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FOREWORD

We are delighted to present the latest number of Silesian University of Technology. Scientific Papers. Organization and Management Series. The main theme, "Towards the Future of Management," encompasses a range of research topics in management and innovation.

This number focuses on management challenges and strategies across various sectors, from healthcare to energy and new technologies. The articles highlight the importance of modern approaches in solving current problems, including research on the effectiveness of social media in public institutions and innovative project management practices. Each article significantly contributes to the development of management theory and practice, reflecting the dynamic nature of the modern business world.

Mateusz Trzeciak

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STRESS MANAGEMENT IN THE WORK OF MEDICAL PERSONNEL – STRATEGIES TO COUNTERACT ITS EFFECTS

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Purpose: The aim of this study was to subjectively assess the effectiveness of coping with stress by healthcare professionals through the skillful selection and use of available stress management strategies as a factor determining the maintenance of work-life balance.
Design/methodology/approach: The study covered 129 medical workers. As a research method, a diagnostic survey was used with the use of an original questionnaire, which consisted of 25 questions divided into two parts. The collected material was subjected to quantitative and descriptive analysis, and appropriately selected statistical tests were used to verify the hypotheses.
Findings: The results of the research indicate that health care establishments lack tools supporting the reduction of stress at work. In most cases, employees are forced to fend for themselves. Nevertheless, they are satisfied with their work stress management skills and consider their strategies to be effective. However, they say they would like to deepen their knowledge in this area, which is a positive attitude. However, the frequency of perceived stress situations at work by these employees is worrying.
Research limitations/implications: Therefore, it is important for health care establishment managers to take specific actions to prevent this phenomenon. In this context, further studies are needed, which are already in progress and their results will be presented in subsequent publications.
Originality/value: Stress is a common phenomenon in societies that experience a high pace of life and work-related pressures. This publication addresses the subject of occupational stress in a group of medical workers exposed to a high risk of professional burnout and high levels of stress, not only during epidemics or pandemics, but also due to difficult situations and requirements related to patient care. In this approach, on the one hand, the theoretical aspects of occupational stress are presented, and on the other hand, the results of surveys on stress management in the workplace of medical personnel and the effectiveness of using strategies to counteract its effects.

Keywords: stress management, work, medical staff, strategies for coping with stress.

Category of the paper: Research paper.

1. Introduction

Stress is a common phenomenon in societies that experience a high pace of life and work-related pressures. For this reason, as an inseparable part of modern life, it is one of the most important factors threatening health of those affected by it and is considered one of the civilization diseases of the 21st century. The issue of stress, its sources, causes and consequences is still a current subject of academic discussions and dilemmas both in terms of the intensity of this phenomenon and the consequences it causes.

We encounter the concept of stress in everyday life. Stress is usually bad for us. Few people know, however, that it is a neutral term. Stress has accompanied humanity since the beginning of its existence. Our ancestors lived in harsh environments long before scientists defined the term "stress". The brain's response to a stressor is exactly the same in modern humans as in our ancestors. The natural reaction is a result of the action of 20-30 stress hormones released into the bloodstream (Cichosz, 2018). When the brain notices a threat, it triggers changes in the body called the "stress response" or, simply, "stress". These changes prepare us for action – flight or fight. The brain's goes on alert, the senses become sharper, breathing quickens and becomes shallow. In addition, the heart rate increases and the muscles tense in readiness for action, blood sugar levels rise to provide more "fuel" to the muscles (Glenn Schiraldi, 2017). The person in stress sweats and panics (Clayton, 2012). This behavior is a natural phenomenon, and the purpose of the stress reaction is to enable the individual to adapt to changes occurring in the environment and then restore homeostasis, i.e. the balance of the internal environment of the human body in relation to external conditions (Popiel et al., 2012). Therefore, a stressor for a person will be any challenge from the environment, the appearance of which will exceed the body's regulatory capacity due to the unpredictability of the situation and the lack of control (Lucassen, et al., 2013).

The concept of stress is an extremely broad subject, as indicated by the large number of definitions functioning in the literature on the subject. The term itself is used mainly in medicine and psychology, although it comes from physics and is understood as "load" – an external force (stimulus), "pressure" – an internal response to an external force, and "tension" – a change in state caused by the external force (Lazarus, 1984). The beginning of interest in stress in medicine dates back to 1936. It was then that Hans Hugo Seley, a physician and professor at the Institute of Experimental Medicine and Surgery in Montreal, presented a theoretical model of the "general adaptation syndrome". He defined stress as a state caused in the body as a result of harmful stimuli. The scientist noticed that stress mobilizes the body's defense forces, but its long-term effects, especially in severe cases, lead to organic disorders and psychosomatic diseases. According to Sele, stress results from the general adaptation syndrome (Soley, 1956). Lazarus and Folkman defined stress as a relationship between a person and the environment that is perceived by the person as burdening or exceeding his or her resources and threatening his or her well-being (Lazarus, Folkman, 1984).

Nowadays, the WHO calls stress "the disease of the century" and defines this concept as any type of change that causes physical, emotional or mental strain. Stress is the body's response to anything that requires attention or action (Stress, 2023). According to Heszen-Niejodek, stress is a change in an individual's environment, which causes a high degree of emotional tension in the average person, preventing normal functioning and proper reaction to events (Heszen-Niejodek, 2028). According to Gałuszko, stress is a reaction that is mainly based on emotions, creating experiences for a person (Gałuszka, 2005), forcing the body to extraordinary, rare or unusual physical or physiological reactions. On the other hand, Everly and Rosenfeld explain the importance of the stress reaction as psycho-physiological preparation for physical effort (Everly, Rosenfeld, 1992).

One of the first symptoms of stress is sleep problems. Sleep disorders result in constant fatigue and even fear of falling asleep. The person affected becomes susceptible to diseases, numerous colds, runny nose, sore throat. Skin problems and herpes appear. Other signs of stress can also include problems with the digestive system: diarrhea, constipation, headaches. Back and neck pain is also more common. All this results in impaired concentration, difficulties in coping with duties and panic attacks due to uncompleted tasks. There is also an increased susceptibility to irritability and quarrelsomeness. Patience is being tested more and more. The person becomes explosive, forgetful and makes mistakes more often (Clayton, 2012).

2. Review of the literature

This publication addresses the issue of occupational stress among medical workers as a chronic factor, not only in times of epidemics or pandemics, but also due to difficult situations and requirements related to patient care.

There are two types of stress in the workplace: positive (motivating) and negative (demotivating). The latter over time causes negative professional, health and social consequences. Whether stress will have a negative character depends, on the one hand, on the employee, his or her physical and emotional intellectual abilities to cope with stress, and on the other hand, on the superiors and co-workers (Hart, 2005).

We talk about positive stress in the workplace when our superiors place demands on us that are adjusted to our physical, intellectual and emotional capabilities. What is more, the employee should have appropriate knowledge, skills and constant support from colleagues and superiors. Energy is used to get the job done and accumulated stress subsides. The work performed then becomes a source of success and satisfaction (Sowa, Hess, 2015).

In turn, we talk about negative stress in the workplace when our superiors place on us demands that exceed our physical, intellectual and emotional capabilities, especially if we do not have sufficient knowledge or skills or support. In the latter scenario, the employee is unable

to complete the task on their own and stress appears more and more often. If this condition is long-term and the employee or employer does nothing to change the situation, the employee becomes to feel angry and irritated. Over time, discouragement and helplessness appear, and then the feeling of "burnout" begins to prevail (Gólcz, 2012).

Occupational stress is closely related to psychosocial risk factors, including excessive workload and its pace, job uncertainty, irregular hours, inflexible shift system, poor relationships with colleagues or superiors, communication problems, vagueness of the professional role of employees, poor career development opportunities and a conflict between work and home. The effects of experiencing stress at work have various consequences for the employee, including primarily health. Mental problems appear, mainly depression, cardiovascular diseases, musculoskeletal diseases and diabetes. It should be noted that the costs on the employer's side are also significant: an increase in the level of sickness absence, increased employee turnover and a decrease in productivity (Terelak, Chodkiewicz, 2005).

In occupations involving intensive and frequent contact with many people, a higher risk of stress and excessive physical and mental strain can be observed. In addition, in many cases, stressful factors can make it difficult for a person to focus more and do a good job. One of the professional groups burdened with particular responsibility and having work of a special nature is medical staff (Cox, 1993). In British studies that analyzed mental well-being, health and job satisfaction among representatives of 26 professions, it turned out that nurses and related professions were among those least satisfied with their jobs (Johnson et al., 2005). Similar conclusions come from research conducted in Poland. Physicians and nurses are the occupational group most exposed to occupational burnout, and the exposure of nurses is much higher (Orzechowska, 2008). Therefore, skillful coping with stress can protect against burnout and affect the effectiveness of patient care. In addition, effective coping with stress through the use of an appropriate strategy is considered an important condition for mental health (Liu, 2008).

One of the best-known theories on coping with stress was developed by the aforementioned R. Lazarus and S. Folkman, who stated that a stress coping strategy is a cognitive and behavioral action that an individual takes in a specific stressful situation in order to calm down emotions. These activities include, but are not limited to, seeking information to make a rational decision, or stopping activity (Lazarus, Folkman, 1987). The choice of strategies used by an individual in a stressful situation is related to the perception of the requirements of the situation, the style of coping characteristic of a given person and personality predispositions that are not included in the styles (Heszen-Niejodek, 2008). Nevertheless, it is worth noting that there are other categories of coping with stress, such as confrontation, seeking social support or distancing oneself, the purpose of which is to combat stressors or factors limited to "defensiveness" by improving well-being without eliminating the causes of stress. The rest are aimed at avoiding difficult situations (Ogińska-Bulik, Juczyński, 2008).

Based on various studies, it can be concluded that the effect of coping with stress depends on both individual and situational factors. According to Heszen-Niejodek, confrontational strategies are more effective in situations with a high degree of control, and avoidance strategies in uncontrolled situations (Heszen-Niejodek, 2000). On the other hand, Havlovic and Keenen distinguished 5 detailed strategies of coping with stress, divided into strategies of situation control (direct action, seeking help, positive thinking) and avoidance strategies (avoidance, resignation, alcohol use) (Havlovic, Keenen, 1991).

Effective stress management helps us alleviate the stress that has an impact on our lives so that we can be happier, healthier and more productive. The ultimate goal is a balanced life with time for work, relationships, relaxation and play – and resilience to stress and facing challenges. But there is no single formula for stress management. That is why it is important to experiment to find out what works best (Robinson, Smith, 2023). It is therefore worth asking about the best ways for a given individual to manage stress. The research conducted by the authors of this article focused on the main groups of stress coping strategies distinguished by Lazarus, among others (Lazarus, 1986). Based only on uncontrolled observations, it may seem that some people from the group of medical workers use strategies that bring only a temporary improvement in well-being, such as relieving or alleviating tension with the use of psychoactive substances, which is extremely harmful in the long run. Therefore, when analyzing the effectiveness of tools and techniques that can help medical staff cope with stress related to their work, it is worth checking to what extent this [improvement] is true in the analyzed research group. Meanwhile, in practice, we can use a few simple and, at the same time, relatively positive strategies that can help reduce the negative effects of stress (Kluczyńska, 2003). One of them may be confronting a stressful situation by recognizing the problem and planning its resolution. Another may be an attempt to relieve or alleviate tension, but this time through relaxation exercises, laughter, contact with nature, singing, music or physical effort. Thirdly, one can avoid stressful situations by denying, ignoring the stressor, distancing oneself or controlling one's daily duties by giving them a specific status, such as: important / not important or urgent / not urgent. Fourthly, one can try to seek help from others. In the process of coping with stress, social support is extremely important, in this case among superiors and co-workers, which should upkeep good self-esteem or provide emotional support. Fifthly, one can try to endure stress by mastering his or her emotions, self-control, and not giving in to impulses and provocations to an emotional outburst. It should be emphasized that there are no universal strategies, and a given strategy is effective only in certain situations and for specific people or groups of people. The most important thing when dealing with stress is the proper assessment of the situation and only then an action, i.e. the ability to choose an appropriate strategy and the ability to quickly change it depending on changing conditions.

3. Purpose and methodology

The aim of this study was to assess the effectiveness of health care workers in dealing with stress through the skillful selection and use of available stress management strategies as a factor determining the maintenance of work-life balance. The main research questions were formulated:

Are the stress management strategies chosen by medical workers effective in coping with stress at work?

Do seniority and the place of work affect the level of perceived stress among medical workers and do they play an important role in coping with stress through the skilful selection of appropriate stress management strategies for oneself?

Therefore, the following research hypotheses were put forward:

H1: There is a statistically significant relationship between seniority and the frequency of perceived stress among medical workers.

H2: There is a statistically significant relationship between the workplace and the frequency of perceived stress among medical workers.

The study covered 129 healthcare professionals. It was conducted using the diagnostic survey method – a proprietary questionnaire containing 25 questions divided into two parts. The first part concerned socio-demographic data and the other asked the respondents about sources of stress for medical workers and how to deal with it.

The authors' survey allowed to collect socio-demographic data of the surveyed persons. In addition, it was used to gather knowledge among their attitude to stress at work, its sources, knowledge of stress coping strategies, as well as information on support or lack of it from superiors in order to minimize stress in the workplace.

The survey was created using the Microsoft Forms application, which became a mobile response platform. All questionnaires were sent by members of the research team via electronic means. Taking into account the pilot nature of the research, it was considered that the sample was representative, and the results were subjected to statistical analysis.

Link to the survey:
https://docs.google.com/forms/d/19m4EsknnEYj5JIB1iiBYTOpnKObJIVCJc9LWkoN7Og0/

The collected material was subjected to quantitative and descriptive analysis. The data were collected in tables and subjected to statistical analysis using Microsoft Excel. Appropriately selected statistical tests were used to verify the hypotheses. Relationships between variables were shown using contingency tables (cross-tables) and chi-square tests were used. $P < 0.05$ was taken as the limit of significance. Explanation of the abbreviations used: n – number of persons in the group, Chi^2 – value of the chi-square test statistic, df – number of degrees of freedom, p – level of statistical significance, r – Pearson's C coefficient. This survey was anonymous and answering did not pose any risk to the respondents. The subjects were adults and consciously consented to participate in the study.

4. Results

The largest group among the 129 medical workers who took part in the study were women (90.70%) working mainly as general nurses, specialist nurses and ward nurses. There were 12 men including two general nurses, one paramedic and one ward nurse. The remaining respondents were doctors and physiotherapists. The detailed characteristics of the surveyed persons are presented in Table 1.

Table 1.
Characteristics of the surveyed medical workers (n = 129)

Characteristcs	Test		Characteristic	Test	
	n	%		n	%
Sex			**Place of work**		
Woman	117	90,70	hospital	100	77,52
Man	12	9,30	clinic	19	14,73
Job position			emergency medical services	1	0,78
Medical specialist	9	6,98	hospice	2	1,55
Physician	1	0,78	individual practice	5	3,88
Dentist	2	1,55	social welfare home	1	0,78
Ward nurse	24	18,60	senior's house	1	0,78
Specialist nurse	36	27,91	form of employment		
General nurse	49	37,98	regular employment	106	82,17
General midwife	0	0,00	temporary employment	7	5,43
Specialist midwife	1	0,78	own business	8	6,20
Paramedic	2	1,55	contract	8	6,20
Physiotherapist	5	3,88	Locality		
Seniority			city, more than 100,000	71	55,04
Less than 5 years	26	20,16	city, 50,000-100,000	26	20,16
5-10 years	8	6,20	town, less than 50,000	27	20,93
10-15 years	6	4,65	village	5	3,88
15-20 years	10	7,75			
Over 20 years	79	61,24			

Source: The authors' own study based on surveys.

When analyzing the research problems included in the survey questionnaire, showing attitudes of medical workers of various groups towards stress at work and their knowledge on this subject, the first topic was the most stressful area in their lives. According to as many as 39 of the respondents, the only source of stress in their lives was work, and for 43.41% also family problems and health were important sources of stress apart from work. Personal relations and finances came next. Only 26.35% of the respondents did not list work as a source of stress. This attitude of the latter group, although small, may result from the fact that they feel great satisfaction from the work entrusted to them and performed. Interestingly, 72.86% of the respondents considered stress to be an exclusively negative and undesirable phenomenon at work, which may reveal incomplete knowledge in this area among the studied group. Only 9 respondents had no opinion on this matter. In addition, the respondents considered excess duties, followed by difficult cases of patients and traumatic situations, as the main sources of occupational stress. Slightly more than 40% of the respondents listed lack of support from their supervisors, poor management style and the need to make quick decisions at work

as the most important sources of stress. These dependencies are also confirmed by the question about personal sources of stress at work among those respondents who chose the answer clearly indicating excessive administrative work and documentation as the main source of stress at work. The detailed distribution of the responses is presented in Table 2.

Table 2.
The distribution of answers related to the sources of stress at work (n = 129)

In your opinion, what are the most important sources of occupational stress among medical workers?	Test		What is your main cause of stress at work?	Test	
	n	%		N	%
Excess professional responsibilities	97	75.19	The work itself, the decisions and their consequences	48	37.21
Lack of support from superiors	42	32.56	Incorrect management of the employing establishment	27	20.93
Conflicts with co-workers	35	27.13	Lack of opportunities for self-development and improving qualifications	7	5.43
Bad management style at work	43	33.33	Excessive administrative work and documentation	72	55.81
Lack of resources and equipment	29	22.48	Long working hours and no free time	33	25.58
Shift work	20	15.50	Technical equipment at the employing establishment	11	8.53
The need to make quick decisions	43	33.33	Shortages of medicines	4	3.10
Difficult patient cases and traumatic situations	51	39.53	Interpersonal conflicts	28	21.71
Patient violence and aggression	33	25.58	Overload with patients and staff shortage	52	40.31
Low earnings	19	14.73	Difficult ethical decisions	13	10.08
Other: complaints or verbal aggression from patients' families, co-workers smoking at work, responsibility, work reorganization	5	3.88	Patient's death	29	22.48
			Form of employment	5	3.88
			Untimely payment of remuneration	3	2.33
			Other: untimely payment, fraud related to the form of employment, low trust on the part of patients and their families	5	3.88

Source: The authors' own study based on surveys.

It is worth emphasizing here that most of the respondents worked in hospitals located in cities with more than 100,000 inhabitants. In these units, one should take into account a large number of patients and, at the same time, a high workload, hence nearly 69% of the respondents felt frequently stressed at work (daily and several times a week). Only 15.51% experienced it rarely or very rarely. The next question was about the relationship between the workplace and the frequency of perceived stress at work. The statistical analysis did not show statistically significant relationships ($Chi^2 = 0.19$) between the place of work and the frequency of stress experienced there by the medical workers. Pearson's C contingency coefficient was 0.02. It can therefore be concluded that there is a very weak relationship between the place of work and the frequency of experiencing stress there. This data is presented in Table 3.

Also, no statistically significant relationships were found between seniority and the frequency of stress experienced by the medical workers ($Chi^2 = 0.52$). Pearson's C contingency coefficient was 0.05. Also in this case, it should be concluded that there is a very weak

relationship between the seniority of medical workers and the frequency of experiencing stress at work. The data is presented in Table 4.

Table 3.
Chi² test, the relationship between the place of work and the frequency of stress experienced there

	Daily/ several times a week		Once a week/ several times a month		Rarely/very rarely		Total	
Place of work	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Hospital	69	79.31	18	81.82	13	65	100	77,52
Clinic	14	16.09	2	9.09	3	15	19	14,73
Other	4	4.60	2	9.09	4	20	10	7,75
Suma	87	100.00	22	100.00	20	100	129	100
Test Chi²								
Chi²	df		p		r		N	
0.19	4		0.05		0.02		129	

Source: The authors' own study based on surveys.

Table 4.
Chi² test, the relationship between seniority and the frequency of experiencing stress

	Daily/ several times a week		Once a week/ several times a month		Rarely/very rarely		Total	
Seniority	n	%	n	%	n	%	n	%
Up to 20 years	32	36,78	10	45,45	7	35,00	49	37,98
Over 20 years	55	63,22	12	54,55	13	65,00	80	62,02
Total	87	100	22	100	20	100	129	100
Test Chi²								
Chi2	df		p		r		N	
0,52	2		0,05		0,05		129	

Source: The authors' own study based on surveys.

The ability to separate work and private life is also important for mental health. As the results of the survey show, more than half of the respondents declared that there was, however small, an overlap between their private life and work, which is not overly optimistic. This data is presented in Figure 1.

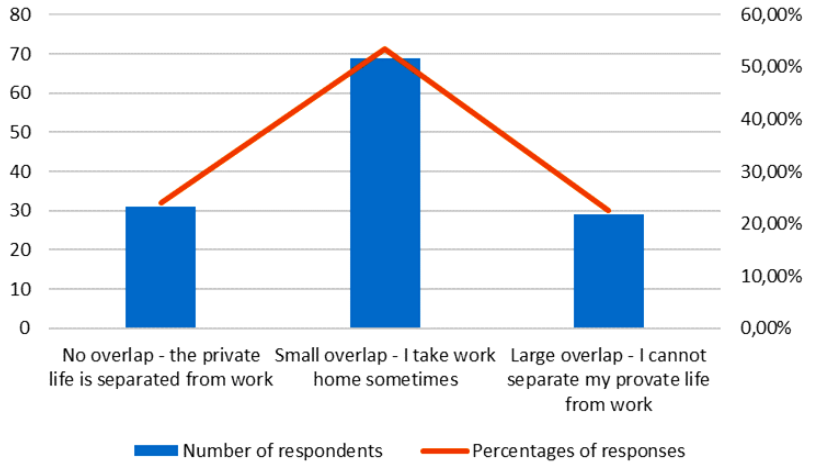

Figure 1. The overlap of private and professional lives in the subjective opinion of the respondents.
Source: The authors' own study based on surveys.

