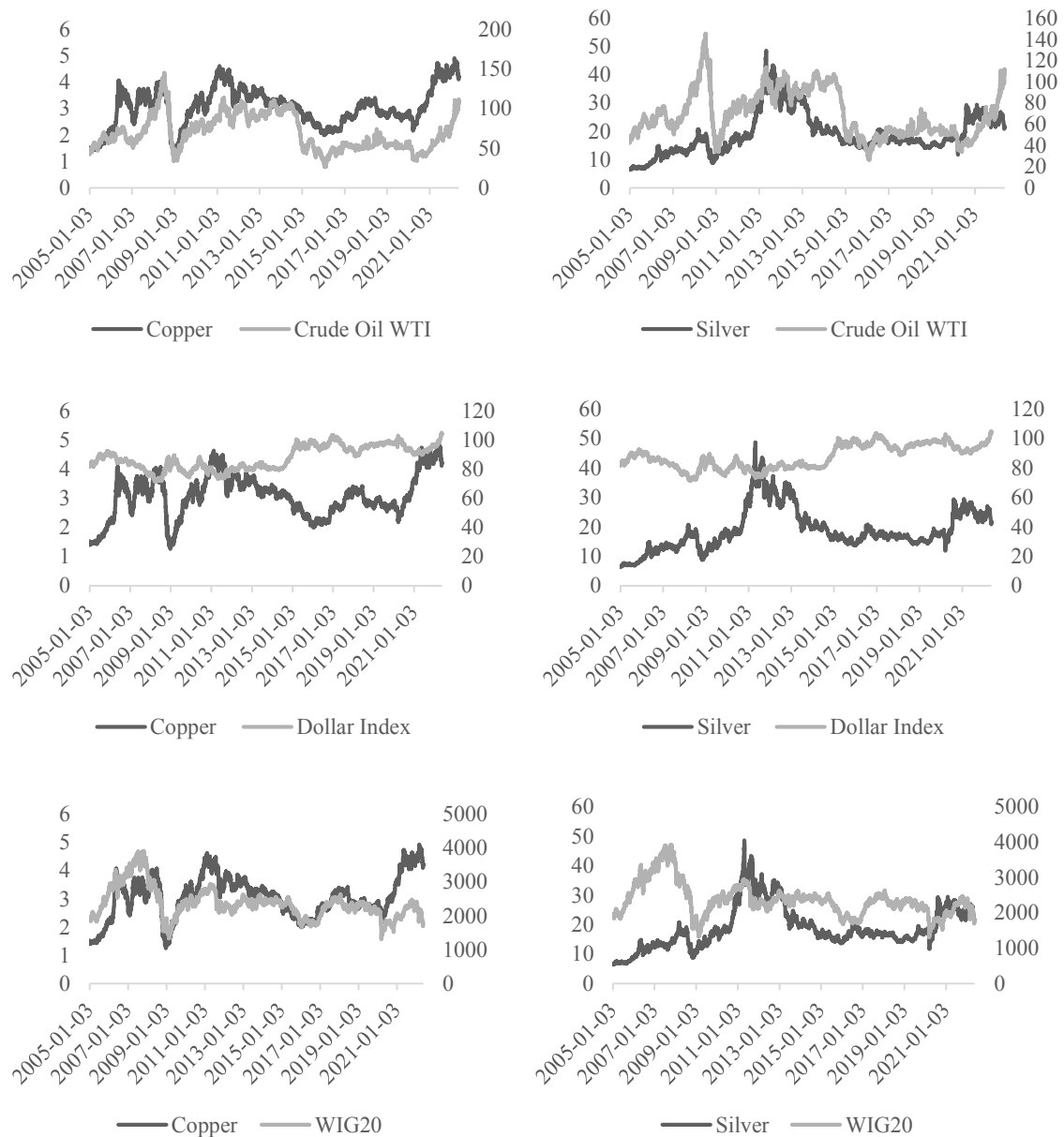


Figure 1. Development of silver and copper prices in comparison with the quotations of crude oil, the dollar index and the WIG20 stock exchange index in 2005-2022.

Source: own study.

3. Granger causality

Causality in the sense of Granger (Grenger, 1969) occurs when the variable X is the cause of the variable Y , i.e. if the current values of Y can be predicted with greater accuracy using the historical values of X , with the remaining information unchanged (Charemza, Deadman, 1997). This means that the forecast error for the Y variable will be smaller if the model includes the X variable than if it is omitted.

The definition of causality formulated by Granger concerns the occurrence of causal relationships between the stationary processes X_t and Y_t in the category of conditional probability distributions. By this definition, X_t is not the cause of Y_t if:

$$F\left(Y_t | \left(X_{t-l_x}, \dots, X_{t-1}; Y_{t-l_y}, \dots, Y_{t-1}\right)\right) = F\left(Y_t | \left(Y_{t-l_y}, \dots, Y_{t-1}\right)\right) \quad (1)$$

for any delay $l_x, l_y \geq 1$. In a situation where equation (1) does not hold, then X_t is the cause of Y_t , which in particular makes it possible to use the past values of X_t to predict Y_t .

The study of the occurrence of causal relationships consists in verifying the null hypothesis that X_t is not the cause of Y_t , which by definition is equivalent to condition (1). However, in econometric practice, the verification of the difficult-to-apply condition (1) is replaced by more operational methods (Orzeszko, Osińska, 2007). One of them is the limitation of the scope of the study to the identification of only linear causal relationships. In such a situation, the test consists in building and analyzing the VAR model with the same number of delays for both variables, k , and applying the test of the combined significance of the delays of a given variable in the equation explaining the second variable:

$$y_t = \alpha_{10} + \sum_{j=1}^k \alpha_{1j} y_{t-j} + \sum_{j=1}^k \beta_{1j} x_{t-j} + \varepsilon_{1t} \quad (2)$$

$$x_t = \alpha_{20} + \sum_{j=1}^k \alpha_{2j} x_{t-j} + \sum_{j=1}^k \beta_{2j} y_{t-j} + \varepsilon_{2t} \quad (3)$$

In equation (2), the null hypothesis:

$$H_0: \beta_{11} = \beta_{12} = \dots = \beta_{1k} = 0 \quad (4)$$

denotes no causal dependence in the Granger sense of the variable X to Y .