Results of studies on employees of various professions show that a wrong work-life balance may result in choosing unfavorable strategies for coping with stress (Shanafelt et al., 2008). Importantly, strategies for coping with stress most frequently chosen by the respondents, both male and female, were active, such as "confronting a stressful situation by recognizing the problem and planning its resolution." Passive strategies were in the second place, such as "withstanding stress, surviving by controlling one's emotions, self-control, not giving in to impulses and provocations. More rarely, which is important, respondents "relieved tensions using psychoactive substances" or, as one might assume, they did not want to admit it. This data is presented in Figure 2.

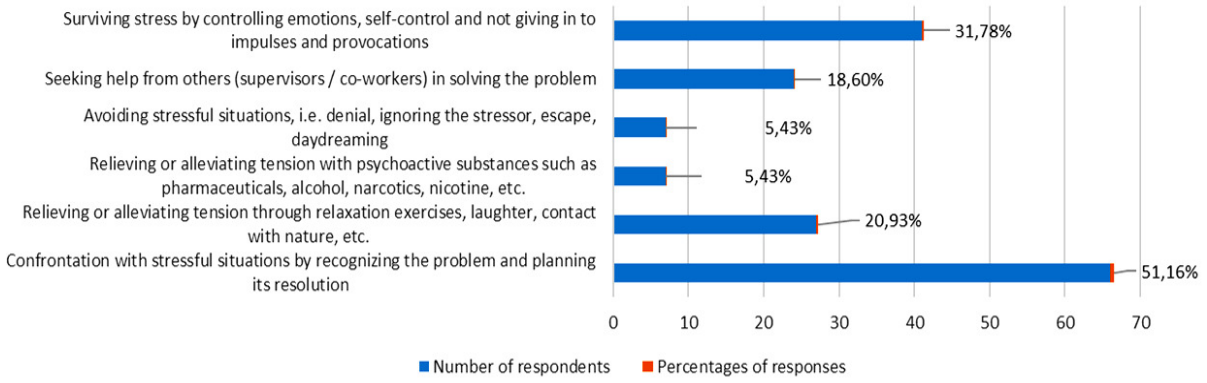

Figure 2. Groups of strategies adopted by medical staff in the fight against stress at work

Source: The authors' own study based on surveys

However, it is disturbing that 10% of the respondents (13) did not use any strategy to counteract stress at work, even though 11 of them described their work as the main source of stress, which may consequently affect relationships with patients. Only 8.53% of the respondents used more than two groups of strategies to counteract stress, and 32.56% of the respondents chose only between two strategies. Despite this, half of the respondents consider the strategies they have chosen to be "very or rather effective", especially the group of 24% of the respondents who subjectively assessed that they cope well with stress and are satisfied with their skills. This data is presented in Table 5.

Table 5.

Subjective assessment of the effectiveness of stress management strategies by the medical workers (n = 129)

Do you consider the stress management strategies you have chosen to be effective?	Test		What is your general opinion on stress management in your workplace?	Test	
	n	%		n	%
Very effective	12	9.30	I feel I am doing well and I am satisfied with my stress management skills	31	24.03
Rather effective	62	48.06	I am doing well sometimes but I could improve my skills	52	40.31
I'm not sure	34	26.36	I often have difficulty managing stress and would like to learn better strategies	39	30.23
Rather ineffective	19	14.73	I'm not sure	7	5.43
Absolutely ineffective	2	1.55			

Source: The authors' own study based on surveys.

Although these subjective assessments by the respondents may be somewhat optimistic, the frequency of stress experienced by respondents at work clearly contradicts this. Interestingly, only 20% of the respondents admitted that they had so far used help from a stress management specialist, such as a psychologist or therapist. The reluctance of medical staff to admit to using such specialists may result from the fear that, by expressing their own needs or difficulties, they will be perceived as weak or incapable of helping others. However, it is worth promoting awareness of mental health also among medical staff. Educating them about benefits of specialist help can help break down barriers and encourage them to seek it from a psychologist, if needed.

According to the survey results, over 70% of the respondents believe that regular breaks at work are crucial. They give an opportunity to calm down, catch internal balance and, as a result, better manage stress. Taking a breather at work helps reduce stress and is important for maintaining the health of medical workers, not only for their good mental condition but also for ensuring high-quality patient care. Only five of the respondents had no opinion on this matter.

Since persons at various levels of management and types of interactions took part in the survey, the answers about interpersonal relationships at work as a source of stress were distributed proportionally between relationships with superiors, co-workers and patients. Only slightly more than 6% of the respondents (8) perceived their relations with their subordinates as the main source of stress at work. It is difficult to draw any specific conclusions in this case.

The survey was extended to include questions regarding information on stress management support, or lack of it, from the organization or superiors, in order to minimize it in the workplace. Almost half of the respondents had no support from the organization, and over 60% lacked programs and training in this area. Also, organizations do little to prevent professional burnout, or the respondents had no information on this subject. Importantly, a large group of the respondents (62.79%) were interested in participating in recreational events and programs to reduce stress and improve well-being at work. Participation in such projects gives an opportunity to break away from the routine of work and relieve tension. In addition, such events offer good settings for building relations between employees outside the work environment. Such activities are very important because they can positively affect the mood of medical staff, which in turn should translate into better quality of patient care.

5. Conclusions

Stress is often considered an inevitable part of modern life, but for employees and their employers it is a problem that poses a huge challenge today. Constant civilizational, social and economic development cause changes in working conditions. What is important, especially

employees burdened with a large amount of responsible work, to which they devote huge amounts of energy, are particularly exposed to stress in the workplace. It can therefore be concluded that stress is part of the medical profession, regardless of its positive or negative nature. There is also no doubt that stress contributes to the emergence of many disorders in the health of the medical team. This is primarily due to the fact that medical workers experiencing stress are often physically and mentally exhausted, which in turn leads to a decrease in quality of their work and the risk of making wrong decisions. Therefore, managing stress in the right way is the key to reducing its harmful effects. The survey conducted with the group of medical workers has shown that these activities are currently not at best. There are no tools to support stress reduction in health care establishments. In most cases, employees are forced to fend for themselves. The results of the research show that, despite this, they are satisfied with their work stress management skills and consider the strategies they use to be effective. However, they would like to deepen their knowledge in this area, which is a positive attitude. The research conducted by the authors has shown that there is no statistically significant relationship between the seniority of medical workers and the place of work and the frequency of stress experienced there. However, the mere fact of the frequency of stress at the workplace among the respondents, which should be counteracted, is worrying. Most of the respondents do not see the need to use different stress management strategies that would be adapted to a given situation. They focus on using one or two. Some do not use any stress management strategies at all, claiming that they are ineffective, which may betray low awareness and knowledge of the respondents about strategies for coping with stress. In order to effectively manage stress, healthcare workers must be provided with the right environment that respects their needs and provides appropriate support. This can be achieved by offering them, for example, training that would helps them cope better with stress. Training healthcare professionals on techniques and strategies for coping with stress is essential not only for them but also for ensuring safety and quality of care. Such training should ideally address all aspects of stress, from prioritization to dealing with difficult situations.

Stress management should primarily focus on eliminating its source in the workplace, modifying the way people react to stressful situations and minimizing the costs of stress, such as absenteeism at work, which translates into efficiency of operation of health care establishments. Therefore, it is important for health care establishment managers to take specific actions for this purpose. In this context, further studies are needed, which are already in progress and their results will be presented in subsequent publications.

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STRATEGIES OF ENERGY COMPANIES IN THE CONTEXT OF A ZERO-EMISSION ECONOMY

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Purpose: The global imperative to fight climate change and the transition to a zero-emission economy has forced significant transformations in the energy sector. The aim of the article is to examine the strategies and analyze the actions taken by energy companies in order to transition to a zero-emission economy.
Design/methodology/approach: By using desk research and case study analysis, policy frameworks and industry trends, this paper offers a comprehensive overview of the different approaches used by energy companies to align their operations with environmental sustainability goals.
Findings: The results of the conducted research contribute to understanding the strategies of enterprises in the context of environmental challenges and provide valuable insights on the key role played by energy companies in shaping the applied solutions towards a sustainable future.
Practical implications: Energy companies can use the results of this research to develop and implement strategies to achieve a zero-emission economy. These studies provide guidance on best practices, technologies and business models that can be used to reduce greenhouse gas emissions and negative environmental impacts.
Social implications: The strategies used by energy companies allow the implementation of a zero-emission economy and reduce the negative impact on the environment, generate a significant social impact, such as improving the quality and living conditions, clean air, reducing energy poverty. In addition, the development of renewable energy and energy efficiency technologies can attract foreign investment and create new export opportunities for green technologies, which translates into economic growth and job creation.
Originality/value: The novelty of the research is the presentation of strategies (mainly adaptations) that allow energy companies to adapt to external requirements and enable the implementation of tasks related to renewable energy and energy efficiency. This provides the basis for the development of new technologies. Enterprises can use this research to design and implement modern solutions, such as digitization, developing more efficient photovoltaic panels, building energy storage or smart energy grids.

Keywords: energy, zero-emission, strategy, adaptations, innovations.

Category of the paper: Research paper.

1. Introduction

The urgency of addressing climate change and reducing greenhouse gas emissions has catalyzed global efforts to transition to a carbon-free economy (Dilanchiev et al., 2023). Our planet is facing major environmental challenges, including global warming, sea level rise and more frequent and intense extreme events (Borowski, 2020b; Borowski, 2022). As ecological tensions grow, so does the pressure on governments, international organizations and, above all, businesses to adopt a more sustainable approach to energy production and consumption.

As the main participants in emissions, energy companies play a key role in this transformation. Energy companies, through the supply of electricity and propulsion fuel, generate a significant share of greenhouse gas emissions. However, paradoxically, they also have the potential and the ability to transform the way we produce and consume energy. This is the starting point for this article - understanding how energy companies are responding to the challenges of climate change and how they contribute to global sustainability efforts.

The purpose of this article is to examine the strategies used by energy companies to adapt to the changing energy landscape and achieve the Sustainable Development Goals. The various approaches these companies are taking to minimize greenhouse gas emissions, increase energy efficiency and promote the use of renewable energy sources will be discussed. By analyzing case studies, assessing policy frameworks, and identifying key industry trends, this research aims to provide a comprehensive view of how energy companies fit into the drive for a sustainable future.

Therefore, in the face of impending climate challenges and the imperative for sustainable development, it is crucial to comprehend the actions taken by these companies and their impact on the future of energy and the natural environment. By exploring these issues, we are able to not only assess progress towards a more sustainable energy future, but also to draw valuable lessons about the role that energy companies play in shaping the economic future.

2. Methods

In this study, a qualitative research approach was utilized to comprehensively investigate the strategies adopted by energy companies operating in a changing energy environment and working towards achieving sustainable development goals.. The utilization of qualitative research is particularly well-suited for this study as it enables an in-depth exploration of complex phenomena such as the strategies and actions of companies in response to environmental challenges.

The first stage involves gathering data from available published materials, encompassing an extensive review of existing literature, including policy frameworks, academic articles, statistical data, and industry reports. This analysis of secondary data plays a crucial role in contextualizing the strategies of energy companies within the broader regulatory and industry landscape. It allows for a comprehensive examination of external factors influencing and shaping the strategies of these companies.

For the analysis of the research findings obtained through desk research, a content analysis method is employed. This method involves a systematic examination and categorization of textual data from published policy documents, academic literature, and industry reports. Such an approach aids in the identification of key policy frameworks, trends, and regulatory influences impacting the strategies of energy companies. Furthermore, qualitative data obtained from case studies and insights derived from secondary source research are integrated to ensure a comprehensive understanding of the strategies employed by energy companies in response to environmental challenges. The combination of these two data sources enables the triangulation of results, enhancing the validity and reliability of the research findings.

In this study, a qualitative research approach was applied within the context of a changing energy landscape and the imperative of sustainable development. The integration of diverse data sources and robust qualitative analysis techniques facilitated a comprehensive analysis of companies' responses to environmental challenges, shedding light on the role of energy companies in shaping the future of sustainable energy.

3. Literature review

This study is based on a comprehensive literature review, which is the basis for research conducted using the desk research method. Contemporary literature provides an insight into the strategies and approaches used by energy companies seeking to mitigate the negative environmental effects associated with energy production and presents innovative solutions in the field of adaptive technologies. Table 1 presents the latest research in the field of strategies and activities of energy companies.

Table 1.
Selected most important studies related to energy companies

Title of the paper	Main contents presented in the paper
Incentives and strategies for financing the renewable energy transition: A review.	The paper encourages increased investment in environmentally friendly energy. Additionally, it discusses some of the strategies required to transition from fossil fuels to renewable energy sources (Qadir et al., 2021).
Energy management strategies and multi-objective optimization of a near-zero energy community energy supply system combined with hybrid energy storage.	The article discusses energy storage, which effectively addresses the issue of inconsistent energy supply and low renewable energy penetration in nearly zero-energy communities. An energy system integrated with electrical energy storage and hydrogen storage enables seasonal energy utilization with improved overall economics (Fan, et al., 2022).
Open and collaborative innovation for the energy transition: An exploratory study.	The paper identified energy companies' strategies for innovation. An open approach to innovation varies and depends on local circumstances, underlining the importance of cooperation and international partnerships for the energy transition (Dall-Orsoletta et al., 2022).
A net-zero emissions energy system in India by 2050: An exploration.	A transformational level of electrification, improved energy efficiency and a shift towards decarbonised fuels (largely green hydrogen, decarbonised electricity and bioenergy) are among the main elements of a decarbonisation strategy that could move the energy sector towards net zero emissions (Vats, Mathur, 2022).
Digital transformation in the resource and energy sectors: A systematic review.	Digital technologies have also started to have a significant impact on the commodities and energy industries. The paper identifies the technologies that have delivered the most value in different parts of the energy sector (Maroufkhani et al., 2022).
Digitalization in Energy Production, Distribution, and Consumption: A Systematic Literature Review.	In the energy sector, the infrastructure required to achieve specific goals is based on the digitization of energy production, distribution and consumption. An important element of digitization is data mining and machine learning as well as smart grid, smart metering, smart home (Simion et al., 2023).
The impact of resources on digital transformation in energy sector companies. The role of readiness for digital transformation.	Energy companies inevitably need to undergo a digital transformation to be able to dynamically respond to changes, ensuring open, automated communication and real-time operation of the energy system (Chwiłkowska-Kubala et al., 2023).
Sustainable development policies of renewable energy and technological innovation toward climate and sustainable development goals.	The achievement of climate goals is influenced by economic development, technologies, environmental policy and energy, together with technological influences on the transition to renewable energy (Xing et al., 2023).

Source: own elaboration based on literature indicated in the table above.

From the conducted literature review, fields emerge regarding the strategies and directions pursued by energy companies to achieve greenhouse gas emission reduction and the production of cleaner, environmentally friendly energy. This in-depth exploratory process allows for an examination of various practices and innovative solutions that energy companies undertake in response to urgent environmental protection and climate change challenges.

One significant aspect evident in the research is the drive of energy companies to increase the share of renewable energy in their energy mix. This often involves investments in wind farms, solar panels, hydroelectric power plants, and other renewable energy sources. The shift towards more energy sources is crucial in the sustainable pursuit of reducing greenhouse gas emissions.

Additionally, energy companies are exploring technologies that enhance energy efficiency. This encompasses the implementation of advanced energy management systems, optimization of production processes, and distribution network enhancements to reduce energy losses and fossil fuel consumption.

Furthermore, there is a growing interest in energy storage, which enables the accumulation of surplus energy during periods of abundance (e.g., from solar or wind sources) for use during periods of scarcity. This can significantly contribute to stabilizing energy supply and increasing the utilization of renewable sources.

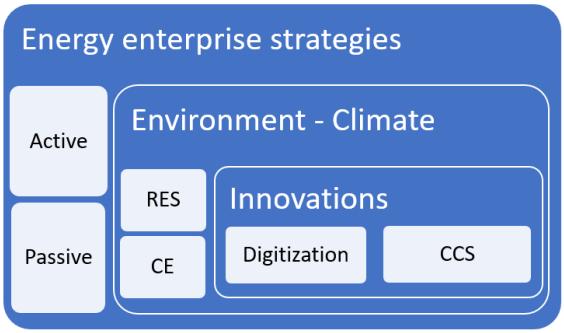
It is worth noting that energy companies are increasingly collaborating with research institutions and innovative startups to develop new technologies and solutions. This open collaboration can accelerate progress towards cleaner and more sustainable energy.

Overall, this literature review sheds light on the diverse strategies and development directions pursued by energy companies to contribute to the reduction of greenhouse gas emissions and the production of cleaner energy. These are vital in addressing pressing environmental efforts protection and climate change imperatives.

4. Results and discussion

The results of desk research reveal a multifaceted activieties within the energy sector, as companies within this industry are actively engaged in a comprehensive range of initiatives aimed at addressing the urgent issue of decarbonisation. Their endeavors extend beyond only discussions and not limited to rhetoric but embark on tangible actions as they are dedicating significant resources to invest in renewable energy sources. This substantial commitment reflects a pivotal shift in the industry's priorities and values, indicating a collective recognition of the pressing need to combat climate change. One of the most noteworthy aspects of these efforts is the deployment of a diverse array of innovations. These innovations span various aspects of the energy sector, ranging from cutting-edge technological advancements to novel business models and operational strategies. These innovations signify a clear departure from conventional practices and exemplify the industry's willingness to adapt in response to the challenges posed by climate change and environment. In XXI century, energy sector became a modern and thriving. Moreover, energy companies are not operating in isolation. They have forged strategic partnerships and collaborations with sectors across the broader economy. This collaborative approach underscores the interconnectedness of environmental sustainability and economic prosperity. Energy companies are joining forces with other industries to leverage synergies, share expertise, and create holistic solutions that benefit not only their own operations but also the wider society. The aforementioned actions taken by energy companies have been elucidated in specific, well-defined points, offering a detailed breakdown of their

commitment to decarbonisation, investments in renewable energy, innovative pursuits, and collaborative ventures. This multifaceted approach reflects a dynamic and forward-thinking industry that is actively shaping the future of energy production and consumption in a more sustainable and environmentally responsible manner. A schematic presentation of the main elements of the research results and conducted discussion is presented in Figure 1.



RES – Renewable Energy Sources; CE – Circular Economy; CCS – Carbon Capture and Storage.

Figure 1. Schematic presentation of the main research results.

Source: Own results.

This section provides a comprehensive analysis of the strategies used by energy companies to thrive in a zero-carbon economy. The strategies are divided into the following categories:

4.1. Decarbonization of Energy Core Operations

In recent years, the need to address climate change and reduce greenhouse gas emissions has become increasingly obvious. Companies around the world are taking proactive steps to reduce their environmental footprint by focusing on reducing emissions from their core operations. The urgent need to address climate change and the transition to a low-carbon economy has driven energy companies around the world to undertake the transformation of energy production towards decarbonisation (Papadis, Tsatsaronis, 2020). Thanks to their unwavering commitment to reducing greenhouse gas emissions and minimizing their impact on the environment, these companies undertake a number of comprehensive actions aimed at transforming the energy landscape. This study looks at various actions companies are taking to reduce emissions, including fuel switching, carbon capture and storage (CCS) and process optimization, highlighting their importance in promoting a more sustainable future.

Another strategic action is moving towards the circular economy (CE). The circular economy principles can be effectively applied to the energy sector in several ways to promote sustainability, reduce resource consumption, and minimize environmental impacts (Janik et al., 2020). One of the most important factor is energy efficiency which can be introduce by designing and optimizing energy systems and processes to minimize energy waste. Companies can adopt energy-efficient technologies, implement energy management systems, and continuously improve operations to reduce energy consumption. Next common factor is renewable energy sources which are considered "circular" because they harness energy from

naturally occurring and renewable processes, minimizing the depletion of finite resources and reducing greenhouse gas emissions.

The article reviews the multifaceted activities undertaken in the pursuit of decarbonisation in energy companies.

4.2. Investment in Renewable Energy

Many energy companies have taken decisive action to reallocate their financial resources towards renewable energy projects. The direction of these investments includes the development of technologies based on energy sources such as solar, wind, hydroelectric and geothermal energy. This strategic action not only shows the clear commitment of these companies to issues related to sustainable development, but also provides many benefits for society and the environment (Abbas et al., 2023; Hailemariam et al., 2022). Energy companies make significant investments in the development of infrastructure to create favorable conditions, mainly for the development of photovoltaics and wind energy. These investments include the construction of the necessary technical infrastructure, the development of transmission and distribution networks, as well as the improvement of energy storage systems to effectively integrate these renewable energy sources into the existing power grid. The first step is often the creation of high capacity photovoltaic and wind farms that generate significant amounts of renewable energy. These installations require appropriate infrastructure, including specialized energy converters, installations to transfer energy to distribution points, as well as monitoring and management systems that ensure the effective operation of these energy sources. In addition, energy companies invest in the expansion and modernization of transmission and distribution networks. This is a key aspect that enables the efficient transport of electricity from distant photovoltaic and wind farms to end users. In addition, energy storage is becoming increasingly important in the context of photovoltaics and wind energy, which are dependent on the variability of weather conditions. Energy companies invest in the development of advanced energy storage systems, e.g. batteries. These investments in infrastructure are not only crucial for increasing the share of renewable energy in the energy mix, but also for increasing the reliability and flexibility of the entire energy system. By investing in the development of such infrastructure, energy companies play a key role in accelerating the energy transition and moving towards a more sustainable future.

4.3. Technological Innovation

Energy companies face the necessity of significant transformations. One of the key aspects of this transformation is investment in research and development in clean technologies, energy storage solutions and modernization of energy networks (Hailemariam et al., 2022). Energy companies, understanding the need to reduce greenhouse gas emissions, focus on searching for innovative solutions. This ranges from the development of more efficient

photovoltaic panels and new wind technologies to research into new energy sources such as geothermal and nuclear energy.

Modern technologies, such as high-efficiency photovoltaic panels, not only increase energy production, but also reduce installation costs, making photovoltaics more accessible to a wide group of recipients. An example of innovation is also the development of perovskite-based solar energy technology, which promises even greater efficiency and lower costs (Liu et al., 2023; Xu et al., 2023).