However, in the case of equality (3), the null hypothesis:

$$H_0: \beta_{21} = \beta_{22} = \dots = \beta_{2k} = 0 \quad (5)$$

denotes the lack of (linear) causality of the variable Y to X .

Causality in the Granger sense enables the study of information transmission between variables and the identification of the directions of the causality flow of the observed changes (Orzeszko, Osińska, 2007).

4. Nonlinear dependency test

Let (X, Y, Z) denote a random vector of the form $(X, Y, Z) = \left(X_{t-l_x}^{t-1}, Y_{t-l_y}^{t-1}, Y_t\right)$, and f is the probability density function. Diks and Panchenko (2006) proved that the null hypothesis, according to which X_t is not the cause of Y_t , means that the equality is satisfied:

$$\frac{f_{X,Y,Z}(x,y,z)}{f_Y(y)} = \frac{f_{X,Y}(x,y)}{f_Y(y)} \frac{f_{Y,Z}(y,z)}{f_Y(y)} \quad (6)$$

They also indicated that the following equality is equivalent to the key formula of Hiemstra and Jones (1994) as the starting point for nonlinear causality analysis:

$$\frac{E[f_{X,Y,Z}(x,y,z)]}{E[f_Y(y)]} = \frac{E[f_{X,Y}(x,y)]}{E[f_Y(y)]} \frac{E[f_{Y,Z}(y,z)]}{E[f_Y(y)]} \quad (7)$$

where

$$E[f_W(w)] = \int f_W^2(s) ds \quad (8)$$

is interpreted as a measure of the concentration of the random vector W .

In their study, they showed that in order to study causality, one should not focus on equality (7), but study the following formula:

$$E \left[\frac{f_{X,Y,Z}(x,y,z)}{f_Y(y)} - \frac{f_{X,Y}(x,y)}{f_Y(y)} \frac{f_{Y,Z}(y,z)}{f_Y(y)} \right] = 0 \quad (9)$$

Thus, the implication of the null hypothesis is as follows.

$$E \left[\left(\frac{f_{X,Y,Z}(x,y,z)}{f_Y(y)} - \frac{f_{X,Y}(x,y)}{f_Y(y)} \frac{f_{Y,Z}(y,z)}{f_Y(y)} \right) g(X, Y, Z) \right] = 0 \quad (10)$$

where $g(X, Y, Z)$ is a positive weighting function. Assuming that the null hypothesis is true, this expression is zero because by the formula (9) the value in parentheses is equal to zero. We reject the null hypothesis when the calculated value of the test statistic is too high.

For $g(X, Y, Z) = f_Y^2(Y)$ formula (10) takes the form:

$$E[f_{X,Y,Z}(x, y, z)f_Y(y) - f_{X,Y}(x, y)f_{Y,Z}(y, z)] = 0 \quad (11)$$

Its estimator is based on the indicator function and is expressed by the formula:

$$T_n = \frac{(2\varepsilon)^{-1}x^{-1}y^{-1}}{n(n-1)(n-2)} \sum_i [\sum_{k,k \neq i} \sum_{j,j \neq i} (I_{ik}^{XYZ} I_{ij}^Y - I_{ik}^{XY} I_{ij}^{YZ})] \quad (12)$$

where n is number of observations, $I(\cdot)$ is indicator function:

$$I_{ij}^W = I(\|W_i - W_j\| \leq \varepsilon) = \begin{cases} 1, & \|W_i - W_j\| \leq \varepsilon \\ 0, & \|W_i - W_j\| > \varepsilon \end{cases} \quad (13)$$

$\|\cdot\|$ denotes norm supremum.

5. Empirical analysis of causality

Conducting a study of linear and nonlinear causality requires quite a complicated time series analysis. In the study, for each analyzed variable, daily time series covering the period from the beginning of 2005 to May 2022 were prepared. Days for which one or more variables were missing were removed from the sample. To carry out the necessary analyzes, selected data were taken from the investment portals stooq.pl and investing.com. All calculations were made with the use of Gretl and GC programs and Microsoft Excel package. The abbreviations used in the

further considerations and the basic descriptive statistics for the variables under consideration are presented in Tables 1 and 2:

Table 1.

Full and abbreviated variable names

Full name of the time series	Abbreviate name of the time series
Copper Futures	CU_F
Silver Futures	SI_F
Crude Oil WTI Futures	CL_F
U.S. Dollar Index Futures	DX_F
Stock Exchange Index WIG20	WIG20
KGHM Polska Miedź SA	KGH

Source: own study.

The selection of the above series for the study was based on a previous analysis of the factors influencing changes in the prices of copper and silver. On the other hand, the testing of causality between the prices of these metals and the closing prices of KGHM was dictated by the fact that the company is the largest producer of copper and silver in Poland.

Table 2.

Selected statistics for the full sample

Series	Mean	Median	Stan. Dev.	Kurtosis	Skewness	Range	Min	Max	ADF	p-value
CU_F	3.0627	3.0955	0.7377	-0.2589	-0.0874	1714875	230105	2638969	-2.6502	0.2578
SI_F	18.881	17.1450	7.1728	0.7417	0.9184	42.1570	865778	48.5840	-2.3787	0.3907
CL_F	69.739	63.6300	22.0957	-0.5165	0.5665	119.080	26.2100	145.2900	-1.8739	0.668
DX_F	87.499	86.5900	8.0746	-1.2639	0.0086	33.520	71.3300	104.8500	-2.2124	0.4821
WIG20	2366.7	2324.820	459.9313	1.2995	0.9510	2612.140	1305.73	3917.870	-3.1209	0.1013
KGH	86.123	89.7430	43.6544	-0.0890	0.3446	212.5444	678136	221.9200	-2.5998	0.2804

Source: own study.

The stationarity study of the time series under consideration is a starting point in the Granger causality study. The ADF test (Table 2) provided a solid basis for stating that all the time series considered are non-stationary (stationarity tests were performed at a significance level of 5%).

Table 3.