Other areas of research focus on energy storage, which is crucial for the efficient use of volatile renewable energy sources such as solar and wind power. High-capacity, long-life batteries are becoming more commonplace, allowing excess energy to be stored during times of abundance and used during times of scarcity.

Energy companies in many countries have aging electricity transmission infrastructure, the average age of which is over forty years, which is why this infrastructure requires investment in its modernization. Due to the rapidly growing supply of renewable energy, transmission grids require large investments to meet the technical requirements for uninterrupted transmission (Invernizzi et al., 2020). In addition, the energy market model in many countries is changing from zonal to nodal, and the one-way transmission model is slowly being replaced by a two-way model based on distributed generation and renewable energy using digital solutions based on smart, flexible networks. The new model requires a different network concept, more flexible and less dependent on centralized infrastructure (Borowski, 2022).

4.4. Collaborative Partnerships

In the energy sector, cooperation with technology companies, research institutions and other industries is a key element related to innovation and the pursuit of sustainable development and effective reduction of greenhouse gas emissions. This wide-ranging cooperation between various actors plays a key role in shaping the future of energy, bringing a number of benefits to society, the environment and the economy as a whole.

Firstly, cooperation enables the exchange of knowledge and experience between the energy sector and technology companies. Thanks to this, it is possible to use the latest technological achievements to improve energy production, improve its efficiency, implement new energy market models and increase the share of renewable sources. Examples include the development of advanced energy storage systems or the introduction of smart energy grids that reduce losses and enable more precise management of energy supply (Borowski, 2022; 2020ca).

Secondly, cooperation with research institutions allows to accelerate the process of research and development of new technologies (Wang, Su, 2020). Working together on research projects and testing prototypes allows you to shorten the time to market of innovative solutions (Popp et al., 2020). This is crucial, especially in the context of the need to quickly adapt to the increasingly restrictive standards regarding greenhouse gas emissions.

Thirdly, cooperation between the energy sector and other sectors, such as transport or industry, enables a holistic approach to reducing emissions. Thanks to this, comprehensive solutions can be developed that include both improving energy efficiency in energy production and reducing emissions in other areas of the economy (Li et al., 2022; Du et al., 2019). For example, the electrification of transport and the use of electricity in industrial processes can significantly contribute to reducing overall greenhouse gas emissions.

Another fascinating example is the close cooperation between energy companies and printed food producers. Jointly implemented projects focus on the use of advanced 3D printing technologies in food production, which aims not only to meet the demand for food, but also to reduce the negative impact of food production on the environment. This modern method of food production can contribute to a significant reduction in the carbon footprint and greenhouse gas emissions associated with traditional food production processes, such as agriculture and animal husbandry. As a result, the synergy between energy companies and printed food producers not only allows you to meet the needs of society in the field of nutrition, but also contributes to the implementation of sustainable development goals by reducing energy consumption and environmental impact (Derossi et al., 2023).

As a result, cooperation between the energy sector and various sectors of the economy contributes to the creation of a more sustainable and green energy system, economic development and the development of the financial sector, supporting innovative investments (Mukhtarov et al., 2023; Baloch et al., 2021; Bekun et al., 2019). This is a key step towards meeting emissions reduction targets and transforming the energy industry into a greener ecosystem.

4.5. Strategies used by energy companies

The research results show that active and passive adaptation strategies used by energy companies increase their ability to implement innovative activities, develop cooperation and achieve the status of a modern enterprise. In the context of a dynamic energy environment, it shows how energy companies adapt to changes, using both active approaches and passive strategies. The presented analyzes are based on research conducted in the energy sector and on a literature review. The results indicate that a balanced adaptation strategy, combining active innovation activities and passive adaptation to changes, can contribute to the long-term success of energy companies, enabling them to compete effectively and meet the requirements of the modern market (Borowski, 2020a). In addition, the implications of these strategies for the development of the energy sector and prospects for the future are discussed.

4.6. Active adaptation strategy

One approach that energy companies often choose is an active adaptation strategy. This strategy consists in proactively adapting well in advance to legal, political, environmental and ecological requirements. A key feature of this strategy is the ability to anticipate and prepare

for future changes, and even participate in the preparation of these changes. Companies choosing this path can invest in new technologies that reduce greenhouse gas emissions and in renewable energy sources, even if current regulations do not directly require it. As a result, they become more flexible and better prepared to respond to changing market conditions and social expectations. The strategy of active adaptation adopted by energy companies represents a forward-looking and proactive approach to taking into account the constantly changing landscape of legal, political, environmental and ecological requirements. The strategy has several distinct features that distinguish it as a powerful tool for sustainable development:

Proactive anticipation - characterized by the fact that energy companies that choose the strategy of active adaptation show a high ability to anticipate future changes in the regulatory, legislative and social fields. By staying ahead of the competition, they can not only meet the upcoming requirements, but also influence the development of these changes. This proactive attitude allows them to shape the trajectory of their industry towards greater sustainability.

Investment in innovation – is a hallmark of an active adaptation strategy, as it demonstrates a willingness to invest in cutting-edge technologies and practices. These investments go beyond the scope strictly required by applicable regulations (Zhang et al., 2022). For example, energy companies may choose to fund research and development initiatives to develop cleaner and more efficient methods of energy production, or they may allocate resources to research new technologies such as carbon capture and storage (Golombek et al., 2022).

Shifting towards renewable energy – is an important element in the adaptation strategy. Companies using this strategy often devote significant resources to the development and implementation of renewable energy sources (Gielen et. al., 2019). They recognize that moving away from fossil fuels is not only environmentally friendly, but also economically viable in the long run. The transition towards renewable energy sources is also a direction commonly promoted in the current world. Investments in solar, wind, hydro and other renewable energy sources demonstrate a commitment to reducing greenhouse gas emissions and promoting sustainable development.

Greater enterprise agility – means that by actively adapting to future requirements, companies become more agile and flexible in responding to changing market dynamics. They are better equipped to change their business and adapt their strategies in response to changing consumer preferences, technological advances and regulatory changes. This flexibility is a valuable asset in an industry where rapid change is increasingly becoming the norm.

Social responsibility – this is an important element included in the strategy. Energy companies applying the strategy of active adaptation see the growing importance of meeting social expectations in the field of sustainable development and responsibility for the environment. They understand that stakeholders, including consumers, investors and the general public, are increasingly holding them accountable for their impact on the planet.

By actively taking initiatives in the field of sustainable development, these companies strengthen their competences in the field of social responsibility.

Competitive advantage – this is another aspect of the adaptation strategy, as companies that actively adapt to the requirements of sustainable development often gain a competitive advantage. They can position themselves as leaders in their industry, attracting customers and investors who care about the environment. Additionally, they can access government incentives and subsidies to support renewable energy initiatives, further strengthening their competitive position.

To recapitulate, it can be said that the strategy of active adaptation adopted by energy companies is a proactive and visionary approach to meeting the challenges of our times. This includes not only complying with existing regulations, but also actively seeking opportunities to make positive change, reduce environmental impact and ensure the company's long-term success in an increasingly sustainable world.

4.7. Passive adaptation strategy

On the other hand, there is also a group of energy companies that prefer the strategy of passive adaptation. This strategy means that such companies react to requirements and regulations only when they are put into effect, not before. The choice of this strategy may result from various factors and carries both certain benefits and potential risks. There are several key elements in the passive adaptation strategy, including:

Reacting to Specific Circumstances - Companies adopting a passive adaptation strategy often argue that it is difficult to predict the exact changes in the future. In such a situation, reacting to specific circumstances once they have been established may be more effective than taking action based on speculation. Thanks to this, you can avoid investing in resources and solutions that may turn out to be unnecessary.

Minimization of Costs - in some cases, adaptation in advance may be associated with high costs. Investments in new technologies, changes in infrastructure or restructuring of operations may require significant financial outlays. Companies choosing a passive adaptation strategy may try to maintain lower operating costs, especially if current regulations do not impose direct restrictions on them.

Risks and Challenges – it should be borne in mind that the choice of a passive adaptation strategy carries some risk. Waiting for the introduction of new regulations can cause companies to be surprised by sudden changes that they will have to implement quickly. This can lead to a situation where accelerated adaptation is necessary, which can be costly and organizationally difficult.

Environmental pollution - for companies that delay their actions to protect the environment, there is a risk that their impact on ecosystems and greenhouse gas emissions remains significant. Such delays can also put companies under pressure from a society that increasingly expects companies to contribute to sustainability.

Lack of Competitive Advantage - by choosing a strategy of passive adaptation, enterprises may not gain a competitive advantage, which is achieved by competitors who adapt to changes earlier. This may affect the market position and ability to attract investors who are increasingly paying attention to sustainability issues.

To recapitulate, it can be stated that the choice of the passive adaptation strategy by energy companies is justified, especially in the context of uncertainty as to future changes and adaptation costs. Nevertheless, this approach carries some risks, especially if the growing pressure of society and environmental regulations are not taken into account. Ultimately, the effectiveness of an adaptation strategy, whether active or passive, depends on the specific circumstances, risk management capability, and long-term vision of the company.

5. Conclusion

The conducted research indicates that energy enterprises actively employ adaptive strategies, undertaking numerous actions aimed at meeting escalating environmental and ecological requirements. In the current era where sustainable development stands as a paramount priority, energy enterprises face the challenge of aligning their operations with increasingly stringent ecological standards.

An exceedingly pivotal facet of these adaptive strategies lies in the cultivation of innovations within the realm of Renewable Energy Sources (RES). These innovations wield a profound influence on mitigating adverse environmental impacts. The transition of a portion of energy production from conventional sources, such as fossil fuel combustion, to renewable sources, such as solar, wind, or geothermal energy, permits a substantial reduction in greenhouse gas emissions and other harmful substances. As a consequence, energy enterprises contribute significantly to global endeavors aimed at combating climate change.

Simultaneously, innovations in the field of RES pave the way towards a zero-emission economy. This paradigm advocates for the minimization of carbon dioxide and other polluting substance emissions through the exclusive utilization of clean energy sources. By implementing such solutions, energy enterprises contribute not only to environmental preservation but also to the creation of a more sustainable energy future.

It is noteworthy that innovations in RES also exert an impact on energy efficiency. Modern technologies enable more effective utilization of available energy sources, reducing losses in the transmission and distribution processes. This, in turn, leads to a decrease in operational costs for energy enterprises and potentially results in more favorable prices for consumers.

Furthermore, innovations in RES open the door to the development of distributed energy systems. Consequently, an increasing number of individuals and businesses can become not only energy consumers but also producers. This engenders a novel energy model wherein so-called "prosumers", individuals or organizations, generate energy for personal use or for sale into the energy grid. This amplifies societal engagement in the energy sector and contributes to greater energy independence.

In conclusion, energy enterprises that embark on adaptive strategies and invest in innovations within the sphere of Renewable Energy Sources not only meet escalating ecological demands but also contribute to the transformation of the energy sector towards a more sustainable, efficient, and democratic energy future. These endeavors are pivotal in achieving objectives related to environmental conservation and the fight against climate change.

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PMS TOOLS FOR AGILE PROJECTS

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Purpose: This discourse aims to examine the categorisation of Project Management Software (PMS) with focused attention on those devised and integrated within the framework of Agile methodologies. The discourse highlights the functionalities of PMS that are most beneficial in Agile projects. It provides an overview of the underlying motives for their adoption and the potential advantages they can offer to project teams, Agile Project Managers, and their stakeholders.
Design/methodology/approach: A comparative analysis of existing tools supporting project management based on an agile approach was applied. Existing software features were analysed to identify similarities and differences, mainly in basic software functionality.
Findings: Effective communication within the project team through IT tools can be a basis for building a competitive advantage in the market. It increases the quality of project outputs through continuous monitoring of project implementation and quick interaction to improve the efficiency of project work.
Research limitations/implications: The number of existing tools and improvements to existing IT tools make it necessary to analyse the IT market situation cyclically.
Practical implications: The present article endeavours to serve as a comprehensive overview that draws upon relevant literature and existing market offerings of PMS to illustrate the discussed functionalities. The article is aimed both at practitioners deciding on the right tool and at software developers bringing newer versions of tools to market.
Social implications: The results of the comparative analysis have an indirect social impact. The agile approach relies heavily on continuous and direct communication between project stakeholders. The study results can help project teams choose the best tool to support project communication.
Originality/value: The literature search indicated a research gap in the comprehensive analysis of existing IT tools currently used in business practice.

Keywords: project management, agile approach, project management software, PMS.

Category of the paper: General review; technical paper.

1. Introduction

According to the authors, comprehending the potential benefits and hazards associated with PMS tools is paramount to the effective implementation of Agile projects within organisations of diverse natures. On the one hand, PMS tools can significantly aid participants in the project management process by facilitating their routine activities, communication, and project status determination. On the other hand, the consistent utilisation of selected IT support creates a foundation for accumulating project experiences and disseminating information pertaining to previously executed projects within the organisation. This enables, on the one hand, the enhancement of the quality of data regarding the actual progression of projects and the efficacy of planning projects similar to those previously executed (referred to as 'planning by analogy'), and, by systematising the Project Lessons Learned (PLL) process, a gradual increase in the project maturity level of the organisation.

Furthermore, in the context of the ongoing pandemic and the current labour market challenges, there is a rising interest in the re-structuring of project frameworks towards virtual (distributed) teams and remote work, specifically with regards to the delegation of tasks to remote teams located in areas that enable a reduction in overall personnel expenses in projects (Chaos Manifesto, 2020). Given the magnitude of the challenges in this domain, it is imperative to explore the sources and extent of potential support in the comprehensive processes of planning, executing, controlling, and steering the progression of projects, particularly those organised in a distributed manner with flexible Agile management frameworks.

For these reasons, and in view of the fact that the topic of this article is only partially addressed in international literature, if at all, the authors of this paper set out to examine and evaluate the scope of possible IT support in Agile projects and the most commonly used functionalities (especially GTD-type) in Agile projects, against the backdrop of the diverse PMS-type software available on the market, as well as the reasons for their use and the benefits that can be attained at different decision-making levels, with a particular emphasis on Agile projects.

2. Literature review

To acknowledge the extent of previous analyses in the subject area, the authors conducted a systematic literature review using two databases of scholarly studies: Springer Nature (SN) and Web of Science (WoS). The keywords taken into account were *Agile*, *software*, and *project management*. In the WoS database, when conducting a search across all fields (title, content), only one publication was identified when using the above-mentioned keywords.

In the SN database, there were 14 publications, but after analysing the content of the articles, only two of them could be utilised. Filtering of the searched articles was performed by considering the phrase: 'agile project+management+software' in the WoS database resulted in 9 articles, with only 4 of them being from the past 5 years. In the SN database, the same phrase resulted in 339 articles. Upon analysis, it was evident that the majority of the articles focused on the functionality of PMS software in relation to communication management in agile projects. The absence of a comprehensive analysis of other software functionalities valuable in agile projects impairs our understanding of the reasons for their utilisation and the potential benefits they bring to agile initiatives. This includes, but is not limited to, task management, documentation, the relationship between Scrum and kanban concepts, Scrum of Scrums project execution, and scheduling.

To address the article's main topic, the authors have devised a model for categorising IT support for project management. Using this framework, they present the extent, scope, and critical features of IT systems and software specifically geared towards agile project execution. The authors also elaborate on the reasons for using these systems and the benefits they offer in implementing agile projects.

3. PMS tools for project management

Information technology tools play a crucial role in the effective management of projects, both in conventional and agile methodologies, particularly for those classified as possessing high levels of complexity. The crucial role of IT tools is to provide support to project managers and team members during the defining, planning, and controlling phases of a project. Additionally, they furnish key stakeholders and decision-makers with timely and comprehensive information regarding the progress of the project, allowing them to revise the business case or assess progress at critical junctures in the project's implementation.

Although it is common in practice to refer to 'project management software', this terminology is incorrect. It is important to note that software does not manage the project itself, but rather serves as an aid to project stakeholders and decision-makers in collecting, analysing, disseminating, and reporting data. This enables them to make more informed and rational decisions about their projects, including those executed using agile methodologies. Therefore, it is more appropriate to use the term 'IT support for project management', which encompasses the following components:

- for support in managing individual projects: PMS (Project Management Software),
- for support in managing multiple projects: MPMS (Multiple Project Management System) or PPMS (Project Portfolio Management System).

Each of the aforementioned software categories possesses unique capabilities that can aid project managers in addressing various domains of influence. An illustration of the scope of such support is presented in Table 1.

Table 1.
Selected possibilities of IT support for project management

Features	IT support
Gathering project initiatives and defining the project	partial
Project planning, including: • structure planning, • scope and progress planning, • scheduling, • resource planning, • assigning tasks to staff/teams, • cost planning, budgeting.	 partial partial full full partial full
Implementation controlling and project steering	partial
Gathering project knowledge, analysing changes, analysing deviations	full
Reporting and documenting project progress	full
Managing distributed/virtual teams, remote working	partial/full
Reporting and documenting the multi-project management process, multi-cutting analysis and knowledge gathering on project portfolios	partial

Source: own study based on: Trocki, Grucza, Ogonek, 2003, p. 299.

At present, a plethora of software options exist in the marketplace that cater to the needs of project management, particularly during the planning and execution stages. In particular, the agile methodology necessitates the utilisation of software that facilitates team communication and reporting, such as the SCRUM Burn-Down charts. These software offers vary in terms of pricing, with options available that range from being free of charge to highly sophisticated integrated systems that may cost upwards of several hundred thousand Polish złotys. The potential applications of these software solutions are extensive, encompassing simple scheduling, identification of critical paths, and basic resource management. Furthermore, they also offer advanced features such as multi-dimensional economic analysis of resource utilisation, networking, coordination of the progress across multiple departments within an organisation, and comprehensive support for the simultaneous management of multiple projects.

For the purpose of this study, the software solutions will be divided based on their leading functional scope and main purpose in relation to projects. In light of this classification, the subsequent section will present functionalities and exemplars of Information Technology (IT) support in agile projects. From this perspective, IT support for project management can be categorised into the following categories:

- specialised programs (fragmented support for project implementation),
- comprehensive support for single project management (PMS) – for managers and project teams,
- software to support multiple project management (MPMS, PPMS) – business, product owners, and key stakeholders (For more see e.g. Bukłaha, 2020; Harrin, 2016).

The software solutions in the first category are characterised by basic functionalities in selected aspects of project management. Examples of these software solutions include programs for creating and recording mind maps (mind mapping), managing work in distributed teams (such as *Getting Things Done*, GTD), and tools for planning, scheduling, and controlling tasks. These software solutions typically feature basic progress visualisation tools such as Gantt charts and simple network diagrams, the capability to generate rudimentary project progress control statements, and in some cases, the ability to define a project's critical path. This category encompasses a diverse range of freeware and shareware programs. Examples of these software solutions include:

- Mind Mapper, Free Mind (mind maps).
- Slack, Trello, Asana, Jira, Nozbe (for task management in distributed teams, especially useful in agile projects).
- Gantt Project, ConceptDraw Project, Project+ (task management and scheduling).

Software solutions belonging to the second category (PMS) offer a much more extensive range of functions and are primarily targeted towards project managers and project team members. In addition to the fundamental planning functions for time, resources, budget, and tasks, they generally feature advanced reporting and control modules, such as for resource utilisation, cost control, and budget execution (using techniques such as Earned Value Management), the scope of work completed, time and schedule, etc. They also possess the capability to visualise the project through network diagrams, determine critical paths using methods such as MPM or PERT, identify crucial stages in the execution of work, generate reports from a wide range of functional areas of the project, and assist in risk assessment. Furthermore, these types of software solutions enable the creation of resource alignment charts and their automatic balancing, the assignment of costs to individual activities, and the development and control of a project budget. These software programs may also incorporate a database of template documents that can be utilised at various stages of the project lifecycle (such as P2Ware PM for the PRINCE2 methodology). These include: Microsoft Project, Project Libre, dotProject.net, ProjeQtOr, P2Ware Project Manager.

The third category of software programs (MPMS/PPMS) is intended for organisations that have a mature project management practice and run multiple, often interconnected projects simultaneously (such as portfolios, programs, chains). It is aimed at key stakeholders, organisational boards, project steering committees, product owners, strategic project management offices (PMOs), program and project portfolio offices. They enable, among other things, control over the status of multiple concurrent projects, streamline the flow of information about ongoing projects, and provide modules for aggregating data and generating comparative analyses between projects, allowing for the assessment of the condition of each project in the portfolio and making prioritisation of project execution possible. Their distinctive feature is the ability to generate in-depth reports on individual projects as well as the entire

project portfolio, across a wide range of dimensions. Examples of programs in this group include Microsoft Project Server, Primavera Project Management (as part of the Oracle Business Solutions PPM software), Clarizen One, Daptiv PPM, Hadrone PPM, and FlexiProject.

4. Scope of IT support for agile projects

Within the IT support for project management, it can be observed that agile projects prioritise the first two categorisations, specifically, the sectional project support and programs that facilitate a holistic approach to agile project management, such as the SCRUM methodology. The third category of software, referred to as Enterprise Agile Planning (EAP) Tools, is still in its nascent stages within the realm of agile methodology. Consequently, the options for software **specifically** designed for this type of project are relatively scarce (exemplified by solutions such as SpiraPlan Enterprise Agile Program Management (https://www.inflectra.com/SpiraPlan/), PlanView SAFe Kanban Software (https://www.planview.com/…) and JiraAlign (https://www.atlassian.com/…).

It should be noted that a significant number of software programs are available for supporting teams in agile projects, with the market for this type of software exhibiting rapid growth. Therefore, in the interest of brevity, only a selected few programs pertaining to specialised support and intricate project management will be presented below.