Selection of the number of delays in the VAR model and the results of the Granger test for pairs of returns on financial instruments

Variable pairs	AIC	BIC	Hypothesis H_0	Test G [p-value]	Hypothesis H_0	Test G [p-value]
CU_F/CL_F	0.731(3)	0.749(2)	CU_F \rightarrow CL_F	0.7481 [0.5233]	CL_F \rightarrow CU_F	5.8630 [0.0005]
CU_F/DX_F	-2.066(2)	-2.052(1)	CU_F \rightarrow DX_F	3.7562 [0.0234]	DX_F \rightarrow CU_F	0.0981 [0.9066]
CU_F/WIG20	6.665(3)	6.680(2)	CU_F \rightarrow WIG20	0.5987 [0.6158]	WIG20 \rightarrow CU_F	3.8510 [0.0091]
CU_F/KGH	1.212(4)	1.228(2)	CU_F \rightarrow KGH	1.6977 [0.1476]	KGH \rightarrow CU_F	11.739 [0.0000]
SI_F/CL_F	5.121(6)	5.143(2)	SI_F \rightarrow CL_F	2.9910 [0.0064]	CL_F \rightarrow SI_F	4.5383 [0.0001]
SI_F/DX_F	2.253(3)	2.263(1)	SI_F \rightarrow DX_F	3.6662 [0.0118]	DX_F \rightarrow SI_F	1.5236 [0.2062]
SI_F/WIG20	11.11(5)	11.12(1)	SI_F \rightarrow WIG20	3.4833 [0.0038]	WIG20 \rightarrow SI_F	1.0738 [0.3727]
SI_F/KGH	5,689(5)	5,707(2)	SI_F \rightarrow KGH	3.9627 [0.0014]	KGH \rightarrow SI_F	6.8678 [0.0000]

Source: own study.

In the next step, the results of studies on linear and non-linear causality are presented. The numbers in Tables 3 and 4 represent the values of the Granger test (G test) and the Diks-Panchenko test (D-P test) and the probability values (in square brackets) obtained when testing

the null hypothesis of no causality. The situations in which the test showed the existence of causality at the significance level of 10% are marked in bold (Gurgul, Lach, 2009).

Table 4.

Diks-Panchenko test results for pairs of returns on financial instruments

Hypothesis H_0	l	Test D-P [p -value]	Hypothesis H_0	l	Test D-P [p -value]
CU_F \rightarrow CL_F	1	3.589[0.0002]	CL_F \rightarrow CU_F	1	2.579[0.0049]
	2	2.994[0.0014]		2	2.370[0.0089]
	3	2.304[0.0106]		3	2.748[0.0029]
	4	0.667[0.2524]		4	1.288[0.0989]
CU_F \rightarrow DX_F	1	2.811[0.0025]	DX_F \rightarrow CU_F	1	1.406[0.0799]
	2	2.543[0.0055]		2	1.909[0.028]
	3	0.113[0.4549]		3	2.106[0.0176]
	4	-0.208[0.5824]		4	1.526[0.0635]
CU_F \rightarrow WIG20	1	5.225[0.0000]	WIG20 \rightarrow CU_F	1	2.641[0.0041]
	2	2.615[0.0045]		2	1.717[0.0429]
	3	1.611[0.0536]		3	0.970[0.1661]
	4	1.269[0.1022]		4	1.608[0.0539]
CU_F \rightarrow KGH	1	5.995[0.0000]	KGH \rightarrow CU_F	1	2.595[0.0047]
	2	3.783[0.0001]		2	2.586[0.0049]
	3	1.604[0.0544]		3	1.032[0.1509]
	4	1.067[0.1431]		4	0.341[0.3667]
SI_F \rightarrow CL_F	1	3.747[0.0001]	CL_F \rightarrow SI_F	1	3.815[0.0001]
	2	2.300[0.0107]		2	2.410[0.0079]
	3	2.268[0.0117]		3	2.469[0.0068]
	4	2.217[0.0133]		4	2.375[0.0088]
SI_F \rightarrow DX_F	1	2.894[0.0019]	DX_F \rightarrow SI_F	1	3.314[0.0005]
	2	2.076[0.0189]		2	2.037[0.0208]
	3	1.688[0.0457]		3	1.676[0.0469]
	4	1.006[0.1572]		4	0.579[0.2812]
SI_F \rightarrow WIG20	1	3.383[0.0004]	WIG20 \rightarrow SI_F	1	2.650[0.0040]
	2	1.882[0.0299]		2	2.387[0.0085]
	3	1.923[0.0273]		3	1.938[0.0263]
	4	1.707[0.0439]		4	1.237[0.1081]
SI_F \rightarrow KGH	1	3.890[0.0001]	KGH \rightarrow SI_F	1	1.973[0.0243]
	2	2.414[0.0079]		2	2.250[0.0122]
	3	1.395[0.0815]		3	1.239[0.1076]
	4	0.857[0.1956]		4	0.067[0.4732]

Source: own study.

For each of the models considered, the maximum delay order was set at the level $r_{max} = 10$, and then, using the Akaike information criteria (AIC) and Bayesian Schwarz criterion (BIC), the optimal delay order was selected from the $\{1, 2, \dots, r_{max}\}$ set. Their values were determined for 10 delays, and the optimal number of delays for each criterion was given in brackets (Table 3). Then, the models for the logarithmic returns were estimated (Osińska, 2008) and the cumulative significance test was applied to the first 2 delays, corresponding to the null hypothesis. It should also be added that in the case of nonlinear tests for each of the analyzed pairs of variables (Table 4), different delay levels were used: $l = 1, 2, 3, 4$ and the parameter $\varepsilon = 0.5$ (Syczewska, 2014).

In the causality analysis carried out using the Granger test among 8 pairs of variables, 2 two-way relationships were recorded (for pairs silver and crude oil, and silver and KGHM) and 6 one-way relationships. It was also noted that changes in the prices of crude oil and KGHM's shares are driving the price of metals. Additionally, the price of the WIG20 stock

exchange index has an impact on copper. It follows that the inclusion of appropriate delayed variables in the individual equations allows for a better explanation and prediction of the development of the studied phenomena.

The results of the Diks-Panchenko test calculation (Table 4) indicate that the statistic may have different values with a different number of lags in the pair of variables. The analysis focused on the results for the value $l = 1$. The obtained results indicated the existence of bidirectional relations for all pairs of variables.

6. Testing of causality for pre-crisis and crisis, and pre-pandemic and pandemic periods

An interesting issue is the impact of the crisis or pandemic of coronavirus on possible changes in the direction of the causal relationship. Based on the literature (Olbryś, Majewska, 2014), the following subperiods were selected: 1.2005-9.2007 the period before the financial crisis and 10.2007-2.2009 as the period of the global crisis. This selection of dates allowed for the creation of time series with the same number of observations. The next two subperiods for the coronavirus pandemic include the following dates: pre-pandemic - 2.2018-2.2020; pandemic time - 3.2020-3.2022.

Based on the AIC and BIC information criteria, the selection of the optimal delay order was presented again, determined for the variables covering the periods before and during the financial crisis, as well as before the coronavirus pandemic and during the pandemic. The optimal number of delays for each criterion is shown in parentheses (Table 5).

In Table 6, columns 2 and 3 contain the values of the Granger test statistics for the pre-crisis period and during the crisis, and columns 4 and 5 for the pre-Covid 19 and during the pandemic period. Values for which the hypothesis of no causality has been rejected are marked in bold.

Table 5.

Selection of delays in the the number of VAR model for pairs of variables for the periods: before and during the financial crisis and before the coronavirus pandemic. and during the pandemic

Variable pairs	Before crisis		Crisis		Before pandemic		Pandemic	
	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
CU_F / CL_F	-9.96(1)	-9.89(1)	-8.12(1)	-8.05(1)	-10.56(4)	-10.44(2)	-10.22(5)	-10.17(1)
CU_F / DX_F	-13.20(3)	-13.13(1)	-11.37(1)	-11.30(1)	-14.89(4)	-14.83(1)	-14.02(1)	-13.96(1)
CU_F / WIG20	-10.33(1)	-10.26(1)	-9.08(1)	-9.01(1)	-12.39(3)	-12.34(1)	-11.17(7)	-11.07(1)
CU_F / KGH	-9.31(2)	-9.23(1)	-8.21(1)	-8.14(1)	-11.34(1)	-11.29(1)	-10.17(2)	-10.11(1)
SI_F / CL_F	-10.06(1)	-9.99(1)	-7.97(1)	-7.00(1)	-10.32(3)	-10.22(2)	-9.12(2)	-9.06(1)
SI_F / DX_F	-13.49(1)	-13.42(1)	-11.51(1)	-11.44(1)	-14.75(1)	-14.70(1)	-13.05(3)	-12.98(1)
SI_F / WIG20	-10.43(3)	-10.34(1)	-8.93(1)	-8.86(1)	-12.09(1)	-12.04(1)	-10.09(4)	-10.02(1)
SI_F / KGH	-9.24(3)	-9.15(1)	-7.88(6)	-7.81(1)	-10.87(1)	-10.81(1)	-9.04(4)	-8.99(1)

Source: own study.

Table 6.

Results of the linear Granger test for pairs of financial instruments obtained for the periods: before and during the financial crisis and before the coronavirus pandemic and during the pandemic

Hypothesis H_0	Before crisis	Crisis	Before pandemic	Pandemic
CU_F \rightarrow CL_F	1.3564 [0.2450]	0.4540 [0.5009]	0.9113 [0.4571]	1.1741 [0.3208]
CL_F \rightarrow CU_F	4.1486 [0.0424]	1.2002 [0.2740]	2.1156 [0.0778]	3.3072 [0.0060]
CU_F \rightarrow DX_F	1.8946 [0.1302]	4.2351 [0.0403]	1.7886 [0.1298]	8.4880 [0.0037]
DX_F \rightarrow CU_F	0.5456 [0.6514]	0.0066 [0.9352]	3.0279 [0.0174]	2.2999 [0.1300]
CU_F \rightarrow WIG20	0.0235 [0.8784]	0.0067 [0.9347]	1.1508 [0.3281]	6.2972 [0.0000]
WIG20 \rightarrow CU_F	1.4242 [0.2335]	0.3902 [0.5326]	3.1498 [0.0248]	0.9827 [0.4430]
CU_F \rightarrow KGH	4.0879 [0.0176]	0.0150 [0.9025]	0.2289 [0.6325]	1.9217 [0.1474]
KGH \rightarrow CU_F	5.5501 [0.0042]	6.5737 [0.0108]	6.3926 [0.0118]	3.5405 [0.0297]
SI_F \rightarrow CL_F	2.2084 [0.1382]	1.9741 [0.1609]	1.1200 [0.3405]	0.0387 [0.9620]
CL_F \rightarrow SI_F	0.0113 [0.9152]	3.8760 [0.0498]	0.8248 [0.4806]	7.0474 [0.0010]
SI_F \rightarrow DX_F	0.8596 [0.3545]	6.5690 [0.0108]	6.4944 [0.0111]	2.1064 [0.0985]
DX_F \rightarrow SI_F	0.0632 [0.8016]	0.0580 [0.8098]	0.0776 [0.7806]	10.104 [0.0000]
SI_F \rightarrow WIG20	5.3212 [0.0014]	0.4360 [0.5095]	1.5293 [0.2168]	8.7057 [0.0000]
WIG20 \rightarrow SI_F	0.8114 [0.4882]	0.3594 [0.5493]	0.8174 [0.3664]	0.9074 [0.4594]
SI_F \rightarrow KGH	5.1524 [0.0017]	2.7386 [0.0130]	0.1502 [0.6986]	5.3989 [0.0003]
KGH \rightarrow SI_F	0.8224 [0.4822]	2.5466 [0.0200]	0.2308 [0.6312]	1.7043 [0.1478]

Source: own study.

Granger's test suggests the presence of two-sided causality in the periods: before the crisis only for the pair {CU_F, KGHM}; crisis - {SI_F, KGH}; pandemic - {SI_F, DX_F}. The results obtained partially confirm the influence of the crude oil, dollar, and WIG20 indexes on the price of copper, but not the other way round. The impact of crude oil can be observed during a crisis, before a pandemic, and during a pandemic. On the other hand, the dollar index and WIG20 only in the period before the pandemic. In the case of silver, the impacts of crude oil in crisis and pandemic periods and the dollar index in pandemic period can be observed.

Then, for the same variables, the nonparametric Diks-Panchenko test was used in the sample covering the pre-crisis and pre-pandemic period and the period of crisis and pandemic (Tables 7-10).

Table 7.