Table 2.
Selected examples of PMS software for agile projects

No.	Program name	Developer	Selected features
1.	**Active Collab**	Active Collab	documentation **management**, task and resource allocation, GTD, reporting, remote collaboration, SCRUM-ready
2.	**Asana**	Asana	documentation **management**, task and resource allocation, GTD, remote collaboration, SCRUM-ready
3.	**Backlog**	Nulab	task management, GTD, versioning, change control, SCRUM-ready
4.	**Blueprint**	Blueprint	document **management**, task and resource allocation, GTD, reporting, remote collaboration, Scale Agile Mgmt.
5.	**ClickUp**	ClickUp	document **management**, task and resource allocation, GTD, kanban boards, remote collaboration, SCRUM-ready
6.	**Github Project Management, Github PM**	GitHub	task and resource allocation, GTD, kanban boards, remote collaboration, SCRUM-ready, bug tracking
7.	**Jira, Confluence**	Atlassian	documentation **management**, task and resource allocation, GTD, reporting, remote collaboration, SCRUM-ready, scheduling
8.	**Project Insight Software**	Project Insight	task and resource allocation, GTD, kanban boards, remote collaboration
9.	**ScrumMate**	Adaptive Consulting	kanban boards, task management, remote collaboration, SCRUM-ready

Cont. table 2.

10.	**Scrumwise**	Scrumwise	documentation **management**, task and resource allocation, GTD, reporting, remote collaboration, SCRUM-ready, scheduling
11.	**Teams + Planner**	Microsoft	documentation **management**, task and resource allocation, GTD, remote collaboration, SCRUM-ready
12.	**Toggl Plan**	Toggl Plan	task and resource allocation, GTD, kanban boards, remote collaboration, SCRUM-ready, bug tracking
13.	**Trello**	Atlassian	documentation **management**, task and resource allocation, GTD, remote collaboration, SCRUM-ready
14.	**VersionOne**	VersionOne	documentation **management** "Budgeting, task and resource allocation, GTD, reporting, remote collaboration, SCRUM-ready, budgeting, scheduling

Source: own study based on: https://www.softwareadvice.com/project-management/agile-comparison/; https://toggl.com/blog/agile-project-management-tools; https://blog.capterra.com/agile-project-management-software/; https://clickup.com/blog/agile-tools/; https://www.capterra.com/agile-project-management-tools-software/; https://thedigitalprojectmanager.com/agile-tools/.

Based on the aforementioned overview, a clear representation emerges regarding the magnitude and breadth of project delivery assistance provided by Project Management System (PMS) programs, with regards to facilitating the strategic planning, steering, executing, and controlling of Agile projects. Additionally, a significant number of PMS programs offer both free and premium versions of their software. It should be noted that the free versions often come with limitations in terms of functionality compared to the premium versions. They may also restrict the number of team members or concurrent projects that can be managed through the program. As an illustration, Table 3 presents a condensed summary of selected features of the free and premium versions of several prominent Getting Things Done (GTD) programs.

Table3.

Comparison of key features of GTD tools for agile projects

Features	**Asana**		**Trello**		**Jira**	**MsTeams Planner**
	Free	**Premium**	**Free**	**Premium**	**Premium**	**Premium**
Goal setting	+	+	-	-	+	-
Timeline	+	+	-	-	+	+
Monitoring project progress	+	+	+	+	+	+
Automatic operation/ calculation/chart generation	+	+	-	-	+	+
Kanban boards	Up to 1000 tasks	+	+	+	+	+
Project calendar	+	+	-	+	+	+
Assigning tasks to team members	+	+	+	+	+	+
Milestones	+	+	-	+	+	+
Appearance personalisation	-	+	+	+	+	-
Project overview and summaries	+	+	-	+	+	+
Attachments	Up to 100 MB	+	Up to 10 MB	+	+	+

Cont. table 3.

Team mate cooperation	Up to 15 team mates	+	+	+	+	+
Comments and activity	+	+	+	+	+	+
Suggested size of agile projects	Medium and large		Small and medium		Medium and large	Small and medium
The project management approach	is executed through multiple perspectives, which encompass the task list, kanban board, schedule, and calendar views.		is executed on a single kanban board (additional widgets can be used).		is executed through multiple perspectives, which encompass the backlog, kanban boards, reports, releases, components, incidents, etc.	is executed through multiple perspectives, which encompass the task list, Kanban board, schedule, and calendar views.

Source: Malesińska, Bukłaha, reproduced material, own study.

The examination of Project Management System (PMS) software market offers reveals a continuous progression of development and adaptation by the software providers to meet the current demands of project teams and comply with the updated standards for project implementation. The adoption of agile methodologies for software development has seen a surge in recent years, resulting in an increased demand for tools that can support this approach (Azizyan, Magarian, Kajko-Mattson, 2011).

Irrespective of the magnitude of IT support for agile project management, the utilisation of Project Management Systems software has been observed to result in the following advantages. In particular, these include:

- for **project planning**:
  - increasing the accuracy of task planning,
  - better structuring of the project with clearly defined objectives,
  - more efficient gathering of experience and its use in the planning of future projects,
  - faster availability of project data,
  - improved communication between project participants and between the project and its environment,
  - improving the transparency of ongoing projects,
  - closer monitoring of project progress,
  - ability to integrate with other data sources in the organisation;
- for **scheduling**:
  - setting more realistic deadlines for tasks,
  - shortening/optimising project implementation time,
  - agreeing deadlines more effectively with project participants and stakeholders;

- for **task assignment and organising the work** of the project team:
  - setting deadlines more effectively with project participants,
  - allocating resources and people to tasks more efficiently,
  - better opportunity to verify competence against assigned tasks,
  - providing a unified information platform to allow distributed teams to operate more effectively;
- for **resource planning**:
  - transparent resource planning and better use of resources,
  - faster identification of resource bottlenecks and overallocated resources,
  - ability to enforce accountability for the accuracy of the data entered;
- for **planning and cost analysis**:
  - more precise cost analysis and control,
  - project liquidity analysis,
  - better ability to define project evaluation indicators;
- for **project steering and work implementation control**:
  - a clearer overview of the project progress,
  - the ability to integrate project, resource and cost data with other services used in the project management process through a number of plug-ins,
  - near real-time project control,
  - faster response to risks and changes in monitored projects,
  - a more carefully prepared project steering process,
  - providing a uniform source of up-to-date information for reports and analysis.

5. Conclusion

The successful development of IT project management systems is becoming a source of competitive advantage for many organisations, which means that the implementation of PMS software, among others, is a big step into the future (Sánchez, 2015). Project management tools, such as Trello, Jira, Asana and GitHub PM, are widely utilised in agile teams to facilitate the efficient and effective delivery of projects. These tools enable project teams to have a comprehensive overview of the project, allowing for the creation and execution of tasks, ensuring adherence to deadlines, coordinating work and resources, and facilitating the production of detailed notes and plans. Additionally, they provide templates for standardising the summary of information, which is crucial in managing projects, programs, and portfolios. Utilised effectively, project management tools have the potential to enhance team productivity and significantly reduce the frustration caused by overlooked assignments or

duplicated efforts (Nowogrodzki, 2020). The level of support provided to teams, managers, and stakeholders varies based on the nature of the project and the degree of project maturity within an organisation. Nevertheless, the rapid pace at which the software industry is adapting to the evolving needs of agile project environments suggests that the functionality of project management tools will continue to improve in the future. Despite the authors' assertion that a complete unification of the functionalities of project management tools is unlikely, the diverse range of offerings in the market will allow agile teams to identify the most appropriate solution for their specific projects.

Despite the availability of numerous tools that support the management of agile projects, proper communication between the parties involved remains a persistent challenge for distributed project teams. This is crucial for ensuring the quality of the final product. This challenge is especially relevant in regards to coordination issues, including the sharing of requirements, schedules, tasks, changes, and code artefacts (Eckhart, Feiner, 2015). This once again highlights that while software and IT systems can provide support for teamwork, they cannot substitute interpersonal relationships that serve as the foundation for communication within projects, especially those subjected to intense change during implementation, such as agile projects. Nevertheless, if feasible, teams should be provided with support in areas that can benefit from improved information flow, coordination, and control. In this regard, project management software can prove to be invaluable, both in the present and in the future.

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HR CONTROLLING IN PROJECT MANAGEMENT – SELECTED ISSUES

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Purpose: The aim of the article is to provide a broader context for the discussion on the significance and role of HR controlling in project management. Despite being a type of project controlling, it appears to be overlooked in the existing literature. The objective of the authors is to "demystify" these problems to some extent and show why personnel-related issues should also be a major area of interest for those responsible for developing the project information flow system, both in terms of strategic and – above all – operational controlling.
Design/methodology/approach: The article is cross-sectional, based on a literature review and desk research technique.
Findings: The cross-sectional approach and literature review employed in this study have contributed to a comprehensive understanding of HR controlling in project management. It is imperative for project managers and stakeholders to recognize the value of HR controlling and employ appropriate tools and techniques to ensure the successful implementation of projects.
Originality/value: This paper has provided an in-depth exploration of HR controlling within the context of project management. By shedding light on the significance and role of HR controlling, it underscores the importance of personnel-related matters in the overall project management process.

Keywords: HR Controlling, human resources, project management, desk research, tools and techniques.

Category of the paper: General review.

1. Introduction

Controlling is a concept that has gained popularity in the management literature in recent times (Bracci et al., 2022; Laitinen, 2023; Sahudi et al., 2022; Schwolgin, 2022). Defining controlling is challenging due to its abstract nature, etymology, and interdisciplinary origin (Messner et al.,

2008). Traditionally, controlling is often considered as a unit in the organizational structure of a company and related to financial reporting (Doyle et al., 2007; Perovic et al., 2012).

However, a contemporary perspective on controlling identifies it as an instrument of the management system that includes planning, control, monitoring of goal achievement indicators, analysis, and interpretation of information (causes of deviations) (Horváthová, Mokrišová, 2021). Its main goal is to ensure efficiency in all areas of the company's functioning by integrating separate control functions into a coherent whole, which distinguishes them from control processes often carried out by autonomous units of the organization and related to a limited area of its activity (Harasheh, Provasi, 2023).

Compared to the vast literature on organizational controlling (Vlasenko, Gaytmazov, 2023; Secchi, Seri, 2017), project controlling is still an issue that is insufficiently represented in the subject literature both in Poland (Cabała, 2002; Łada, Kozarkiewicz, 2007; Niedbała, 2008; Głodziński, Marciniak, 2016; Bukłaha, 2019) and abroad (Kapuganti et al., 2019; Trzeciak, Jonek-Kowalska, 2021; Trzeciak, 2022). Analysis of relevant publications (Lin, 2002; Grishunin, Suloeva, 2015) indicates that project controlling mostly involves coordinating the basic functions of project management processes, such as planning, organizing, motivating, and controlling. In this study, the authors defined project controlling as a subsystem of management (a set of methods, procedures, and techniques) that provides decision support with appropriate managerial information at important decision-making levels in the project, considering the various stages of its implementation. Regarding projects, controlling should also involve providing current and transparent information (Brady et al., 2018) necessary to take remedial action to avoid or mitigate deviations from the assumed costs and schedule (Martens, Vanhoucke, 2019), as well as optimizing the use of available resources (Ulusoy et al., 2021). This approach should also extend to the variance analysis concerning quality plans or project risks.

In addition to the areas of controlling mentioned above, personnel controlling also plays a significant role. Furthermore, personnel issues should also be the main area of interest for those responsible for developing the information flow system in the project, both in terms of strategic and operational controlling. HR controlling is the process of identifying, measuring, and monitoring key aspects of human resource management to ensure that a company’s human resources are in line with its strategic goals. Moreover, in the implementation of projects, HR controlling supports the determination of the required number and quality of personnel (Monika, Mariana, 2015), assessment of their competencies and development needs (Dwivedula, 2019), ensuring their motivation and involvement in the project (Trzeciak, Banasik, 2022), and monitoring their performance and effectiveness (Kerzner, 2022).

In connection with the above, the aim of the article is to discuss the issue of HR controlling in project management. The article presents a broader context for understanding the importance and role of HR controlling in the project management process. Although HR controlling is one of the types of projects controlling, it is often neglected in comparison to other issues such as

financial control, resource management, or scope of work. The article analyzes what project management controlling is, types of project management controlling, what is meant by personnel controlling, and the elements of personnel controlling involved in project implementation. The article also discusses the most commonly used HR controlling tools in project management. The article is cross-sectional, based on a literature review and desk research technique. Furthermore, the authors aim to "demystify" HR controlling issues and show why personnel issues should be the main area of interest for those responsible for the development of the project information flow system, both in terms of strategic and operational controlling.

2. Materials and Methods

This paper aims to delve into the discussion of HR controlling issues within the specific context outlined below. Firstly, it seeks to provide an understanding of project management controlling, including its definition and various types. Secondly, it explores the concept of HR controlling, elucidating its meaning and examining the elements of HR controlling that are involved in project implementation. Lastly, it investigates the most commonly used HR controlling tools in project management.

By effectively addressing these multifaceted issues, the fundamental objective is to establish a comprehensive framework that enables a holistic grasp of the significance and role of HR controlling in the overarching project management process. Remarkably, despite being classified as a subtype of project controlling, HR controlling seems to have received limited attention in the existing literature, particularly when juxtaposed with other domains such as finance, resource management, or scope control.

Consequently, the authors endeavours to demystify these issues to a certain extent and underscore the rationale behind the imperative need for conscientiously addressing personnel-related concerns by individuals entrusted with the development of the project information flow system. Both strategic and operational dimensions of controlling are emphasized, underscoring the pivotal importance of efficaciously managing HR-related matters.

To achieve these goals, the authors posed the following research questions:

1. What is the definition of project management controlling and what are the different types of project management controlling?
2. How can HR controlling be defined and what are the specific elements of HR controlling that are involved in project implementation?
3. Which HR controlling tools are commonly used in project management?

By considering the chosen deductive approach, this article employs a cross-sectional methodology (Zangirolami-Raimundo et al., 2018) and heavily relies on conducting a thorough literature review and desk research (Wahid et al., 2023; Guerin et al., 2018). These research techniques offer a robust basis for exploring and analysing the extensive knowledge base concerning HR controlling in the realm of project management. Consequently, they greatly contribute to fostering a comprehensive comprehension of the subject matter at hand.

3. Place and role of controlling in project management and the types of controlling

It is only recently that the modern view of controlling as a management support concept has emerged in economic literature. Producing a definition of the concept of controlling poses a certain challenge, due to its abstract nature, etymology, and interdisciplinary origins, and depends for instance. on the scope of activities, it covers in an organisational unit. Traditionally, it is most often regarded as a unit within the organisational structure of the company and associated with financial reporting. However, the modern perspective on controlling identifies it as an instrument of the management system, which comprises planning, steering, control (goal achievement indicators), and analysis and interpretation of the information obtained (reasons for deviations). Its main purpose is to ensure efficiency in all areas of a company's operations by integrating isolated control activities into a coherent whole, which distinguishes it from control processes, often performed by autonomous units of an organisation and concerning a limited area of its operations.

Compared to the wealth of literature on organisational controlling, project controlling is still an issue that is under-represented in expert literature, both in Poland and abroad. An analysis of relevant publications indicates that project controlling most often involves coordinating the basic functions of the project management process (planning, organising, motivating, and controlling). An overview of the ideas of selected Polish and foreign authors on the issues of controlling in project management is presented below.

Table 1.
Selected definitions of project controlling

Author	Year	Definition of controlling
Z. Bass	**2016**	An independent system supporting the implementation of review and control procedures throughout the project implementation period. The purpose is to increase the efficiency of work and to constantly review the formal goals of the project (its business case) as defined at its pre-implementation phases.
R. Fiedler	**2016**	Supporting the project management process by structuring and continuously reviewing project milestones and tasks, and by promoting project planning and control – improving sound project decision making.

Cont. table 1.

P. Gudda	**2011**	**A management subsystem that plays a key role in a project implementing organisation with regard to the selection of appropriate data to assist in steering and monitoring the ongoing project progress, as well as its interim and key results. Unlike monitoring, it should specify the means of collecting, analysing and interpreting such data to provide a reliable and detailed basis for making sound decisions about ongoing projects.**
H. Kerzner	2009	A three-step process involving: measuring progress from the start of the project until its final result, evaluation of work progress, and adoption of corrective and remedial actions (correcting) so as to achieve the intended goal or even exceed the expectations set for the project. Through these measures, it is possible to achieve the defined goals, and with regard to project problems, to take effective anticipatory or corrective actions.
S. Marciniak and P. Gołoś	**2013**	An integrated management subsystem including planning, steering, control, and information functions, supporting the adaptation and coordination of the entire project management system. In their view, it consists of planning, reporting and steering parts.
A. Preissner	**2003**	A comprehensive project control concept consisting of planning, control, information supply and work coordination elements which goes beyond simple project control activities.

Source: own work.

The above definitions have at their core an interdisciplinary and coordinating function to support decision-makers in making managerial decisions in projects. In view of the above perspectives, the authors will consider project controlling as a management subsystem (a set of methods, procedures and techniques) that provides support for the decision-making process with relevant managerial information at the important decision-making levels in the project, with respect to the various phases of its implementation (More on this in: Bukłaha, 2019, pp. 63-64). With regard to projects, controlling should include the provision of up to date and transparent information necessary for adopting countermeasures to avoid or mitigate the deviation of the assumed costs and timeline, as well as to optimize the use of the available resources.

In literature, there is no precisely defined way to break down controlling and classify project evaluation perspectives from a controlling viewpoint. For the purposes of this study, the authors have adopted three forms of breakdown: by project status assessment, by planning limits and scope, and by major project control areas.

Viewed in terms of assessment profiles, project controlling can be broken down into the following perspectives:

- simplified – a comparison of the desired (target) status with the actual status,
- comprehensive – a system of mutually defined undertakings, principles, methods and techniques for an internal control and monitoring system, oriented towards achieving the set result,
- visual – the process of business navigation and control by means of a plan lays out the destination,
- abstract – an integrated supervision, planning, monitoring and information system that supports the adaptation and coordination of the entire management system (Kardasz, Kęs, 2004).

Due to the limits and scope of project activity planning, a distinction can be found in literature between strategic (long-term) and operative (operational, ongoing) controlling.

Strategic project controlling deals with assessing the strengths and weaknesses of projects in relation to the organisation's current development strategy. It examines the preliminary feasibility of projects, evaluates their cost-effectiveness and efficiency from the point of view of the adopted guidelines, develops project ranking lists, and analyses the convergence of their goals with the strategic objectives of the organisation. Strategic controlling makes use of such tools as (Łada, Kozarkiewicz, 2007, pp. 32-33):

- strategic evaluation of the project (multi-faceted assessment of the effectiveness of the project, taking into account external and internal conditions),
- analysis of the project's value for the customer (used to determine the final price of the project using the 'arm's length' method),
- target project costing (determination of the scope, quality and timing of the project based on the cost of the project and its target price),
- project life cycle costing (project cost analysis considering, apart from the implementation phase, also the phase of the use of project deliverables),
- cost analysis in the project value chain (i.e., the value and costs at all phases of project development, implemented both inside and outside the organisation),
- project portfolio analysis (value and cost analysis in which projects are considered as part of the overall portfolio of related projects),
- measuring project performance, e.g., by means of the Balanced Scorecard (an in-process assessment of whether a project is delivering the expected benefits).

The techniques used in controlling and the methods of evaluating the project effectiveness are not going to be discussed in detail in this paper. More information on them can be found e.g., in: Vollmuth (2007), Rogowski (2004), Łada, Kozarkiewicz (2007).

These control tools allow better development of the portfolio of implemented projects, understanding of actual expectations of customers in terms of the scope, quality, and cost of projects, and the determining of the impact potential of stakeholders, risk analysis, etc. The tools and techniques used in strategic controlling, whether for projects or recurring activities, are expected to increase the possibilities and opportunities for ensuring the long-term and stable existence of the organisation and making sound strategic decisions.

Operational (operational, ongoing) project controlling is oriented towards regulating the implementation of projects within a short timeframe (usually up to one year). It focuses on planning, execution and control of projects selected for implementation at the strategic controlling phase. It is most often based on an analysis of cost-revenue-profit and revenue-expenditure relationships. The tools typical of operational controlling of projects include (Łada, Kozarkiewicz, 2007, pp. 32-33):

- planning how the project will proceed and the cost (determining the expected financial impact resulting directly from the implementation of the project),
- evaluation of the financial performance of the project (analysis of the financial costs and benefits of the project),
- reporting for decision-making purposes (a set of information to help make decisions about sourcing and allocating resources to the project),
- recording and accounting for the team's work and resources used against the project's baseline plan,
- recording and accounting for project costs (systematic measurement of the actual financial effects of implemented projects),
- budgeting and review of budget implementation (analysis of the actual financial effects of projects against their baseline budget),
- follow-up project analysis (the so-called post-audit, analysis of actual costs and benefits of project implementation, both financial and non-financial; project lessons learned survey).

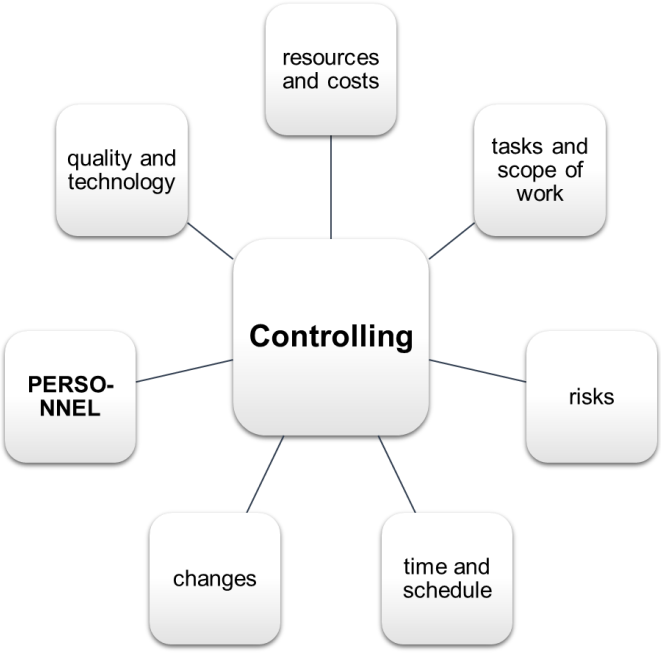

Figure 1. Selected areas of project controlling.

Source: own work.

Operational project planning is a continuation of the strategic planning process. It relates primarily to the project implementation phase, providing a starting point for the implementation of operational plans for projects, in line with the organisation's strategic goals. It is not focused on a project's efficiency but on its implementation (feasibility) in line with strategic goals, considering external and internal constraints (stakeholder analysis, risk analysis, etc.). Strategic controlling guidelines are largely the responsibility of the organisation's management or their authorized units, while operational controlling falls within the domain of project

managers and (less frequently) project team members. In addition, both strategic and operational project controlling in financial terms rely heavily on the results of the organisation's strategic and operational budgeting process.

The third way of breaking down controlling (by significant areas covered in the project) is presented below.

This form of breakdown focuses on the key areas to be evaluated, relevant *en bloc* **primarily in operative controlling of the project**. This is due to the fact that, firstly, strategic controlling deals with the evaluation of projects at a much higher level of generality and, secondly, the project manager or project supervisors need a wide range of information for the ongoing control and monitoring of work specified in the task schedule of the current phase (and the forthcoming phases) of the project. They may not focus solely, for example, on the scope and cost of tasks performed, as otherwise the exclusion of other evaluation elements from the scope of the review could lead to critical deviations, disrupting or even preventing the achievement of key project goals. The major areas in which controlling is employed in projects include (Kendrick, 2012):

- budget, costs, and liquidity,
- availability of resources and resource intensity of work,
- schedule, work completion time, and milestones,
- planned and actual scope of work,
- quality of interim and final deliverables of the project,
- work execution technology,
- risks and project issues, especially in the implementation phases,
- project team and personnel considerations in the project,
- project changes and transformations.

Being aware of the multiplicity of the issues listed above, for the purposes of this paper, the authors will focus on the section below on the issue of HR controlling in projects.

4. HR controlling and how it is employed in project management

Human resource management controlling is an integral part of controlling as a business management concept and is referred to as HR controlling (Zając, 2006). Its chief objectives are planning, analysing, supervision, evaluation, control, and decision-making regarding the HR aspects of the controlled activities. It is used to improve the deployment of human resources and achieve the best possible profits for the organisation. It accounts for combining two policies, human resources policy and economic policy, within the organization (Paździor, Paździor, 2016). The principal tasks of HR controlling can include co-development, support, and coordination of human resource management processes throughout the organisation or in

its selected areas (Zając, 2011; Kuepper et al., 2013). It serves two basic functions: informational (preparation and management of information in the process of personnel decision-making) and coordinating (regarding the deployment of human resources in the organisation to the extent subject to controlling procedures).

While much has been written to date about HR controlling in an organisation as such, a review of the literature (Polish and foreign publications from the last ten years) has revealed an almost complete absence of scholarly publications in the field of personnel project controlling (in other words, human resource controlling). The authors were not able to find during the literature survey a single book, monograph, or textbook on the above topic, thus this seems to be a promising research field for future exploration. Fortunately, given the universality of many recommendations in the field of HR controlling in the organisation, at least some of them can be extrapolated to the problem of project management. As a result of the summaries made, the authors identified the individual elements of HR controlling in projects, as described in Table 2.

Table 2.
Selected elements of HR controlling vs. project management cycle.

Project management phase	**HR controlling elements**	**Intensity of controlling activities in relation to HR controlling**
initiation and definition	• establishment of the Steering Committee or its equivalent, • identification of key project stakeholders (including the principal, sponsor, key contractors, beneficiaries and users, others), • determination of project requirements as a basis for further detailed analysis at the planning phase	low
planning	• identification of required competencies for project positions, including behavioural, technical, and contextual competencies of the project manager, relevant for the controlling process, • appointment of the project manager and providing them with guidance on the project and with adequate decision-making authority, • recruitment, selection, and adaptation of team members, • organisation of the project team and the ways to motivate it, • selection of the project organisation form, • setting the rules of functioning of and communication in the team, • setting the rules of cooperation between the team and those in the proximity of the project, • establishing the responsibilities of each member in relation to the purpose of the project and the resulting scopes of work, • determination of performance indicators for project work, • setting the rules of accounting for working time, • setting the rules for remuneration, bonuses, and rewards for project work, • establishing procedures for handling personnel and payroll matters in the project, • setting the rules for resolving conflicts between the project manager and line managers of persons employed in the project	average/high

Cont. table 2.

implementation and steering	• control of the team management process, including multicultural teams and diversity in the team, • monitoring and control of the situation in the team during project implementation, the dynamics of employment and its developments, • ongoing communication with the team and those in the proximity of the project, including key stakeholders, • strategic control of work progress and periodic communication with the Steering Committee and key stakeholders, • monitoring compliance with labour law under agreements and contracts concluded in the project, • monitoring the established responsibilities of each member in relation to the project plan and the resulting scopes of work, • review of performance indicators, • maintaining personnel files and managing employee records for the project	high
completion	• review of the situation in the team upon completion of the project and acceptance of work upon delivery, • project lessons learned survey, • dissolution of the project team, • preparation and management of personal records terminating the employment relationship in the project	low/average

Source: own compilation based on: Kerzner, 2013; Król, 2017; Podgórska, 2018; Musioł-Urbańczyk, 2010; Chomicz, 2020; Marciniak, 2008; Wachowiaket al., 2004; Lipka, 2021; Górecki, 2001; Pocztowski, 2018.

As the above summary demonstrates, the elements of HR controlling in project management are highly convergent with the corresponding elements of this type of controlling in recurring (functional, process) activities, unless they are used to meet specific recommendations arising from the organisation's existing project management methodology or standard.

As the project controlling concept is developing (with its specialised types, including HR controlling), it is undergoing constant modifications along with the transformations that occur in organisations, necessitated mainly by changing conditions in their business environment and functioning in the "VUCA world." While it plays an important role in planning and controlling of work progress at the planning, implementation and follow-up phases, controlling also provides an essential interface between project management and the management system of the organisation as a whole – including the management of human resources, deployed at least in part in the implementation of the organisation's internal (cost) and external (revenue) projects.

5. Selected tools and techniques of HR controlling in projects

From the point of view of project controlling, there is a variety of HR controlling tools and techniques which are useful in effective project management. They are presented from the perspective of the project phase and their scope of application.

Table 3.
Selected tools and techniques of HR controlling in projects.

Tool/technique	Project phase	Purpose of application
work card	planning	determination of competence requirements for project work by tasks to be performed
personality matrices	planning	successful selection of members to ensure effective and possibly conflict-free work of the entire project team
competency matrix	planning implementation closure	clear division of roles in the tasks to be performed; avoiding work overload and underload; eliminating workload bottlenecks in the project; clear allocation of responsibilities within the team; preventing work from not being completed as no member of the team felt (or was identified as) the owner of the task; facilitating control activities at the project implementation phase
internal and external team communication models	planning implementation	selection of an adequate (successful) form of communication within the team and between the team and those in the proximity of the project (including stakeholders), depending on the characteristics of the project, organisational culture and the complexity of the work performed
communication plan	planning implementation completion	development of a clear communication path; facilitating control activities at the project implementation phase
periodic inspections of personnel-related issues in projects	planning implementation	iterative, periodic or ad hoc inspections regarding HR matters in the project, including the composition and availability of the team, the team's readiness to work in possible conditions under which services are provided in support of the project, absenteeism and volume of regular and overtime work, productivity and volume of work performed in relation to the plan, the relationship between project work and line work, the extent and causes of conflicts within the team
project progress reports	implementation completion	acquisition of information covering the aforementioned personnel-related and other issues, relevant at the control phase from the point of view of those making the relevant decisions in the project
conflict resolution matrices	planning implementation completion	taking effective measures regarding the team when confronted with certain types of crises in the project

Source: own compilation based on: Cabała, Wawak, 2022, pp. 227-232.

As the above summary illustrates, most of the listed HR controlling tools and techniques focus on the planning and implementation phase of the project, and some of them will also be useful at the completion phase. By contrast, despite its diversity, the authors do not find them applicable at the initial phases, i.e., initiating and defining the work. This is understandable from the perspective of project cycle management (Trocki, 2012; Cabała, Wawak, 2022) because these pre-planning phases (the conceptualisation) focus not on HR issues as such but on establishing the project goal, its business case, the overall quality framework, and guidelines for technology, time, schedule and acceptable budget. It is only at the planning phase – after the above information has been compiled, the business case has been developed, and the project idea has been approved – that a project manager is (usually) appointed and the project team begins to be formed. Therefore, the tools and techniques referred to above make it possible to achieve their benefits in the project at later phases, up to and including completion, when an overall summary of the work done in the project is made, final meetings are held with the project team, a 'project lessons learned' (Wyrozębski, 2014) survey is conducted, and the team is dissolved, with its members being assigned to other work.

6. Conclusion

This article was aimed at a comprehensive exploration of HR controlling in the context of project management. By delving into the definition and types of project management controlling, elucidating the concept of HR controlling, and investigating commonly used HR controlling tools, a framework is established to comprehend the significance and role of HR controlling in the overall project management process. The existing literature often overlooks HR controlling, despite its importance in managing personnel-related matters. This article adopts a cross-sectional approach, utilizing a literature review and desk research technique to analyse the existing body of knowledge on HR controlling in project management.

HR controlling involves the systematic management and regulation of human resources within a project. It encompasses the processes and practices that ensure the optimal allocation, utilization, and development of personnel to achieve project goals. In project implementation, HR controlling plays a pivotal role in ensuring that the right individuals with the necessary skills and competencies are assigned to appropriate roles. It also encompasses performance evaluation, training and development programs, and maintaining a motivated workforce. The elements of HR controlling in project implementation include strategic workforce planning, recruitment and selection, performance management, and employee development.

Several tools and techniques facilitate effective HR controlling in project management. These tools enable project managers to monitor and regulate personnel-related matters efficiently. Examples of commonly used HR controlling tools include work card, competency matrices, internal and external team communication models, communication plan, periodic inspections of personnel-related issues in projects, project progress reports and conflict resolution matrices. These tools assist in aligning human resources with project requirements, identifying skill gaps, evaluating performance, and addressing employee concerns. By utilizing these tools, project managers can make informed decisions and optimize the utilization of human resources.

This paper has provided an in-depth exploration of HR controlling within the context of project management. By shedding light on the significance and role of HR controlling, it underscores the importance of personnel-related matters in the overall project management process. Despite being overlooked in the existing literature, HR controlling plays a crucial role in managing human resources effectively. The cross-sectional approach and literature review employed in this study have contributed to a comprehensive understanding of HR controlling in project management. It is imperative for project managers and stakeholders to recognize the value of HR controlling and employ appropriate tools and techniques to ensure the successful implementation of projects. Further research in this area can enrich the existing knowledge and enhance project management practices.

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EVOLUTION OF TRENDS IN INNOVATION STUDIES

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Purpose: The study has two primary goals: the first is to identify trends and their dynamics in innovation research, while the second is to show the original methods of systematic literature review based on text mining tools with the aim of detecting trends in research papers.
Design/methodology/approach: The authors offer an approach that enriches the toolset of classical systematic literature review methods. Analysis was focused on the full texts of papers published in selected subject areas. Categories were discovered automatically in data rather than being pre-defined. The quantitative approach to text-mining that has been successfully tried and tested in multiple studies was supplemented with original tools created by the research team. This approach allowed authors to identify categories and trends within innovation research. The approach applied is consistent with general rules for systematic literature reviews.
Findings: The outcome of this study was the identification of 16 trends, including 5 long-lasting (e.g. new product development and knowledge sharing and management) and 8 emerging trends (e.g. strategic foresight, sustainable application and leadership).
Research limitations/implications: Two limitations of this study were identified – one is related to the number of papers and cluster size. The study was restricted to the years 2000-2020 and 19 top tier journals dedicated to the field of management and innovation research based on the appearance in the rankings and search of journals dedicated to innovation. The issues of innovation have of course also been discussed in other journals, therefore authors decided to limit its number to the most frequently appearing in the citation rankings. Still, the sample size is significantly larger than in most other studies. The other limitation – the minimum cluster size in HDBSCAN – must be defined experimentally. The method requires only one parameter, which is less than is the case with other clustering methods.
Originality/value: Our work constitutes an original in-depth investigation into current advances in innovation research using text mining. Furthermore, our results indicate that the developed approach is universal and could be applied when selecting prospective research areas and spotting fields with increasing potential. Additionally, the text mining procedures adopted in this study could provide researchers with a tool for gaining a thorough grasp of knowledge of a specific field buried in a vast amount of scholarly literature. For practitioners it can offer suggestions on areas of possible business acceleration and transformation. The clustering technique produces an overview of a particular field in greater detail.

Keywords: innovations, systematic literature review, text-mining, trend analysis.

Category of the paper: research paper.

1. Introduction

Innovation has recently emerged as a key strategy for companies keen to maintain a competitive advantage and gain access to broader or new markets (Stock et al., 2002; Ferraris et al., 2017; George et al., 2021). It is also one of the major catalysts boosting the international competitiveness and productivity, output and employment performance of countries as well as a tool for measuring the health of an economy (Becheikh et al., 2006; George et al., 2021).

Innovation is a durable, time-consuming and resource-intensive process organized around ideas and future needs. The outcome of any innovation process is uncertain and challenging to predict. Therefore, to gauge its potential, we must understand its origins (Chesbrough, 2003; Fernandes et al., 2019). The cumulative nature of innovation emphasized by Lazonick (2002) in various of his papers is influenced by social conditions which change over time and can vary depending on the type of activity involved. To make progress and shape innovation, all these factors must be integrated with previous experiences and lessons learned.

It is important to emphasize the complex and diverse nature of business activities that are specific to analyzed countries, regions, and economic sectors. Hence, constructing a universal framework describing the development of the concept of innovation poses a challenge. Efforts have been made to classify eras or "critical technologies" that have played a crucial role in speeding up the development of further innovations constructed on the basis of or correlated with the critical technology (Bruland et al., 2009).

The economics of technological innovation in literature are described as a cumulative process and it is possible to observe the explicit course of development in specific fields (Mukoyama, 2003; Cantwell, 2000). One possible explanation of this phenomenon is that it is a kind of competition between companies to adopt new technologies or solutions and thus avoid locking into potentially less efficient technology and following the choices and strategies made by early adopters (Arthur, 1989). As a consequence, over the years the choices made by these early adopters have greatly influenced the paths taken by the companies which came after them. Although this phenomenon can be observed in relations between competitors, it is also very common among companies working in supportive or complementary infrastructure areas (Nieto, 2004).

Technology is specific, cumulative and differentiated in character, and as such the industrial composition of innovative activity in a specific location or amongst a national group of firms reflects past technological accumulations in that defined area. This suggests that international patterns of technological advantage, once established, remain relatively stable over time, at least in the short or medium term. Those sectors in which each group of firms is technologically strongest changes only gradually (Cantwell, 2000).

Another important concept for management research is disruptive innovation. Christensen, et al. suggest a number of topics that remain under-explored in current innovation research (2018). They propose focusing future research on: response strategies in reaction to disruptive innovation, performance trajectories and metrics of disruption (Christensen et al., 2018).

The data presented in the literature show that over the years changes have occurred in the way in which innovations are analyzed and variations in areas of interest are correlated with innovations. Reviews based on an analysis of patents issued in various countries reveal a shift from industrial innovation towards innovation in services, from the point of view of both companies and research interests (Fagerberg, 2002).

Monitoring the current trends in innovations can support progress and help in defining the direction of future development. The main research question is what the trends in the studies on innovations in the XXI century were. Based on a review of the literature from the years 2000-2020 and using an alternative method of data analysis, our objective was to identify shifts in interests and trends in the field of innovation so as to ensure a better understanding and improved research agenda in the upcoming years. Our second aim was to demonstrate the suitability of the original method based on text mining tools for detecting trends in research papers.

2. Literature review

2.1. Prior literature reviews on trends in innovation

Over the last 20 years various literature reviews have been conducted on the topic of innovations. Some of these were broad in scope (Becheikh et al., 2006; Crossan, Apaydin, 2010; Keupp et al., 2012; Khosravi et al., 2019), while some focused on more specific problems (Garcia et al., 2002; Hossain, Kauranen, 2016; van Oorschot et al., 2018; Gomes, et al., 2018; Cillo et al., 2019; Dziallasa, Blind, 2019). The detailed descriptions of these studies are presented in Table 1.

Table 1.
Summary of previous systematic literature reviews on the topic of innovations

Study	Sample size	Full text analysis	Method of analysis	Results	Detailed area of exploration
Garcia et al. (2002)	21 empirical studies	yes	systematic review of the literature and empirical studies	Method for classifying innovations.	Innovation typology and innovativeness terminology.
Becheikh et al. (2006)	108 articles (1993-2003)	yes	systematic review of empirical articles	Classification of studies by investigated region, discipline, type of innovation.	

Cont. table 1.

Crossan, Apaydin (2010)	525 articles (1981-2008)	yes	systematic literature review	Identification of distinct meta-constructs: leadership, managerial levers and business processes.	
Keupp et al. (2012)	342 articles (1992-2010)	yes	systematic literature review (co-word analysis, cluster analysis and frequency analysis)	25 clusters identified with regard to the following: inter-firm collaborations; strategic management of innovations; deliberate non-innovation; implementing innovation and others.	
Hossain, Kaurane n (2016)	51 articles (2006-2013)	no	abstract analysis (NVivo program)	Following themes identified: search strategies; collaboration; transforming from a closed to an open approach; innovation management; OI performance of SMEs; and challenges of SMEs in OI.	Open innovation in SMEs.
Van Oorschot et al. (2018)	1260 articles (2003-2016)	yes	systematic literature review (bibliographic coupling and co-citation analysis)	Research trends identified: determinants of IT adoption; adoption of technological standards; organizational rationales associated with adoption; modeling diffusion, and adoption of agricultural innovations.	Innovation adoption.
Gomes et al. (2018)	125 articles (1993-2016)	yes	systematic literature review (hybrid method including bibliometric and content analysis)	Identification of six research streams in the innovation ecosystem: industry platforms; innovation ecosystem strategy; innovation management; managing partners; the innovation ecosystem life-cycle; innovation ecosystem and new venture creation.	The innovation ecosystem.
Khosravi et al. (2019)	66 studies (1981-2017)	yes	systematic review combined with a meta-analysis of the literature	A model of management innovation, including organizational, managerial and environmental antecedents.	
Cillo et al. (2019)	69 articles (1995-2018)	yes	systematic literature review (content analysis)	Of three key perspectives, internal managerial perspective is the most frequently applied, whereas external relational and performance evaluation are not that often considered.	Sustainable innovations.
Dziallas, Blind (2019)	226 articles (1980-2015)	yes	systematic literature review	Identification of company specific and contextual dimensions indicators, as well as ex-ante and ex-post evaluation indicators.	Innovation indicators.
Our study	22139 articles (2000-2020)	yes	TF-IDF, cluster analysis	Identification of 16 trends including 5 long-lasting, 1 declining, 8 emerging and 1 ephemeris in character	

Source: Own results.

In 2006 Becheikh, et al. published a systematic review of the literature on technological innovations in the manufacturing sector from 1993 to 2003. The primary aim of this study was to deepen our understanding of the innovation process. As a result, the authors introduced a set of variables linked to the innovation process and the internal and contextual factors driving specific innovations. In their work, the authors highlighted the findings of trends connected with the regions they investigated (with Europe in the leading position), specific disciplines (with economics, management and business administration being the dominant disciplines), as well as the type of innovation investigated (with the focus on product & process and product).

A more extensive literature review, covering over 500 publications over a period of more than 25 years, was presented four years later by Crossan and Apaydin (2010). The authors synthesized the research perspectives and frameworks of organizational innovation, identifying on this basis three distinctive meta-constructs: leadership, managerial levers, and business processes. They suggested viewing innovation as a process and as an outcome. Their approach provides a multi-dimensional framework of organizational innovation.

Another general literature review comes from Keupp et al. (2012). After reviewing 342 articles dedicated to strategic management and innovation, the authors identified theoretical inconsistencies and knowledge gaps in the case of the following topics (Keupp et al. 2012, pp. 383): the performance implications of inter-firm collaboration; appropriation strategies; the strategic management of process innovations, administrative innovations, and service innovations; deliberate non-innovation; the causal relationship between internal organization and innovation; the implementation of innovation; the influence of ownership structure on innovation strategy; the development of resources for innovatory purposes; alternative measures for gauging the performance implications of innovation; environmental contingencies beyond country and industry settings; and the strategic management of innovation in low and medium-technology industries. Their analysis includes a classification of studies based on the types of innovation studied, the dependent and independent variables employed in the studies, the analytical methods used, and the industries analyzed.

The most recent analysis of general trends in innovation studies was published in 2019 by Khosravi et al. Their study was based on a systematic review combined with a meta-analysis of the literature and their objective was to assess existing empirical studies focused on management innovation. The authors analyzed 66 studies with the aim of identifying the trends and background of management innovation research. They proposed a model that included organizational (company size, knowledge management, organizational structure and strategy, human resources management (HRM), dynamic capabilities, culture, networks and resources), environmental (market dynamics, policy and law, people and communities) and managerial (leadership behaviors, stewardship, and characteristics and attitudes) antecedents. They listed a number of major theoretical concepts serving as a background in innovation studies, including: resource and capability based theory; organizational learning; institutional theory; innovation theory; human capital theory; the theory of knowledge inertia; full range leadership

model theory; knowledge management theory; dynamic capability; learning theory; contingency theory; organizational theory; behavioral theory; ability-opportunity motivation theory; knowledge-based theory of the firm; and innovation diffusion.