Results of the non-linear Diks-Panchenko test for pairs composed of copper returns and selected financial instruments obtained for the periods before and during the financial crisis

Hypothesis H_0	l	Before crisis	Crisis	Hypothesis H_0	l	Before crisis	Crisis
CU_F \rightarrow CL_F	1	-0.763[0.7773]	-1.093[0.1372]	CL_F \rightarrow CU_F	1	-1.394[0.9184]	0.958[0.1689]
	2	-1.200[0.8849]	-0.443[0.6711]		2	-0.844[0.8005]	0.373[0.3547]
	3	-0.910[0.8187]	-0.440[0.6699]		3	-0.445[0.6718]	0.812[0.2084]
	4	0.173[0.4313]	0.478[0.3164]		4	-0.691[0.7551]	0.111[0.4558]
CU_F \rightarrow DX_F	1	1.330[0.0917]	-2.068[0.0193]	DX_F \rightarrow CU_F	1	0.093[0.4631]	0.113[0.4551]
	2	-0.245[0.5967]	0.938[0.1741]		2	-0.771[0.7797]	-0.086[0.5341]
	3	0.500[0.3087]	0.130[0.4483]		3	-0.403[0.6566]	0.155[0.4385]
	4	-0.789[0.7851]	-0.752[0.7741]		4	-0.128[0.5509]	-0.431[0.6669]
CU_F \rightarrow WIG20	1	0.304[0.3807]	1.794[0.0364]	WIG20 \rightarrow CU_F	1	0.909[0.1816]	-0.443[0.6712]
	2	-0.122[0.5487]	0.130[0.4481]		2	0.690[0.2450]	-0.588[0.7219]
	3	0.557[0.2887]	0.683[0.2474]		3	0.319[0.3748]	-0.647[0.7411]
	4	-0.589[0.7222]	-1.036[0.8499]		4	0.201[0.4202]	-0.103[0.5409]

Cont. table 7.

CU_F → KGH	1	0.295[0.3842]	2.388[0.0085]	KGH → CU_F	1	1.339[0.0903]	-0.290[0.6142]
	2	0.311[0.3779]	0.624[0.2664]		2	0.441[0.3297]	-0.193[0.5766]
	3	-1.128[0.8703]	-0.019[0.5076]		3	-0.498[0.6907]	-0.604[0.7269]
	4	-0.978[0.8359]	0.511[0.3047]		4	-0.439[0.6696]	-0.042[0.5167]

Source: own study.

Table 8.

Results of the non-linear Diks-Panchenko test for pairs composed of silver returns and selected financial instruments obtained for the periods before and during the financial crisis

Hypothesis H_0	l	Before crisis	Crisis	Hypothesis H_0	l	Before crisis	Crisis
SI_F → CL_F	1	-1.394[0.9183]	0.325[0.3726]	CL_F → SI_F	1	-0.155[0.5616]	0.813[0.2082]
	2	-0.574[0.7169]	0.502[0.3078]		2	-1.086[0.8614]	0.179[0.4289]
	3	-0.687[0.7541]	-0.675[0.7502]		3	-0.425[0.6644]	0.357[0.3605]
	4	0.588[0.2782]	0.739[0.2301]		4	-0.365[0.6426]	0.479[0.3159]
SI_F → DX_F	1	0.390[0.3482]	72.41[0.0078]	DX_F → SI_F	1	1.536[0.0622]	-0.387[0.6506]
	2	0.287[0.3869]	0.533[0.2971]		2	0.967[0.1667]	0.901[0.1838]
	3	0.169[0.4329]	-0.044[0.5174]		3	0.715[0.2374]	0.556[0.2892]
	4	0.298[0.3830]	0.667[0.2524]		4	1.095[0.1366]	0.685[0.2467]
SI_F → WIG20	1	1.208[0.1135]	1.018[0.1543]	WIG20 → SI_F	1	-0.394[0.6534]	-0.568[0.7149]
	2	-0.336[0.6316]	0.007[0.4973]		2	0.188[0.4256]	0.827[0.2042]
	3	0.854[0.1966]	0.471[0.3189]		3	0.924[0.1777]	-0.248[0.5979]
	4	0.788[0.2155]	1.459[0.0723]			0.048[0.4809]	0.374[0.3542]
SI_F → KGH	1	-0.230[0.5909]	-0.238[0.5942]	KGH → SI_F	1	1.147[0.1257]	0.197[0.4217]
	2	-0.401[0.6559]	0.326[0.3723]		2	0.514[0.3035]	0.301[0.3816]
	3	-1.342[0.9102]	-0.931[0.8241]		3	-0.943[0.8272]	-1.359[0.9129]
	4	-0.148[0.5587]	-0.808[0.7905]		4	0.205[0.4187]	-0.688[0.7542]

Source: own study.

Table 9.

Results of the non-linear Diks-Panchenko test for pairs composed of copper returns and selected financial instruments obtained for the periods before the coronavirus pandemic and during the pandemic

Hypothesis H_0	l	Before pandemic	Pandemic	Hypothesis H_0	l	Before pandemic	Pandemic
CU_F → CL_F	1	-0.307[0.6206]	-0.761[0.7766]	CL_F → CU_F	1	0.594[0.2762]	-0.346[0.6354]
	2	-0.109[0.5432]	-1.259[0.8960]		2	-0.211[0.5837]	-1.042[0.8513]
	3	-0.441[0.6706]	-1.698[0.9552]		3	1.047[0.1476]	-0.381[0.6485]
	4	-0.972[0.8344]	-1.290[0.9015]		4	-0.278[0.6094]	0.040[0.4839]
CU_F → DX_F	1	0.410[0.3408]	0.890[0.1868]	DX_F → CU_F	1	1.434[0.0757]	-0.884[0.8116]
	2	0.070[0.4720]	0.874[0.1908]		2	0.942[0.1730]	-0.343[0.6343]
	3	0.019[0.4923]	-0.497[0.6904]		3	0.706[0.2401]	-1.007[0.8430]
	4	-1.334[0.9089]	-0.901[0.8163]		4	0.110[0.4561]	-0.040[0.5161]
CU_F → WIG20	1	0.506[0.3063]	-0.691[0.7552]	WIG20 → CU_F	1	0.086[0.4657]	-3.033[0.9988]
	2	0.292[0.3853]	-0.435[0.6682]		2	-0.535[0.7038]	0.542[0.2939]
	3	0.099[0.4604]	0.191[0.4242]		3	-0.706[0.7598]	-1.545[0.9389]
	4	-0.511[0.6954]	0.917[0.1797]		4	0.236[0.4069]	-0.681[0.7519]
CU_F → KGH	1	-0.307[0.6206]	-0.074[0.5296]	KGH → CU_F	1	0.594[0.2762]	-1.525[0.9364]
	2	-0.109[0.5432]	-0.605[0.7273]		2	-0.211[0.5837]	0.286[0.3875]
	3	-0.441[0.6706]	0.202[0.4201]		3	1.048[0.1476]	-0.223[0.5881]
	4	-0.972[0.8344]	-0.658[0.7446]		4	-0.278[0.6094]	0.048[0.4809]

Source: own study.