As far as studies focused on specific problems are concerned, one of the first issues that was a subject of detailed scrutiny was innovation typology and innovativeness terminology. Garcia et al. (2002) performed a literature review of empirical studies focusing on marketing, engineering, and new product development to ensure more clarity and continuity in the use of the terms employed to classify innovation. Such an approach helps avoid having to remodel the work carried out by researchers involving different labeling (wording) in descriptions. This in turn makes it possible to expand the area of research and avoid duplication of the same efforts. Otherwise, discrepancies in classification and operationalizing innovations in the new product literature may affect the progression of knowledge and can also influence how the research interests of academia and business are defined. The authors suggest that when identifying and describing innovation and its origins it is crucial that we consider various dimensions such as marketing and technological perspectives together with macro and micro-level perspectives. They also provided a method for classifying innovations as a common platform upon which practitioners and academics can define specific innovation types and the way in which the innovation process can be dedicated to a particular type of innovation.

In 2016, Hossain and Kauranen published a literature review that focused on the application of open innovations (OI) in SMEs. They identified six major themes: search strategies and networking; collaboration; transforming SMEs from a closed to an open approach; innovation and technology management; the OI performance of SMEs; the challenges faced by SMEs in OI and how to overcome the challenges. According to the authors' general findings, SMEs can improve their overall innovation performance by adopting OI.

The next issue to be addressed was the adoption of innovations,, which was analyzed by Van Oorschot et al. (2018). Their study, which includes a coherent overview of the theoretical cornerstones in the literature, was based on the bibliographic coupling method, which served as a tool for assessing current trends in research during the period 2003-2016. The authors grouped these trends into five clusters: drivers of, and impediments to, information technology adoption; acceptance and introduction of technological standards; organizational rationales associated with innovation adoption; modeling the diffusion process; and adoption of agricultural innovations. They identified four clusters based on co-citation analysis.

The very same year de Vasconcelos Gomes et al. (2018) published a work clarifying the concepts of innovation and ecosystems and identifying trends and research opportunities. In their work the authors highlighted the most influential papers in the field and discussed the concept of ecosystems whilst at the same time stressing the transition from a business ecosystem (mainly concerned with value capture) to an innovation ecosystem (primarily geared towards value creation). Finally, the authors discussed a number of trends shaping innovation ecosystems: industry platforms; innovation ecosystem strategies, strategic management, value

creation and business models; innovation management; partner management; the innovation ecosystem life-cycle; innovation ecosystems and new venture creation. The authors highlighted not only the most influential papers in the field and described six research streams in the innovation ecosystem, but they also proposed opportunities for further research aimed at supporting the transition from a business ecosystem to an innovation ecosystem.

Following a more general trend of sustainable development, Cillo et al. (2019) reviewed the existing literature on sustainable innovation. Using multiple perspectives of internal managerial, external relational, and performance evaluation, they identified the key issues most frequently considered in each (Cillo et al., 2019, p. 9):

- Internal managerial: strategic management, innovation management, ambidexterity, business model innovation, information systems, knowledge management;
- External relational: strategic alliances, stakeholder theory;
- Performance evaluation: a methodological approach.

Finally, the last of the presented studies, conducted by Dziallas & Blind (2019), covered the problem of innovation indicators throughout the innovation process. A literature review was key both to identifying indicators divided according to company-specific and contextual dimensions, as well as to assessing their potential for ex-ante and ex-post evaluation.

2.2. Prior approach to trend identification and the limitations of previous reviews

A systematic literature review (SLR), which was the most popular method employed in the studies presented above, allows researchers to better understand and describe a field of study. However, because it is a labor-intensive exercise, the number of papers included in an analysis is limited. To solve this problem, the authors use strict and narrow queries.As a consequence, the number of papers providing a more in-depth analysis is limited to a few hundred or less (e.g. Garcia et al., 2002; Becheikh et al., 2006; Hossain, Kauranen, 2016).

In most cases, such an approach is based on metadata: titles, keywords and abstracts (e.g. Hossain, Kauranen, 2016). Several software applications facilitate this process. Unfortunately, some authors report less than 8% of their research claims in abstracts (Blake, 2010). The relative importance of each word in a title or abstract is much higher than in the case of the full text. Abstracts and titles often contain catch-words that are used to increase readership and the likelihood of citation. Finally, many publishers define the structure of abstracts and introduce pre-defined keywords. This makes finding new ideas and topics in the metadata more difficult. Hence, studies relying on metadata cannot be treated as fully reliable.

Often, such studies are limited to specific databases, which narrows the scope of the review (e.g. Crossan, Apaydin, 2010; de Vasconcelos, Gomes et al., 2018). Reviews also usually excluded conference papers, books and unpublished full-text documents focusing only on selected articles (e.g. Khosravi et al., 2019).

Further, analysis is mostly narrative and qualitative (Tranfield et al., 2003) in form. More extensive studies require the adoption of a text-mining toolset and quantitative methods. Some previously presented literature reviews adopted a more complex approach: Van Oorschot, et al., (2018) used co-citation network analysis and cluster identification, while Keupp et al., (2012) relied on co-word analysis, cluster analysis and frequency analysis. This, however, gives rise to new limitations, which can be resolved by analyzing the full texts of papers. However, even in that case, some limitations apply. We found that most authors predefined themes, clusters or categories. This can prevent the discovery of new ones not known before the study and can also induce researcher bias. We are far from criticizing the results of previous SLR in this field. It is a valuable source of insight into the development of many scientific disciplines and an invaluable tool for comparative, network and semantic analysis. In our article, we wanted to point out an alternative approach which can supplement and enrich research efforts.

That is why the central aim of this article is not only to present a systematic literature review of studies on innovation, but also to show the suitability of a method based on text mining tools for detecting trends in research papers.

3. Method

In this study, the authors offer an approach that enriches the toolset of classical systematic literature review methods. We focused our analysis on the full texts of papers published in selected subject areas. Categories were discovered automatically in data rather than being pre-defined. The quantitative approach to text-mining that has been successfully tried and tested in multiple studies was supplemented with original tools created by our research team. This allowed authors to identify not only categories but also trends. The approach applied is consistent with general rules for systematic literature reviews (Ananiadou et al., 2009; Tranfield et al., 2003) and comprises several steps:

1. Selection of journals.
2. Collection of papers.
3. Search for the most critical terms.
4. Discovery of thematic groups (clusters).
5. Discovery of trends.
6. Verification, description and interpretation of trends.

The entire process is presented in Figure 1.

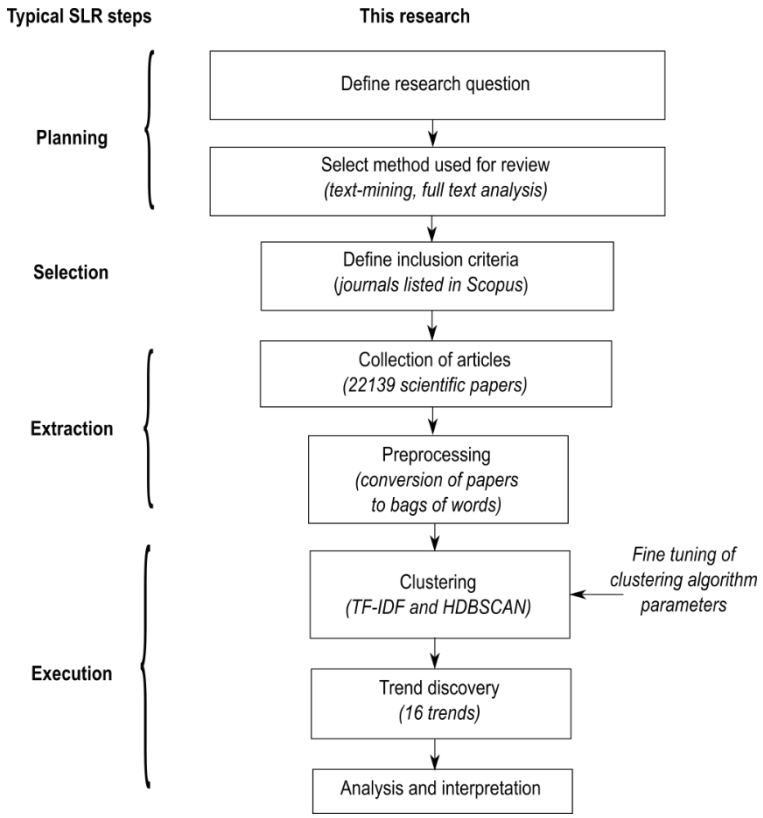

Figure 1. Diagram of the method and steps involved in a systematic literature review (SLR). Source: Own results.

3.1. Collection of papers

The proposed method avoids using predefined keywords and categories. Due to this fact, it was necessary to adopt a novel approach when selecting papers. Instead of keywords, we identified highly cited journals that cover the subject of innovation, technology and management. A similar approach has already been used, e.g. by Wawak, Woźniak (2020) and Wawak et al., (2020). The criteria for choosing journals and papers for analysis were as follows:

- journal is listed in the Scopus database in subject area "Management of Technology and Innovation" (total of 234 journals),
- journal is present in 90th percentile rank based on Scopus Citescore index based on citations between years 2017-2020 (23 journals),
- the full text of the published articles is available for over 10 years of publication (19 journals remained for further study)[1],
- the article was published in selected journal between 2000 and 2020,
- only research papers were included.

[1] Following journals present in 90th percentile of CiteScore ranking were published for less than 10 years in 2000-2020 period and thus excluded from analysis: *International Journal of Precision Engineering and Manufacturing - Green Technology, Journal of Innovation and Knowledge, Entrepreneurship and Sustainability Issues, IEEE Communications Standards Magazine*.

To ensure thorough coverage of the field, we chose all published articles that met the criteria from the 19 journals presented in Table 2.

Table 2.
Journals included in the study

Journal title	Scopus Cite Score	Impact Factor 2020	Number of papers included
International Journal of Management Reviews	15,4	8,63	416
Academy of Management Journal	14,0	7,57	1520
Academy of Management Annals	13,0	11,87	245
International Journal of Project Management	13,0	6,62	1706
Journal of International Business Studies	12,1	9,16	1087
Technovation	11,5	5,73	1292
Journal of Business Venturing	11,3	7,59	838
Organizational Research Methods	11,2	5,71	579
Research Policy	10,4	5,35	2493
Journal of Product Innovation Management	9,8	5,00	962
International Journal of Physical Distribution and Logistics Management	9,8	4,74	839
Journal of Management Studies	9,4	4,89	1225
International Journal of Operations and Production Management	9,1	4,62	1294
Technological Forecasting and Social Change	8,7	5,85	3256
Journal of Knowledge Management	8,5	4,75	1347
Operations Management Research	8,4	2,00	150
Human Relations	7,1	3,63	1387
Electronic Commerce Research and Applications	6,9	3,82	830
Journal of Human Resources	6,8	3,70	673
Total			22139

Source: Own results.

We collected the PDF versions of the papers using the Ebsco, ScienceDirect and Emerald databases. No duplicates were found at this stage due to previous screening. Files that contained editorials, calls for papers, errata or book reviews were removed. Finally, 22139 papers were the subject of further analysis. The size of the sample should be sufficient, as we included a wide range of articles published in highly cited and recognized journals.

Given the concerns raised when restricting an analysis to titles, keywords and abstracts only, in this study we scrutinized the full-texts of papers without titles, keywords, abstracts and references.

Supplementary data, e.g. bibliographical records and number of citations was retrieved from the Crossref database. Each paper was converted into a text file and then into a bag of words, which was required for automatic analysis using computer algorithms. The algorithms have been created using Python libraries including grobid, nltk, scikit-learn, hdbscan, and scipy (Jones et al., 2001; Lopez, 2009; McInnes et al., 2017; Pedregosa et al., 2011).

The approach proposed in this paper has already been applied in similar studies published in several papers (Guzik et al., 2020; Wawak et al., 2020; Wawak, Woźniak, 2020).

3.2. Search for the most important terms

The most important terms are not always those which are the most frequently used. The most frequent words in English are “the" and “of”. In this study, the keyword “innovation” appears in almost every article. As a consequence, it has no impact on decisions made by researchers or algorithms. Keywords that occur only in one paper may be crucial for that one publication but say nothing about the corpus as a whole. The most important terms are those which occur in several papers as a group. An analysis of thousands of such terms allows researchers to identify groups of similar papers, identify clusters, and then trends (Cong et al., 2016; Salton, Yang, 1973). Fortunately, this laborious task can be automated thanks to the term frequency – inverse document frequency method (TF-IDF). It considers the frequency of a term but simultaneously counts the number of documents in which this term was found. The following formula describes the main calculation performed with the TF-IDF method:

$$w_{i,j} = tf_{i,j} \cdot \log\left(\frac{N}{df_i}\right) \tag{1}$$

where:
wi,j – result for term i in document j,
tfi,j – number of occurrences of i in j,
dfi – number of documents containing i,
N – number of documents in the corpus (set of documents).

The TF-IDF method has several limitations, which we took into account. It is not a mathematical model, requires extensive computation, cannot identify synonyms and ignores the multiple meanings of certain words (Zhang et al., 2011). In the case of research papers, these problems have a minimal impact due to the more precise language used by researchers. Other approaches to this problem are available, e.g. Latent Semantic Indexing (LSI) or Latent Dirichlet Allocation (LDA). However, they were not suitable in the present situation as the format of the results was incompatible with the other methods used.

3.3. Discovery of thematic groups (clusters)

Algorithms require the conversion of papers into numbers. The text of each paper was converted into multidimensional vectors. The number of dimensions was equal to the number of keywords used in the analysis (on average over 50000 in this study). These vectors can be compared to each other by means of, among other methods, cosine similarity, and, as a consequence, make it possible to identify thematic groups. This can be achieved using partitioning or hierarchical clustering methods. The fundamental difference between these methods is that with partitioning all papers have to be included in one group, while hierarchical clustering allows some papers to be left unassigned. This second approach leads to better results

in trend analysis because journals often contain papers that are sometimes loosely connected with others. Such papers should not be used in trend discovery, as they could result in false trends being identified. There are multiple hierarchical clustering methods available, e.g. meanshift, DBSCAN, Optics and HDBSCAN (Jain, 2010; McInnes et al., 2017). The latter is the latest technique and resolves some of the shortcomings of other methods. HDBSCAN (Hierarchical Density-Based Spatial Clustering of Applications with Noise) takes each paper (vector) and checks at what distance it can find similar ones. Then it compares the results and detects the densest areas, which it deems to be clusters. The density and number of elements in a cluster can differ. It is the duty of researchers to define the minimum size of a cluster. This requires a series of experiments. In this study, we found that the best results were achieved when the minimum cluster size is set to 20[2].

The whole sample was divided into groups of papers published in five-year periods that overlapped with each other, starting with 2000-2004 and ending with 2016-2020. Each paper was assigned to every group in which it fitted. Cluster analysis was performed on each group separately, and the results provided the basis for discovering trends. The percentage of papers published by different journals each year is presented in Figure 2.

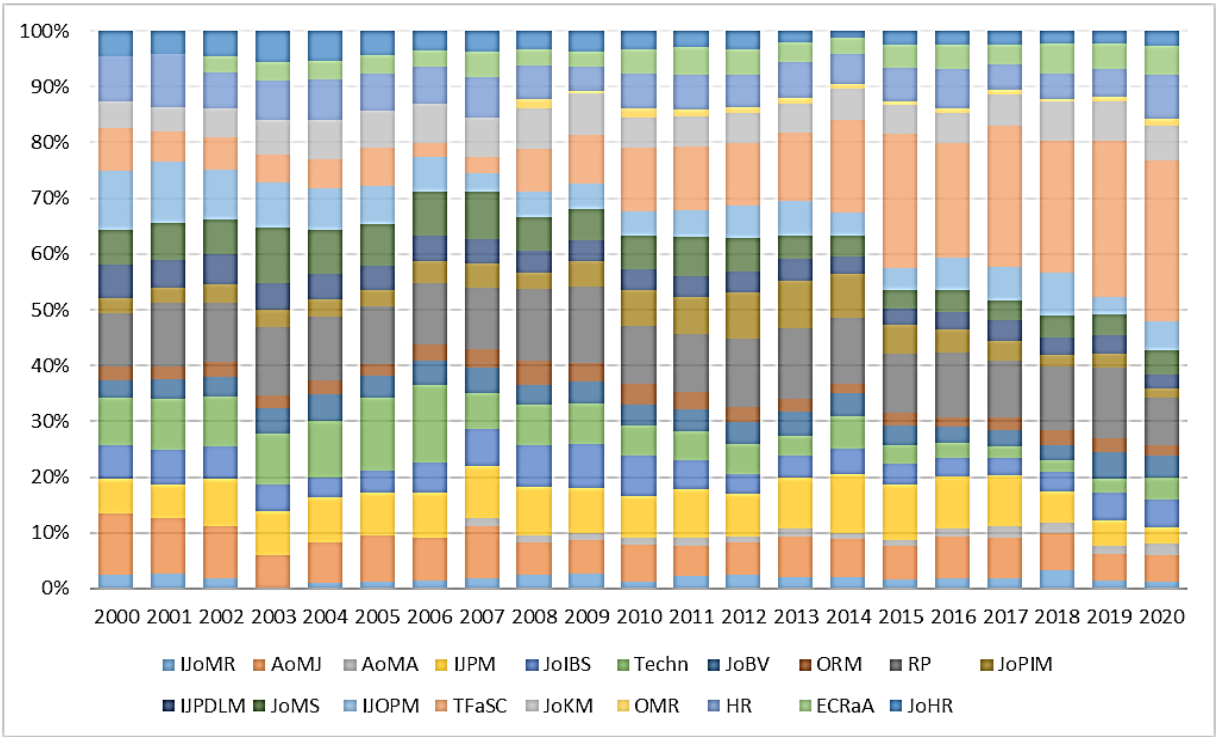

Figure 2. Percentage of papers published by selected journals in the years 2000-2020.
Source: Own results.

[2] We created primary analysis for cluster sizes 15, 20, 25 and 30. The criterion for selecting the size of the cluster was a heuristic consisting in the optimal selection of the level of detail and the number of identified trends (sets of keywords). Too small size of the cluster meant that the number of identified categories of keywords reached 100 or more items, which would increase the volume of the article (many more trends to describe). Too large cluster size resulted in the identification of a few <10 trends too general in nature and obvious. Access to source files for this analysis is made public on the Github platform along with software we created for this purpose (https://github.com/wozniakk-uek/Trends_in_innovation).

Because of the limited length of the paper, it is not possible to present the HDBSCAN algorithm in detail. Full documentation with examples and a comparison with other clustering methods can be found on a dedicated website (http://hdbscan.readthedocs.io).

Software used during preparation of this article is available on GitHub repository (https://github.com/wozniakk-uek/Trends_in_innovation).

3.4. Identification of trends

The identification of a cluster provided the basis for classifying papers included in the study. Clusters have to be identified in multiple subsequent periods to enable trend discovery. Previously, when endeavoring to identify trends authors tried to analyze subsequent and independent periods. This required an analysis of each cluster and could induce researcher bias. In this study, we made use of overlapping periods. Because the analyzed periods intersect with one another, it is possible to track year after year in which clusters each paper was included. Thanks to this fact, we could observe the evolution of clusters, and trends could be distinguished. As a result, four types of trend could be identified:

- long-lasting trends that existed and developed during the studied period,
- declining trends which ended during the studied period,
- emerging trends which began during the studied period,
- ephemeris trends that began and ended during the studied period.

As this approach only applies to groups of papers bigger than the minimum cluster size, it is important to stress that papers not included in clusters cannot be regarded as less important or uninteresting. For example, the average number of citations of both papers included in clusters and papers lying outside clusters is similar (analyzed yearly based on data received from Crossref.org). The only reason why our algorithm did not include a paper in any thematic group was the selected minimum size of a cluster. Papers which are located out of clusters possibly touch upon essential topics that have been studied by very few researchers. Among them, future trends can probably be found that have not been discovered in the current research.

3.5. Interpretation of trends

In the final step trends are verified, interpreted and described. However, the algorithm cannot perform this step yet. Typical situations which depend on the decisions taken by researchers include: a merger of two similar trends and a split in one trend because of multiple paths adopted by different studies. We designed the algorithm so as to detect even slight differences between trends. This requires more analysis by human observers, but at the same time reduces the risk of omissions. Therefore, merging two very similar trends based on an analysis of leading keywords and texts of sample papers is sometimes justified. In this approach, the researcher must also name each trend. The interpretation phase should help highlight changes within trends and try to predict their future evolution.

4. Results

This analysis, based on automatic algorithms and further verification performed by researchers, led to the discovery of 16 trends presented in Table 3. The trends in the table are arranged according to the year of their first occurrence and length.

Table 3.
Trends in innovation research in the years 2000-2020

Year/ ID	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	Internationalization																				
2	New product development																				
3	Patenting																				
4	Knowledge sharing and management																				
5	Project and project risk management																				
6	Work-life balance and career development																				
7		Incubators & spin offs																			
8									Lean management												
9					Innovation policy																
10						Leadership & team management															
11							Strategic foresight														
12										Business cooperation											
13											Corporate Social Responsibility (CSR)										
14														Crowdfunding							
15														Big data							
16															Sustainable applications						

Source: Own results.

We identified 16 trends, of which 5 were long-lasting, 1 declining, 8 emerging and 2 ephemeris in character. The exact year in which a trend was discovered does not indicate when the idea behind it was created, but it shows when the subject became increasingly popular among researchers.

The research problems behind the identified trend are:

1. Internationalization, understood as the potential and specific skills of companies with regard to expanding into foreign markets and export, as well as foreign direct investment (Ibeh et al., 2005).
2. New product development, which mainly concerns its influence on the general condition of companies focused on developing new assets (Lakemond et al., 2006).
3. Patenting, which addresses the role and motives of patent protection for work performed by researchers involved in academia and business sectors (Veer et al., 2011).
4. Knowledge sharing and management, which deals with the ability to use intellectual capability and create new solutions for humans and organizations (Kakabadse et al., 2003).