Table 10.

Results of the non-linear Diks-Panchenko test for pairs composed of silver returns and selected financial instruments obtained for the periods before the coronavirus pandemic and during the pandemic

Hypothesis H_0	l	Before pandemic	Pandemic	Hypothesis H_0	l	Before pandemic	Pandemic
SI_F \rightarrow CL_F	1	0.753[0.2258]	1.477[0.0699]	CL_F \rightarrow SI_F	1	2.737[0.0031]	-0.643[0.7398]
	2	0.750[0.2266]	0.602[0.2735]		2	1.357[0.0874]	0.336[0.3684]
	3	1.109[0.1338]	0.582[0.2804]		3	0.566[0.2857]	-1.287[0.9010]
	4	1.192[0.1167]	-0.580[0.7189]		4	0.079[0.4684]	-1.145[0.8739]
SI_F \rightarrow DX_F	1	0.137[0.4454]	1.202[0.1146]	DX_F \rightarrow SI_F	1	0.545[0.2929]	1.546[0.0609]
	2	0.000[0.4999]	0.684[0.2469]		2	-0.182[0.5721]	0.869[0.1924]
	3	0.726[0.2339]	0.275[0.3916]		3	-1.070[0.8577]	0.679[0.2485]
	4	0.240[0.4052]	-0.667[0.7476]		4	-0.304[0.6194]	0.264[0.3959]
SI_F \rightarrow WIG20	1	0.468[0.3199]	0.148[0.4411]	WIG20 \rightarrow SI_F	1	0.472[0.3185]	0.816[0.2074]
	2	0.524[0.3000]	-0.084[0.5335]		2	0.466[0.3205]	0.700[0.2418]
	3	0.356[0.3607]	0.490[0.3119]		3	-0.455[0.6756]	-0.393[0.6528]
	4	-0.463[0.6781]	0.067[0.4732]		4	-0.097[0.5388]	-1.299[0.9029]
SI_F \rightarrow KGH	1	0.753[0.2258]	0.523[0.3006]	KGH \rightarrow SI_F	1	2.737[0.0031]	0.292[0.3853]
	2	0.750[0.2266]	0.591[0.2771]		2	1.357[0.0874]	0.279[0.3900]
	3	1.109[0.1338]	0.593[0.2767]		3	0.566[0.2857]	-0.284[0.6118]
	4	1.192[0.1167]	0.314[0.3768]		4	0.079[0.4684]	0.435[0.3318]

Source: own study.

When comparing the results of the Diks-Panchenko test for $l = 1$ with the results of the linear Granger test, the following conclusions can be drawn. The results of both tests turned out to be similar only for pairs of variables: {KGH and CU_F} in the pre-crisis period; {CU_F, DX_F}, {CU_F, KGH} and {SI_F, DX_F} in crisis; {DX_F, CU_F} before the pandemic; {DX_F, SI_F} during the pandemic. During the crisis and pandemic, the null hypothesis of no causality was more often rejected. In the pre-crisis and pre-pandemic periods, the causal relationships were weaker. Contrary to the author's expectations, events of global importance (financial crisis and pandemic) did not affect the causal relationships between the variables studied in a similar way.

7. Summary

The industrial metals market is sensitive to the impact of many market and non-market determinants, which are short or long term. As mentioned earlier, these may include supply and demand, inventories, the prices of some commodities, including crude oil, fluctuations in the dollar exchange rate, financial crises and those related to global events (e.g. the Covid-19 pandemic). These factors also include investor sentiment in capital markets and the state of the economy, which are best reflected by stock indices. Due to such a large group of variables influencing the prices of copper and silver, the study focuses only on the causal relations with the prices of crude oil, the stock index, and the dollar index. The research was carried out first for the entire period, i.e. from January 2005 to May 2022, and divided into four sub-periods,

i.e. before the financial crisis and for the crisis, and before the Covid -19 pandemic and during the pandemic period.

The presented test results indicate the presence of causality between the tested instruments for the entire sample. The use of the non-linear Diks-Panchenko test allowed the detection of two-way dependencies in most cases. This is important information from the point of view of market participants investing in the copper and silver market, investors conducting currency transactions, or decisions related to KGHM. Knowing about this type of relationship can help to get better forecasts for both the metals and stock markets.

Due to the impact of the global financial crisis on changes in the relationship of returns from financial instruments discussed in the literature, the results for the crisis and the previous period were compared, as well as the results obtained for the period before and during the coronavirus pandemic. The causality study conducted for selected periods confirmed this change. The null hypothesis of no causality in most cases has not been rejected.

The indications of the Diks-Panchenko test depend on the number of variables. At a later stage of the research, one should, inter alia, check in more detail the influence of the delays adopted for the variables in this test.

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KNOWLEDGE MANAGEMENT AS A TOOL SUPPORTING THE IMPLEMENTATION PROCESS OF AN INTEGRATED ERP SYSTEM

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Purpose: Identification of knowledge management methods in the process of implementing an integrated ERP class IT system.

Design/methodology/approach: The research method was a case analysis, during which two methods of data collection were used (an unstructured interview with a participant of the implementation team, observation of the author of the article). Research on knowledge management in ERP systems implementation projects is justified and necessary to enable more efficient management of these projects.

Findings: The study proves that the phases of the life cycle of knowledge are closely related to the phases of the project. During the project preparation phase, the necessary organizational knowledge is identified. During the design phase of the IT solution, knowledge about the organization is transferred (from employees to consultants). In this way, a coherent IT solution project is created, which is implemented in the next phase of the project. From this moment knowledge about the organization is used to create the solution, test it, and then use it.

Research limitations/implications: The considerations contained in this study outline further directions for theoretical and practical analysis. The implementation of an integrated ERP class IT system is a strategic decision, the effects of which will be significant for the course of business processes, use of resources and efficiency of management.

Practical implications: The implementation process requires diverse, often specialized knowledge from the participants, and also involves multidirectional flows of this kind of knowledge. There is a need to carry out research on knowledge management methodologies in the design environment.

Originality/value: Implementation projects require diverse, often specialized knowledge from participants, and involve multidirectional flows of this kind of knowledge. Their subject matter is the organizational, management, business and technological knowledge possessed by all participants (including future users of the integrated system).

Keywords: knowledge management, ERP systems, small and medium-sized enterprises.

Category of the paper: Case study.

1. Introduction

Integrated IT systems of the ERP class constitute one of the most substantively and technologically advanced classes of IT systems that support the overall management of enterprises and institutions. The use of such systems has an influence on the optimization of internal processes as well as those occurring in the immediate environment, e.g. by offering ready-made tools (Miłosz, 2012; Issar, Navon, 2016). The main features of such a system include (Madtinos, Chatzoudes, Tsairi, 2012):

- functionality,
- integration of data and procedures,
- functional and structural flexibility,
- substantive and technological advancement.

The implementation and use of integrated ERP class IT systems is nowadays the basis for streamlining business management processes (integrated systems provide a new shape to the organization) (Bytniewski, Matouk, Hernes, 2018). Enterprises operate in conditions of increased competition, which is associated with higher requirements regarding quality, speed and timeliness, e.g. of trade and production. A fast response to the needs of the customer, as well as the possibility of offering an innovative solution and reduction of project costs is a way to achieve a competitive advantage (Malik, Khan, 2021).

Nowadays numerous small and medium-sized enterprises (SMEs) recognise a need for an integrated ERP class IT system to support enterprise resource management. There is a wide range of systems available on the market aimed mainly at SMEs (Estébanez, 2021). The implementation of an integrated system is a strategic decision, the effects of which will be important for the course of business processes, use of resources and efficiency of management (Grochowski, 2020). The success of an integrated system implementation depends on various factors related both to the type of operational activity run by the company as well as to the way of managing the implementation project. The execution of implementation projects involves not only acquiring and launching appropriate IT infrastructure, but also providing knowledge that enables the effective use of this infrastructure to efficiently support business processes (Finnery, Corbett, 2007; Zwierzchowski, Graul, 2016). Projects require diverse, often specialized knowledge from participants and involve multidirectional flows of this kind of knowledge. Their subject matter is organizational, management, business, technological knowledge, etc. possessed by all participants (including future users of the integrated system). During the projects, various implementation and management activities that make up the project actions are used directly to create knowledge and consolidate it in the implementation products, as well as to create its resources, simultaneously becoming the intellectual capital of the entities participating in the projects (Alaskari, Pinedo-Cuenca, Ahmad, 2021; Żółtowski, 2021). The goal of the article is to identify methods of knowledge management in the process of implementing an integrated ERP class IT system.

2. Knowledge management in the process of implementing an integrated system

In the source literature on knowledge management, the importance of key competences of human capital is particularly emphasized, and so is the appropriate implementation of crucial activities for knowledge management. Proper knowledge management allows to foresee the basis of future competitive advantage on the market. In this case, enterprises make a strategic decision, e.g. regarding the implementation of an integrated ERP class IT system (Rodriguez, Molina-Castillo, Svensson, 2020).

One of the most complicated IT projects in business organizations is the implementation of a standard integrated system. Such a project covers the majority of the key economic processes and involves significant resources of the organization, as well as simultaneously causes the necessity to manage different types of knowledge (Sedera, Gable, 2010; Rupcic, 2021). Some authors postulate the formulation of specific knowledge management procedures in projects for the implementation of integrated systems, or at least the inclusion of knowledge management procedures in existing practices of project management of the implementation of ERP systems (Chaudhry, Nawab, Shafi, 2021; Mohd Zamhari, 2020). It should be noted that research on knowledge management in IT projects, and ERP implementation projects in particular, is justified and necessary to enable more efficient management of these projects.

The aim of the article is to identify methods of knowledge management in the ERP system implementation project. Therefore, it is necessary to describe the implementation process in detail. Esteves et al. propose to divide the project in accordance with the ASAP methodology of the system implementation into the following phases (Esteves et al., 2003):

1. Preparation of the project – in which the scope of the project, its budget and schedule are specified, project structures and teams are formed as well as project infrastructure is prepared.
2. Business concept – during which the organizational structures as well as economic processes of the organization are analyzed, and then a project of their reproduction in the IT system is developed, along with the concept of data migration from previous systems.
3. Implementation – during which the system configuration occurs, programming extensions, reports, interfaces as well as data migration tools are developed, and then the system is tested and corrected.
4. Preparation for project launch – when the production environment is prepared and real data are migrated, as well as end users are trained.
5. Launch and post-launch support – the system is launched and its stabilization phase takes place, errors are corrected, as a result of which the system goes into normal operation.

There are also other approaches to the structuring of an IT project in the source literature (Lech, 2011). In the case analyzed in the empirical part of this article, a methodology similar to the ASAP methodology was used, therefore, the division of the project into the above-mentioned phases was adopted.

The knowledge management model in the ERP project should give answers to the questions on how appropriate knowledge (about the project, about the product, about the organization, business, technical, project management, communication) is identified, acquired/created, saved/stored, transferred/disseminated and used in the particular phases of this project in order to enable its implementation in compliance with the assumed scope, budget and schedule (Usman, Ahmad, 2012; Ranjan, Jha, Pal, 2016).

In this article, further considerations will be limited to one type of knowledge, namely knowledge about the organization because of its crucial role in designing a dedicated solution based on the standard functionality of the ERP class system.

3. The process of implementing an integrated ERP class IT system in a trade and production enterprise

3.1. Characteristics of the problem in the company's practice

Contemporary enterprises are aware of the fact that the implementation of integrated ERP class IT systems plays a significant role in the process management. Such IT solutions have become one of the most efficient tools for increasing the effectiveness of activities in the enterprise.

A trade and production company from the small and medium-sized enterprises (SMEs) industry, in which the implementation of an integrated system had been undertaken, has been operating on the Polish market since 2003. The company deals with wholesale and retail sale of electronic products. The headquarters of the company is located in Bydgoszcz and operates mainly throughout the entire country. The main direction of the company activity is to ensure customer satisfaction by guaranteeing the provision of a complete range of high-quality goods at a competitive price. Heading in this direction allows for daily sales of up to 1000 pieces of goods.