5. Project and project risk management deal with issues such as time, resource and cost in relation to the definition, planning and monitoring of complex projects (Petit, 2012).
6. Work-life balance and career development covering various aspects of family welfare and career planning related to market opportunities, managerial competences and income (Caceres-Delpiano, 2006, Gomez-Mejia 2011).
7. Incubators & spin offs; where researchers defined as a role of university linkage and knowledge transfer (Rothaermela et al., 2005, Fontes, 2005) and relationship between university and industry (Perkmann et al., 2007).
8. Lean management is defined as a method of organizing and managing a company's work to improve product quality and profitability of production processes (Hasle et al., 2012; Bhamu et al., 2014).
9. Innovation policy – reflecting how policy-makers and governments have realized the importance of innovation for economic conditions (Dodgson, 2011).
10. Leadership & team management where researchers focused on transformational leadership seen as important aspect of project-based organizations and risk management (Keegan et al., 2004; van Knippenberg et al., 2013).
11. Strategic foresight where we observe structured and systematic approach to analyze available information to roadmapping and anticipation of future events and changes (Lee et al., 2005, Bezold, 2010).
12. Business cooperation, including relations with various partners: other companies, partners from academia and non-profit organizations, as well as the problems of outsourcing, offshoring, and public-private partnership Schwartz et al., 2010; Colombo, 2012.
13. Corporate social responsibility (CSR), which correlates mainly with ISO and corporate communication (Hemingway et al., 2004).
14. Crowdfunding, mainly geared towards an analysis of sources of funding for innovations (Stanko, Henard, 2017).
15. Big data, a set of relatively new tools and techniques used for creating knowledge and supporting decision making (Hartmann et al., 2016).
16. Sustainable applications, which is focused on implementing innovative technologies in manufacturing and business (Markarda et al., 2012).

5. Discussion

An extensive literature review based on an analysis of the full-texts of over 22.000 papers published over the last 20 years led us to identify 16 different trends in studies on innovations, the nature and dynamics of which are highly diversified.

New product development is a relatively coherent, long-lasting trend identified in the analyzed literature. Over the years considerable attention has been paid to the management area to foster innovation and its efficiency (Lewis et al., 2002). Researchers explored the nature, changes and factors affecting specific project and knowledge management behavior and styles (Kim, Kim, 2009; Magni et al., 2013), as well as of corporate culture (De Brentani, Kleinschmidt, 2004). The publications connected with this trend discuss the methods and consequences of planning as well as how to control the performance of NPD. Researchers worked on business design and risk at each step of NPD, and these factors are also broadly described in various works produced by the academia and business experience sectors (Salomo et al., 2007). If we observe the development of this trend we can see more interest in new technologies designed to improve product design (Perks et al., 2005; Mauerhoefer et al., 2017), globalization and international cooperation (Dubiel et al., 2016) followed by open innovation, social media (Du et al., 2016) and a need for dialogue with customers (Lynch et al., 2015) as constructive tools for NPD-related innovation (ex. complex adaptive systems in the article by McCarthy et al., 2006).

The next long-lasting trend is *patenting*, in which authors consider the quality of the patents introduced on the market with a view to discussing the commercial market value of protected innovations and analyzing potential differences (Harhoff et al., 2003; Sapsalis et al., 2006). Originally the focus was on the innovative capabilities and research commercialization of universities (Owen-Smith, Powell, 2003; Hsieh, 2013). The analyzed publications often referred to the patenting index, which is a tool for describing and comparing the level of economic development of countries in which patents are filed in various areas of technology (Park, 2008). Over the years there has been an increase in the number of patents filed for business, academia and joint research. Innovation can be stimulated and managed by changes in patenting policy, grant funding regulations, and policy supporting businesses in their efforts to speed up development so as to maintain a competitive advantage over others, which as a consequence causes an increase in the interest of companies in basic research from academia (Encaoua et al., 2006; Belderbos et al., 2014; Shu et al., 2015). The discussion on patenting shifted towards the ways in which the commercial value of patented ideas can be boosted by supporting technology transfer, academia-business collaboration, and spin-off creation as well as by helping venture capital enter the field of innovation (Gredel et al., 2012; Suzuki, 2011). Another dimension of this trend relates to the practices of different countries and regions and focuses on how these geographical differences change over the years in ways that influence the economic development and competitiveness of specific markets (Cohen et al., 2002; Goto et al., 2007; Mariani et al., 2007; Acosta et al., 2012; Li, 2012).

Knowledge sharing and management is another trend identified in the whole 20-year period of analysis. The articles in this trend describe the impact of knowledge management on the performance of an organization and its innovativeness and the extent of influence that is exercised by the support policies of the management system (Darroch, 2005; Du Plessis, 2007).

The articles also identify different approaches to developing knowledge management competences in projects and programs (Koskinen et al., 2003). Majority of articles in this section relate to practice-based or reflective learning, while qualitative research approaches focus on analysis and discussion and conceptual studies. Another area in the field of knowledge management taken up by the identified articles is the issue of knowledge transfer. Organizations may significantly improve their knowledge and innovative capabilities by leveraging the skills of others through the proper communication and transfer of knowledge both within and across firms (Easterby-Smith et al., 2008; Liyanage et al., 2009). Knowledge transfer is also considered in an international context, through the transfer of knowledge across firms in foreign cultures and knowledge developed by firms in foreign countries to other countries (Fang et al., 2010). This topic is often discussed with analysis of subsidiary effectiveness and absorptive capacity as means through which we can view knowledge transfer (Chang, 2012). Some authors also point to challenges and barriers related to sharing knowledge, in particular the difficulties in gaining access to knowledge (Gächter et al., 2010).

Another long-lasting trend identified during our study is *project and project risk management*. A common theme throughout the literature surveyed is the need for a process and set of tools that can help project managers to identify where their attention should be focused on and provide necessary guidelines. A number of researchers investigate the influence of project portfolio management on innovation and entrepreneurship. Authors are looking for methods for managing project portfolios in dynamic environments such as new product development, where the rate of technological innovation is high (Petit, 2012; Sundström et al., 2009; Abbassi et al., 2014). Some authors see project management offices as an organizational innovation helping to achieve higher efficiency (Hobbs et al., 2008). It is often understood as an innovation driver, providing the right tools, and making research and development (R&D) projects more efficient (Gemünden et al., 2018). Project risk management has been a common subject in articles identified in this trend. Risk described as the negative outcome of an uncertainty is sometimes interpreted as a probability, but in real life, it is an expected return of some event or state. The opposite of risk is opportunity, which describes the positive outcomes of uncertainty. Some authors assume that the risk management process is not enough, and managers should instead try to manage opportunities to improve the project outcome (Olsson, 2007).

Work-life balance and career development is the last long-lasting trend identified in the analyzed literature. We can observe the focus of researchers on the interactions between work and family communities (Voydanoff, 2001; Grant et al., 2008). The topic is correlated with family-owned companies (Romano et al., 2001, Matzler et al., 2014) and in consequence with family welfare (Caceres-Delpiano, 2006; Gomez-Mejia, 2011). Studies investigate correlation between work and private life (Carlson et al., 2009) and how it influences career planning and development (Arthur, 2008; Bennett et al., 2016). We can also see interest in a role of mentoring in that process and managerial aspects influencing decision making process of career paths

(Lee et al., 2010; Roach et al., 2010). Additionally income inequality and health welfare were investigated and discussed (Gerdtham et al., 2004; Leana et al., 2015; Berrone, 2018).

Two ephemeral trends identified during our study were *incubators & spin offs* and *lean management*. Incubators and spin offs trend emerged in 2001 and declined in 2012. After 2001 researchers became increasingly interested in incubator firms and spin-offs creation (Rothaermela et al., 2005; Wright et al., 2006) discussing the role of university linkage and knowledge transfer (Rothaermela et al., 2005, Fontes, 2005). Additionally, the role of technology transfer organizations was investigated (Debackere et al., 2005, Walter et al., 2006). Researchers discussed the importance of patenting (Sampat, 2006; Baldini, 2008), various types of alliance and cooperation to increase knowledge transfer and innovation creation (de Man et al., 2005). Next we can observe interest in open innovation, academic entrepreneurship activities (Grimaldi et al., 2011) and relationship between university and industry (Perkmann et al., 2007). The nature of this trend reflects business processes: at the beginning of a century many innovative initiatives were started which induced academic research in that field. With business growth the focus of scientists was on more advanced problems of business operations. That resulted in the fading of this trend.

Lean management was classified as another ephemeral trend in the analyzed time period. The first publications on this topic occurred in the 80's and 90's, however what originated as a method of organizing and managing company's work to improve products quality and profitability of production processes was analyzed in the context of innovations much later (Hasle et al., 2012; Bhamu et al., 2014). It was inspired by the Toyota Production System aiming at resource optimization and elimination of redundant steps or operations (Cochran, 2010; Moyano-Fuentes et al., 2012). In analyzed literature we can observe that first researchers emphasized lean in supply chain management and industry implementations (Halldorsson et al., 2008; Hofmann, 2010). Then the interest was moved to services according to the lean philosophy and sustainability of processes e.g. in healthcare (McCann et al., 2015), finances or sales (Leyer et al., 2014, Piercy et al., 2015). Then the field of lean management was fulfilled with six sigma methods to provide organizations tools improving business capability and quality of processes (Lambert Marzagão et al., 2016). Additionally interest was put on lean leadership discussing profiles and capabilities of managers in companies implementing lean philosophy (Ruiz-Benitez et al., 2019).

The only declining trend was *internationalization*, various aspects of which have been described in the literature. First, the problems of multinational companies (Kumar, 2001; Rugman et al., 2004) and export (Nassimbeni, 2001) were addressed. Second, skilled management is an important factor enabling companies to expand their network of markets (Ibeh et al., 2005). More efficient and cheaper ways of exporting innovation are required, enhanced by greater competitiveness in case of small and medium-sized companies (Fischer et al., 2003). Another dimension of this trend is innovation driven by various regional, cross-country and cultural aspects (Roper et al., 2002; Özçelik, Taymaz, 2004). Throughout the

whole analyzed period, high interest was also on foreign direct investments (Meyer, Nguyen, 2005; Filatotchev et al., 2007; Buckley et al., 2009). Trends of declining importance and ephemeral appearance involved issues of less interest to current research work on innovation, possibly because there was a good understanding of these aspects and extensive research had largely exhausted the topic. The disappearance of specific trends is a natural phenomenon observed in science and research. It is usually signaled by a decrease in the volume of publications and research work, as was observed in our own studies.

Our most interesting observations concern trends that emerged during the studied period and are still active. These trends include CSR, business cooperation, crowdfunding, innovation policy, leadership & team management, strategic foresight, sustainable applications, and big data.

In 2004 the first identified emerging trend appeared: *innovation policy*. The importance of innovation for the economy as a whole, an issue that was also considered in previously defined trends, is addressed in the theme of innovation policy emerging since around 2004. This trend highlights the need for more sophisticated solutions for coping with legal and macro-challenges to innovation at the global and regional levels (Laranja et al., 2008; Chaminade et al., 2008). Both Europe and the European Union can serve as examples of the increased awareness of the importance of this specific trend for cross-country cooperation based on joint rules and guidelines (Blind, 2012; Borrás et al., 2019). As a consequence, innovation policy (from 2005 open innovation policy in particular) has emerged as a separate aspect of innovation concerned not only with the technical or scientific perspectives of knowledge development, but also the political parameters to be regulated at the governmental and regional levels (Aghion et al., 2009; Bodas et al., 2008). Companies and institutions also need to adjust to the regulations and requirements affecting their focus on innovation and its sources (Fernandes et al., 2013), absorptive capacity (Wang, Han, 2011), and sustainable development (Nill, Kemp, 2009).

For *leadership & team management* we can observe long lasting interest of researchers. From around 2005 researchers focused on transformational leadership, seen as an important aspect of project-based organizations and risk management (Keegan et al., 2004; van Knippenberg et al., 2013). Due to the course of research in the space we can observe some references to another trend which is knowledge sharing and management, in the form of the discussion on learning (Edmondson, 2009), tacit knowledge management (Mooradian, 2005) and focus on knowledge distribution and sharing (Lawson et al., 2009; He et al., 2014). Furthermore, researchers analyzed leadership and team management supporting development of innovation (Yang et al., 2008; Le et al., 2019) in cross-functional and international project teams (Aime et al., 2013; Bertolotti et al., 2015). Additionally, leadership competency profiles (Muller et al., 2010), styles and methods (Yang et al., 2011) were broadly discussed to analyze their influence on team creativity and company performance (Bolden, 2010).

Another trend for which we can observe an increase of interest is named *strategic foresight*. It emerged around 2006 and was defined as a structured and systematic approach to analyze available information to road mapping and anticipation of future events and changes (Lee et al., 2005; Bezold, 2010). Researchers were discussing this topic by approaching strategic management (Linstone, 2011), and financial performance, strategic alliances of the organizations as well as planning of organizational sustainable development (Ravasi et al., 2006). To some extent this trend is related to the implementation in supply chain and risk management (Kirchoff et al., 2016), strategic flexibility (Miles, 2010; Huang et al., 2014), and to another trend identified in our study which is new product development (Kahn et al., 2006). What is more, we can find emphasized importance of strategic foresight for innovation development and implementation (Andersen et al., 2014) followed by strategic knowledge management and organization performance (Ruff, 2015; Bamel et al., 2018).

Business cooperation, another rising trend in innovation studies deals with participation of many different parties in business activities. While innovation has recently become one of the key drivers of a company's life cycle, since 2009 the interest has been growing in the idea of fostering collaboration to help speed up and support the development of competitive assets (Lasagni, 2012). As a consequence, in the analyzed papers business cooperation appears as a key, emerging aspect of the discussion on innovation (Schwartz et al., 2010; Colombo, 2012). The articles revealed a multi-dimensional discussion on models of collaboration that can meet the expectations of partners, for example public–private partnerships (Cruz, Marques, 2013). Also, there is a considerable need for highly skilled managers to coordinate joint work on innovation and to support this not always straightforward relationship, where mutual trust and help are needed (Chiaroni et al., 2011; de Araújo Burcharth, 2016). Researchers also discussed the role of science parks, incubators, hubs and an open innovation spirit in promoting the idea of business cooperation (Hansson, 2005; Ratinho, 2010; Bøllingtoft, 2012), and were attracted to the topics of outsourcing, alliances or consortiums as potential models of cooperation (Colombo, 2006; Wagner, Goossen, 2018). Finally, the role of reshoring (Foerstl et al., 2016), outsourcing (Scherrer-Rathje et al., 2014), and offshoring (Lin et al., 2017) was under the scrutiny.

Another interesting rising trend we spotted during our analysis was related to *corporate social responsibility (CSR)*. Before that most times authors highlighted the fact that CSR should be treated from the perspective of the commercial dimension of responsible marketing rather than as an ideological approach to business operations (Hemingway et al., 2004). Over the years, however, we have observed the increasing role played by ISO regulations, ISO 9001 and ISO 26000 (Manders et al., 2016). Especially the introduction of the latter in 2010, the guidance on social responsibility, boost the interest in innovations and strategies and in the context of CSR (Moratis, 2016). Another aspect of this trend is correlated with the increased popularity of public policies combining the formation and fulfillment of the needs of various stakeholders and interdependencies (Wang et al., 2016). This, in turn, has led to research on the

attitudinal employee and consumer typology shaped by different cultures and countries and as well as by the economic conditions of a society (Öberseder et al., 2011; Frynas, Stephens, 2014). There has also been a discussion on the need for CRS communication channels and tools (Seele et al., 2015) depending on social norms (Steven et al., 2017).

Next emerging trend we observe in the literature is the sources of *crowdfunding* for the development of innovation. Finances play a crucial role in innovation development, allowing research organizations to conduct their work, use the latest technologies and, in the end, commercialize innovation (Reynolds, 2011). Some companies often finance their work on innovation with revenue from other areas of their operations, e.g. from sales of generic products. Over the last years we have observed a trend towards accessing external funds for development purposes by means of various instruments provided by investors, governments or financial intermediaries (Hanley et al., 2006; Watkins, 2007). It emerged as a trend around 2013, as apart from interest in the role of banks and the cost of loans, particularly at the seed and early stages of business development (Rostamkalaei, 2016), we have observed the rise of crowdfunding as an alternative strategy adopted by small companies or startups to finance their ideas and innovations by means of social media and social platforms (Stanko, Henard, 2017; Kgoroeadira et al., 2019). Understandingly, the focus in the studies was on crowdfunding performance (Allison et al., 2017), involving the right crowd (Belleflamme et al., 2013; Ryu, Kim, 2016; Roma et al., 2017), and other determinants of the success of crowdfunding (Calic, Mosakowski, 2016). Moreover, some researchers discussed sustainable competition and human rights as important factors of balanced innovation development when selecting a source of financing (Li et al., 2014).

Big data as a trend emerged in the year 2014 in our analysis as a result of significant increase in the computing capabilities of modern information systems used in organizations. The analysis of large amounts of data on customer behavior and economic processes allows for making development decisions and setting directions for research and development (R&D) work (Hartmann et al., 2016; He et al., 2017; Johnson et al., 2017). The subject matter often discussed by the authors was also the relationship between knowledge management and the use of big data in organizations. Potential of big data lies in valuable knowledge creation which helps and in gaining competitive advantage (Sumbal et al., 2017). Among the important topics undertaken in the field of big data, there was also the issue of compliance of big-data systems with the growing regulatory requirements related to the protection of user privacy or obtaining their consent for commercial use (van den Broek, van Veenstra, 2018).

The last trend identified in our study was multifaceted and involved much discussion to define an appropriate name for it. After internal discussion and analysis of relevant publications the name *sustainable applications* was selected as sufficiently general to reflect areas of articles included in this trend. Innovation and technology studies have received increasing attention over the past years (Markarda et al., 2012). In the analyzed literature we can observe the emergence of sustainable economic, technological and social systems (Coenena et al., 2012).

One of the leading areas are renewable sources of energy (Hsu et al., 2013; Peng et al., 2014) with agriculture as important part of sustainable energy transition (Sutherland et al., 2015) as well as mobile industry and banking (Dahlberg et al., 2015) or implementation of innovations in disasters recovery (Ballesteros et al., 2017). Interesting aspects observed are innovations developed by users especially in emerging markets, and their impact on market shape (van der Boor, 2014). Researchers also analyzed socio-technical and political aspects of applications of new technologies and the need for new construct of policy development requirements (Li et al., 2015) and standardization needs (Wiegmann et al., 2017).

Certain logical interconnections can be observed between trends. For example, in the case of business cooperation, the focus was initially on building strong bonds and relationships between partners. This trend evolved towards technology transfer, which is a subject of much debate nowadays (knowledge sharing and management trend). Then, as has been observed in various areas of business operations, the rapid development of technology and innovations require systematic changes in legal regulations and policies, as is reflected in the appearance of another trend: innovation policy. Finally, innovative businesses search for innovative sources of financing. According to our analysis, companies originally relied on banks and other financial institutions, whereas now the stress is on foreign investments and venture capital (in business cooperation).

It is also worth emphasizing the fact that the trends we identified conform to the results of previous studies but are more extensive. The relations are presented in Table 4.

Table 4.
Correspondence of the authors' own results with those of other studies

Trend	**Corresponding studies**
Internationalization	-
Corporate Social Responsibility	Keupp et al. (2012); Cillo et al. (2019)
Patenting	-
New product development	Garcia et al. (2012); Cillo et al. (2019)
Business cooperation	Keupp et al. (2012); Hossain, Kauranen (2016); De Vasconcelos Gomes et al. (2018); Cillo et al. (2019)
Incubators & spin offs	Crossan, Apaydin (2010); Keupp et al. (2012); De Vasconcelos Gomes et al. (2018); Cillo et al. (2019); Dziallas, Blind (2019)
Crowdfunding	Dziallas, Blind (2019)
Innovation policy	Hossain, Kauranen 2016; Khosravi (2019)
Sustainable applications	Becheikh et al. (2006); Keupp et al. (2012); Garcia et al. (2012); Van Oorschot et al. (2018)
Work-life balance and career development	-
Project and project risk management	Crossan, Apaydin (2010); Gomes et al. (2018); Khosravi et al. (2019)
Knowledge sharing and management	Keupp et al. (2012)
Leadership & team management	Crossan, Apaydin (2010); Khosravi et al. (2019)
Strategic foresight	Keupp et al. (2012)
Big data	-
Lean management	-

Source: own work.

The above table highlights the interdependence between the trends identified in our study and those noted in the literature reviews conducted by other authors. At the same time, it reflects the comprehensive nature of our approach, as none of the previously mentioned literature reviews covered such a broad range of topics. Moreover, a number of detailed issues such as *internationalization, patenting, work-life balance & career development*, *big data*, and *lean management* were given insufficient attention in the previous analysis.

We also appeared to have made a suitable selection of journals for our analysis as they turned out to be the same as those selected by other researchers as leading journals publishing research on innovation (e.g. *Research Policy* – Crossan, Apaydin, 2010; Dziallas, Blind, 2019; *Academy of Management Journal* – Crossan, Apaydin, 2010; Dziallas, Blind, 2019; *Journal of Product Innovation Management* – Crossan, Apaydin, 2010; Dziallas, Blind, 2019, *International Journal of Management Reviews*, Keupp et al., 2012).

6. Conclusions

One of the primary objectives of the present article was to identify present trends in innovation research conducted over the last 20 years. Based on a systematic literature review covering over 22 000 papers we identified 16 trends - 5 long-lasting, 1 declining, 8 emerging and 2 ephemerides in character. The following trends were identified: internationalization, new product development, patenting, knowledge sharing and management, project and project risk management, work-life balance and career development, incubators & spin offs, lean management, innovation policy, leadership & team management, strategic foresight, business cooperation, Corporate Social Responsibility (CSR), crowdfunding, Big data, and sustainable applications.