Since 2009 the company has also been engaged in manufacturing activities, and over the last year, it has placed great emphasis on the development and modernization of its production plant. All offered products can be purchased directly at the company, from sales representatives, as well as at points of sale and via the Internet.

Over time, the company has begun to face problems that had not been experienced before. The increase in the assortment, as well as the continuous increase in the number of customers, contributed to problems with the processing of orders. It has generated a large number of

incorrect handing over of goods (it was necessary to issue corrective documents). The increasing number of orders and the lack of ergonomics of work in the warehouse significantly extended the time of completion of all orders. The system which has been used so far did not adequately support the work of traders, among others, it did not take into consideration automatic changes in price lists. The occurrence of the above-mentioned problems forced the company's management board to decide to implement the Tisoft Work Manager system. The most important criterion for selecting the appropriate system was to integrate all spheres of the company's activity into one system, as well as support for the quality assurance system.

From the beginning of its activity, the trade and production company used separate IT systems for each area of the enterprise, supporting the sales department, accounting department as well as production department. This has led to inconsistencies within the enterprise. As the company kept developing, problems, that nobody from the board had previously been able to predict, began to occur.

Additional problems occurring in the analyzed company, before the implementation of the integrated system, include:

- stock records - inconsistent with the facts,
- incorrect handing over of goods,
- extended time of order processing,
- "paper" records,
- running a company in several databases,
- use of out-of-date database technologies.

Among other things, the problems did not allow for streamlining of decision-making processes and focusing on increasing production. The risk of entering incorrect data into the system was still increasing. The solutions used in the enterprise have become insufficient. Therefore, the implementation of an integrated IT system was a key element for maintaining market position and the development of the company.

3.2. Methodology

The research question formulated for the purposes of this article referred to how knowledge about the organization was managed in different phases of the project of implementing an integrated ERP class IT system. The following data collection methods were used as a research method:

- an unstructured interview with a participant of the implementation team,
- an observation of the author of the article.

The method of data collection was an unstructured interview with a member of the implementation team. The interview lasted 2 hours and it was recorded. The respondent was asked if/what method was used/what effect it brought? individual stages of the knowledge

life cycle were implemented in subsequent phases of the project. During the interview, additional questions were asked as a reaction to the individual answers of the respondent. The results of the interviews were established in the form of a narrative.

3.3. Results of the study

The respondent was a member of the implementation team of the entire system. The knowledge he represented resulted from several years of work experience in a managerial position. Moreover, this person was distinguished by the ability to think analytically and connect facts in cause and effect relationships, which turned out to be very useful in designing a business concept (implementing knowledge about the organization into the functionality of the ERP system).

1. Preparation of the project – the project preparation phase took place at the project management level and the respondent participated in it. The result of this phase was the formal establishment of a project team. On this basis, it can be concluded that the knowledge has been identified, which has resulted in the appointment to the project team of persons who had already possessed it. The method of identifying knowledge and knowledge resources was not known to the respondent.
2. Business concept – at the stage of the business concept, the respondent did not need to identify additional knowledge. There was also no need to acquire additional knowledge about the organization. The main activities related to knowledge at this stage of the project were all about creating a detailed business concept during which knowledge was transferred from individual participants representing various departments of the company to the consultant and among one another. This transfer took place in the form of workshops (also online), run by a consultant who determined the topic which was the subject of discussion. Then, the knowledge about the organization was integrated with the knowledge about the system and it was possible to create a detailed business concept. This document was created by the consultant, based on his own knowledge of the system and knowledge of the organization provided to him by the members of the project team.
3. Implementation – during the implementation phase, the consultant configured the integrated system in compliance with the guidelines contained in the detailed business concept (configuration based on the integrated knowledge from the relevant areas, knowledge about the enterprise and the functionality of the system). In this way, the knowledge transferred in the previous phases was used to build the system.
4. Preparation for project launch – the main activities in the phase of preparation for launch were verification of the correctness of the system configuration as well as end-user training. Preparations for the tests, which were all about generating test scenarios, required the members of the project team to use knowledge about the organization in order to predict all possible variants of the course of business processes as well as the

most common errors. Simultaneously, system operation training took place, i.e. knowledge transfer from the consultant to the end user.

5. Launch and post-launch support – in the launch phase, all team members as well as end users use their knowledge about the organization. The respondent stated that all possible solutions were predicted here, i.e. the connections of knowledge about the organization with the functionality of the system.

Table 1.

Summary of the test results

Phase of the project:	Result
Preparation of the project	– appointment of team members who possess the required knowledge about the organization to the team.
Business concept	– knowledge about the organization transferred to consultants, – creating an IT solution project (detailed business concept), – development of design documents, e.g. workplace instructions.
Implementation	– system configuration for users.
Preparation for project launch	– preparation and verification of test scenarios.
Launch and post-launch support	– working with a new system, – use of new solutions based on the functionality of the system.

Source: personal analysis.

4. Conclusions

The project of implementation of an integrated ERP class IT system covers most crucial business processes and involves significant organizational resources, while creating a necessity to manage various types of knowledge. The case study presented in this article showed the role of knowledge management in the project of implementing an integrated system. Proper management of knowledge about the organization is an essential prerequisite for the success of the implementation project. The proper reproduction of this knowledge in the system ensures that the solution is consistent with the economic objectives of the organization.

Most studies regarding the success factors of IT projects (including ERP projects) mention user involvement in the first place. The introduction of the knowledge management aspect to research on the success of IT projects shows what one of the main effects of this involvement should look like. It is the management of knowledge about the organization so that it can be integrated into the emerging IT solution.

The study shows that the phases of the life cycle of knowledge are related to the phases of the project. During the project preparation phase, the necessary organizational knowledge is identified. Then, in the phase of designing an IT solution, there is a transfer of knowledge about the organization - from employees to consultants (responsible for the implementation of the system, its storage in the form of business concept documents as well as integration with knowledge about the system). In this way, a coherent IT solution project is created, which is

put into practice in the next phase of the project. Ultimately, knowledge about the organization is used to create the solution, test it, and then use it. It indicates an extremely significant role of knowledge management in projects implementing integrated systems and the need to carry out research on knowledge management methodologies in the design environment.

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