The two dominant, long-lasting trends that are most frequently discussed in innovation literature are project and project risk management and knowledge sharing and management. The following emerging trends appear to be the most promising from the perspective of future studies: i*ncubators & spin offs, innovation policy, business cooperation, sustainable applications*, with the latter recently gaining the most attention from academics.

The second aim of this study was to verify the usefulness of the proposed methodological approach based on the term frequency – inverted document frequency method (TF-IDF) performed as a full-text analysis. In fact, such an approach enabled us not only to discover trends that had been singled out in previous studies, but also to identify a number of less popular, yet still significant trends.

Our work constitutes an original in-depth investigation into current advances in innovation research using text mining. Furthermore, our results indicate that the developed approach is universal and could be applied when selecting prospective research areas and spotting fields

with increasing potential. Additionally, the text mining procedures adopted in this study could provide researchers with a tool for gaining a thorough grasp of knowledge of a specific field buried in a vast amount of scholarly literature. For practitioners it can offer suggestions on areas of possible business acceleration and transformation. The clustering technique produces an overview of a particular field in greater detail.

We identified two limitations of this study related to the number of papers and cluster size. The study was restricted to the years 2000-2020 and 19 top tier journals dedicated to the field of management and innovation research. The issues of innovation have of course also been discussed in other journals, but if we had applied a broad keyword-based search it would have introduced more serious limitations. Still, the sample size is significantly larger than in most other studies. The other limitation – the minimum cluster size in HDBSCAN – must be defined experimentally. The method requires only one parameter, which is less than is the case with other clustering methods.

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MANAGEMENT OF HOUSEHOLD FINANCES USING RENEWABLE ENERGY SOURCES

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Purpose: Study of the profitability of investment in photovoltaic cells and building home energy storage facilities.
Design/methodology/approach: Own research.
Findings: A way that can increase household income is to invest surpluses in photovoltaic cells. Energy storage does not increase the profitability of photovoltaic investments at current purchase prices, but in the long run they may be a necessary solution in the development of renewable electricity sources.
Originality/value: The article presents original research related to the profitability of the development of photovoltaic installations for prosumers, which results in an increase in self-consumption of the produced electricity.

Keywords: photovoltaic cells, household, energy storage.

Category of the paper: Research paper, Case study.

1. Introduction

As a result of the energy transformation, a new entity appeared on the market, whose name comes from the combination of two words: producer and consumer. Example of prosumers are the households with photovoltaic micro-installations. On the one hand, it sells the surplus energy produced to the country's energy system, and on the other hand, in case of shortages of its own production, it buys it from this system. Carrying out this type of activity does not require any formal activities, such as registration in the records, but only the possession and connection of a properly prepared photovoltaic installation to the network. This article attempts to assess the benefits of operating such an entity on the market and its financial effectiveness. Due to the saturation of the energy system with photovoltaic micro-installations, the need for prosumers to have energy storage facilities becomes inevitable. Whether such additional, considerable investment outlays make sense for a household is also analyzed in this article.

2. The household as an economic entity

Not only in Poland, but also around the world, scientists try to emphasize the importance of household finances (Campbell, 2006, pp. 1553-1604). The household sector is heterogeneous, which then leads to different divisions and classifications of households and to problems in comparative analysis (Hoffmeyer-Zlotnik, Warner, 2009, pp. 1-26).

Household finance covers the largest group of market stakeholders. It is difficult to establish the boundaries between a household and a business unit, as many individual entrepreneurs respond more to the specifics of a household than an entrepreneur. Household finance as a scientific subdiscipline includes the study of theoretical phenomena and relationships. However, it should be mentioned that it has a wide practical application in economic reality. The subject of interest in household finances is extremely broad, as it concerns: savings, investing, lending, spending (consumption), insurance, taxes, income, pensions, wealth, etc. (Świecka, Musiał, 2016, p. 823).

The household is an active market participant. In economics, the market is understood as an institution enabling transactions between producers and consumers. The market can be divided, taking into account the household, into, among others, the labor market, goods and services market and the financial market (Podolec, Ulman, Wałęga, 2008, pp. 15-16).

The labor market is a special type of market because work has an immaterial dimension. The subject of exchange in the labor market are the specialized skills offered by employed people. The labor market should fulfill the function of allocating and relocating labor factors and ensuring a long-term balance between the supply and demand for labor. Entrepreneurs expect the labor market to provide them with the opportunity to recruit employees with appropriate qualifications. However, from the employees' point of view, it should enable them to find a job that brings them satisfactory income and enable their development. In the labor market, employees offering labor resources and employers meet, which leads to the determination of the price for work, i.e. remuneration.

The next market is the market for goods and services. It is worth noting the change in the function performed by the household. The household plays the role of a consumer and reports demand for a given product or service. Household consumption is a type of collective consumption, consisting in the use of the item of consumption by at least two members of the household. Goods and services are obtained by households through exchange. This exchange takes place between the seller and the buyer and is called a purchase-sale transaction (Świecka, 2008, pp. 26-27).

Some households possess excess cash and often decide to invest it, hoping for a higher profit. Such transactions are made on the financial market and concluded between capital providers and capital recipients. In the literature, the financial market is defined in a broad and narrow sense. In a broader sense, the structure of the financial market includes not only

activities related to money and its flow, but also economic activities based on monetary turnover. In a narrower sense, the financial market includes decisions related to money, the purpose of which is to protect the value of money held or to increase it in future periods. Financial markets enable the creation of the structure of investment and consumption in economic entities over time and increase the efficiency of the use of resources in the economy. Financial markets enable investors to diversify their portfolio of assets, thereby limiting investment risk, and also provide financial information about economic entities in the form of financial statements, especially in the case of listed companies. (Szrama, 2010, pp. 8-9).

Financial markets bring together entities with financial surpluses and entities experiencing financial shortages. The idea of processes taking place in financial markets is based on making temporarily available cash available to those who do not intend to use it at that time to those who need funds for consumption or business development. The reason for both parties to make money available and use it is to gain benefits. The household acts on financial markets as either a seeker or an offerer of money. There is also a third group of entities in financial markets: financial intermediaries who facilitate the transfer of savings from surplus entities to deficit entities. Theoretically, one can imagine a financial market where there are no financial intermediaries and surplus entities communicate with deficit entities themselves, but the modern, developed financial market is based on a widely developed structure of financial institutions (financial intermediaries). Financial intermediaries provide many different types of financial services, but the most important function is to distribute free cash from entities with savings to entities with a deficit (Czekaj, 2008, p. 4).

Modern financial markets are very complex, consisting of many different entities issuing and purchasing financial instruments as well as trading intermediaries and modern technical means enabling transactions. Financial markets can be classified according to various criteria, three classifications are basic. The financial goods market can be divided into: money and capital. The first one covers only one year; the subject of this market are securities and deposits. In turn, the capital market is based on long-term transactions such as the purchase of shares or bonds. Households can participate in both markets, primarily as entities investing financial surpluses. The amount of wealth accumulated in the form of financial instruments by a household is influenced by factors such as financial tradition and culture, the degree of financial market development, and at least an average propensity to save (Świecka, 2008, p. 28).

The amount of savings depends on the household's income and expenses. Namely, this relationship involves the division of income obtained into current consumption and savings purposes. An increase in money resources for consumption causes a decrease in savings and vice versa. In income management, it is necessary to find the so-called "golden mean" that allows for shaping the proportion between the household's expenditure and savings sphere. Savings may be voluntary or compulsory. Voluntary saving involves voluntarily giving up

spending your income on consumption purposes. However, forced saving involves allocating part of one's income to repay, for example, a bank loan (Bywalec, 2009, p. 163).

There are six types of savings strategies. The first strategy is a low-risk strategy. This type of strategy is used by households with savings in the form of bonds. This strategy is used by households with the following socio-economic and demographic characteristics (Anioła, Gołaś, 2013, pp. 1-11).

- households of pensioners,
- households whose place of residence is a city,
- the education of household members is secondary or higher,
- households with health problems or disabilities,
- households with average or higher income.

Another savings strategy is the so-called conservative strategy. This strategy is used by over half of households in Poland, investing all their savings in the form of PLN deposits. Households using this type of strategy lack a cash form of saving. A conservative type of strategy, characterized by a low savings rate. This strategy is used by households in which:

- members are middle-aged and older,
- farms located both in cities and in the countryside,
- households earning an average level of income.

The third type of strategy is an extremely passive strategy. Approximately 25% of households in Poland use this type of strategy. Households have 100% of their savings in cash. A passive savings strategy is characterized by a very low savings rate. Households using a passive saving strategy use credits and loans, but the value of their debt does not exceed their monthly income. Farms of this type show that they have difficulty making ends meet. This strategy is used by households consisting of middle-aged people living in rural areas and very often run by widowers.

The fourth type is an extremely conservative strategy. It is used by households who invest their savings in bank deposits and in cash. This strategy has an average savings rate. According to NBP (National Bank of Poland) data, the value of household deposits in July 2023 was PLN 786,794 million. Households using this type of strategy are characterized by income stability and therefore have no problems making ends meet. Only every fourth household using this strategy has to use credits and loans. An extremely conservative strategy is used by households in which household members are older and middle-aged, the location of households is both urban and rural, and income is obtained from hired work (Anioła, Gołaś, 2012, pp. 1-11).

The next strategy is the diversification strategy. The smallest number of households use this type of strategy - only 0.4%. This type of saving is characterized by a variety of saving forms and the lowest savings rate. Households using a diversification strategy very rarely use credits and loans. Nevertheless, if they do incur debt, the value of this debt is high, most often

exceeding their annual income. This strategy is used by households with the following socio-economic and demographic characteristics (Anioła, Gołaś, 2012, pp. 1-11):

- low age of household members,
- households where the head of the family is a man,
- households located in large cities,
- households with minor health problems,
- household members have secondary or higher education,
- income is obtained from hired work or from running your own business.

The last sixth saving strategy is the aggressive strategy. This type of strategy is used by approximately 1.6% of farms that are not afraid to take risks. Farms using this strategy have the highest levels of debt in excess of their annual income. This strategy is used by households in which (Anioła, Gołaś, 2012, pp. 1-11):

- low age of household members,
- high level of education of household members,
- households whose members are unmarried,
- the income obtained is higher than average,
- there is a low level of disability on farms.

Household financial decisions are complex, interdependent, and heterogeneous, and central to the functioning of the financial system (Gomes, Haliassos, Ramadorai, 2021, pp. 919-1000). In households, the most important is a conservative and very passive strategy based on saving in the form of bank deposits and/or cash. In Poland, households most often use banking services, placing their money in the form of deposits secured by the Bank Guarantee Fund. However, in English countries, a significant part of household funds is allocated to pension funds (Czapiński, Panek, 2014, pp. 87-92).

A relatively new form of functioning of a household is its presence on the market as a prosumer. The name prosumer comes from a combination of the two words producer and consumer. In the light of the Act of February 20, 2015 on renewable energy sources, a renewable energy prosumer is an end user who produces electricity exclusively from renewable energy sources for his own needs in a micro-installation, provided that in the case of an end user who is not a household consumer of electricity, it is not the subject of the main economic activity and the installation power does not exceed 50kWp. In practice, installations up to 10 kWp are most common. On April 1, 2022, new rules for settling prosumers in the net-billing system entered into force. It is obligatory for owners of photovoltaic installations that were launched after March 31, 2022. The change in settlement is that prosumers sell surplus energy to the power grid at market prices published by Polish Energy Networks. The funds obtained in this way go to the prosumer deposit and are used to purchase energy from the grid in periods of shortages of own production. It is difficult to place a prosumer in the strategies of a household's approach to investing and saving, but the features necessary to undertake a prosumer activity are:

- relatively low age of household members due to the long period of operation of the micro-installation and the rather impossibility of cashing it in earlier,
- owning a house and therefore most often living in the countryside or on the outskirts of cities,
- the household consists of at least two members,
- most often have secondary or higher education,
- a household with an income of at least average or higher.

With this in mind, the prosumer has features typical of various household strategies, but the closest one seems to be an extremely conservative and diversified strategy. Analysis, moreover, shows that P2P energy trading based on human decision-making may lead to financial benefits for prosumers and traditional consumers, and reduced stress for the grid (Pena-Bello et al., 2022, pp. 74-82). The number of prosumers currently constitutes a very large group of households and is approaching 10 percent of all households, according to the Central Statistical Office data, amounting to over 15 million. The reason for the increase in the number of households is mainly a decrease in their size. The digital revolution adds new layers to the material cultures of financial inclusion, offering the state new ways of expanding the inclusion of the legible, and global finance new forms of profiling poor households into generators of financial assets (Gabor, Brooks, 2019).

3. Development of photovoltaic installations in Poland

The photovoltaic sector in the country is developing very dynamically, installation capacity in May 2023. increased to 13,926 MW, which means an increase of several dozen times in recent years. Photovoltaics has the largest installed capacity of all renewable energy sources. Prosumer micro-installations still have the largest share in the installed potential of photovoltaic power plants in Poland. Total installed capacity of photovoltaic micro-installations at the end of May this year. amounted to 9,630.31 MW. This means that they had almost a 70% share in the total photovoltaic capacity in Poland. According to the Energy Market Agency, there were a total of 1,269,792 prosumer photovoltaic micro-installations at the end of May 2023, and their number increased by 186.2 thousand within 12 months.

Photovoltaic panels work on the principle of the photoelectric effect, which requires light, which is why photovoltaics generate electricity even on cloudy days. However, the highest efficiency is achieved in sunny weather, which we have relatively a lot in Poland, which translates into an average energy yield in the range of 900-1100 kilowatt hours per year from one kilowatt of solar cell power. A small solar power plant consists of photovoltaic panels, an inverter, cabling and a mounting system. The cost of devices is the largest component of installation expenditure. The devices included in the solar power plant have a long warranty.

This is at least 10 years for panels and 5 years for inverters. The service life of the devices is also very long, for high-quality solar modules it can reach up to 40 years. The expense associated with launching a solar micro-installation begins to pay off immediately, resulting in a significant reduction in electricity bills. A photovoltaic installation on a roof or ground is virtually maintenance-free. Photovoltaic inverters inform about faults themselves, so there is no need to constantly personally monitor the condition of the installation. Inverters connected to the Internet can send information about a failure directly to the service, so that in the event of a failure, it can quickly react and resume the production of free energy.

The legislator obliged energy companies to connect micro-installations with a capacity of up to 40 kW. It also ordered the operator to cover related costs, such as replacing the meter with a two-way one. The requirements for devices and installers are strictly defined in the Act and after meeting them and submitting complete documentation, the energy operator has 30 days to connect the micro-installation. Introducing energy to the grid by prosumers is also beneficial for operators for several reasons. They can sell energy from a photovoltaic installation to the nearest customer, saving on transmission from a distant power plant. Poland must also fulfill international obligations regarding the share of renewable energy in overall electricity production. It is also worth paying attention to the fact that the greatest demand for electricity, which occurs in the summer, occurs during the period of greatest productivity of photovoltaic installations, which will relieve the load on conventional power plants that are overloaded during this period and reduce the possible need to import electricity.

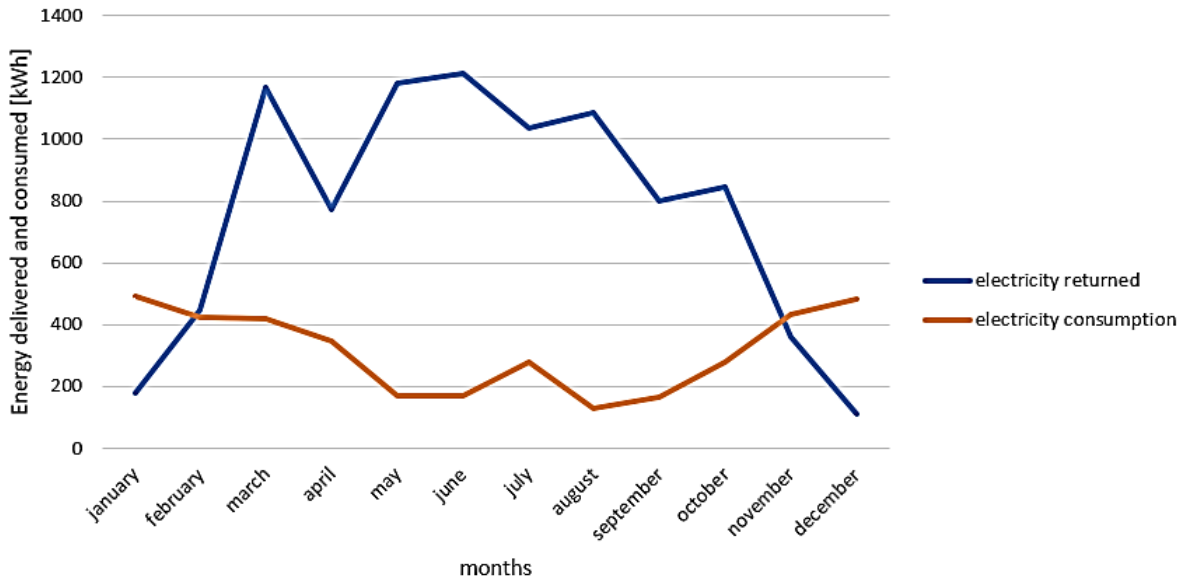

Figure 1. Energy returned and consumed by a household from a 9.92 kWp installation in 2022 [in kWh]. Source: own research.

According to the rules in force before April 2022. it is possible to store surplus energy in the network in the summer and collect it in the winter months in order to compensate for the slightly worse results of electricity production in winter. Thanks to this, we can balance our

energy demand with the production from the photovoltaic power plant throughout the year and reduce electricity bills to subscription and fixed fees.

However, the instability of energy production from photovoltaic installations necessitates its storage. Storage can be organized by specialized companies, energy transmission companies and even their producers, including prosumers. Then, instead of returning the surplus energy from your own solar micro-power plant to the grid, where it is stored virtually, you store it at home, in a battery bank in which electrical energy is converted into chemical energy, and when electricity is consumed, back into electrical energy.

Having an energy storage facility allows you to optimize the energy consumption rate at home, while extending the operating time of electrical devices on electricity generated from a renewable energy source. This applies especially to the summer months, when the amount of energy produced from photovoltaic installations is at the highest level. The electricity produced by photovoltaic panels is stored in a warehouse and used on an ongoing basis. The repetition of this cycle means that self-consumption reaches its highest level.

Analyzing Chart 1, however, it should be stated that increasing autoconsumption does not mean that home photovoltaic installations will be self-sufficient, because the capacity of energy storage would have to be huge. Basically, the energy stored on summer and early autumn days could be used in winter, especially during two months, in December and January. In addition to the increase in self-consumption, arguments for the construction of an energy storage facility may include frequent network failures and, therefore, the need to maintain access to electricity. Another argument is the stabilization and maintenance of voltage in the network. Such an argument may also be the construction of real estate far from the power grid, but in principle it will only apply to real estate used from March to October, where the periods with low energy production by the installations will be relatively short.

Approximate gross prices of Plug & Play energy storage kits (ready to be connected to a photovoltaic installation without the need for additional configuration) at the beginning of 2023 were as follows:

- energy storage 3 kW, 2.4 kWh - from PLN 15,000,
- energy storage 3 kW, 4.8 kWh - from PLN 21,000,
- energy storage 4.2 kW, 5.1 kWh - from PLN 33,000,
- energy storage 5 kW, 10 kWh - from PLN 43,000 to PLN 57,000,
- energy storage 10 kW, 10 kWh - from PLN 49,000 to PLN 60,000.

You can obtain funding for the purchase of an energy storage facility in 2023 under the My Electricity program. The subsidy for a photovoltaic installation with energy storage is currently PLN 16,000. A much larger part of the energy from a home photovoltaic installation is transferred to the power grid. Prosumers whose installations were launched before April 1, 2022, can then collect it within 12 months from the moment it was introduced to the network. However, it should be taken into account that for each kilowatt-hour fed into the network,

only 0.8 kWh is entitled to be collected in the case of installations with a power of up to 10 kWp and 0.7 kWh in the case of installations with a higher power (10-40 kWp).

Households that settle accounts with their energy supplier in the system in force from April 1, 2022, i.e. so-called net-billing, can sell surplus energy from photovoltaic installations. They are purchased from them for the price of energy from the Day Ahead Market of the Polish Power Exchange. The energy value calculated in this way, the so-called prosumer deposit, is recorded on the account kept by the seller. The value of the deposit is then reduced by the value of energy drawn from the grid by the owner of the photovoltaic installation. It is calculated based on the rates specified in the contract with the seller. Since the prosumer deposit is valid for 12 months from the date of posting, energy surpluses generated in summer can cover its shortage in winter. However, to what extent is unknown, because energy prices on the stock exchange constantly fluctuate. Therefore, there may be a situation where prices in winter will be much higher than in summer, which means a loss for the prosumer.

Regardless of the photovoltaic billing system, in order not to lose money on selling surplus energy, you can use an energy storage facility. It is of great importance that the power supply being turned off by the energy company does not mean that the user is also cut off from his own photovoltaic installation.

4. Profitability of a photovoltaic installation using energy storage

Figure 1 shows the supply and consumption of energy from an installation with a capacity of 9.92 kWp, which is subject to the rules in force before April 2022. The installation has a significant surplus of production over consumption due to the owner's planned introduction of one of two solutions:

- purchase of an electric car,
- heat pump installation.

Using either solution means that the entire surplus will be consumed by the household.

The cost of investing in a photovoltaic system is related to the total power of photovoltaic cells and the place where the installation will be built. Small photovoltaic installations, up to 10 kW, are located on the roofs of buildings. Systems with power above 10 kW are usually mounted on the ground with the help of supporting structures. In the analyzed photovoltaic investment, implemented in the Częstochowa district, 36 photovoltaic panels were installed. In total, the installation has a power of 9.96 kWp. The total value of investment outlays is PLN 49,000.

It was assumed in the investment profitability analysis that the investor would benefit from the thermal modernization relief, the maximum amount of which was PLN 53,000. PLN and that he pays income tax of 32% on part of his income (second tax threshold).

The calculations included a loss of efficiency of the installation of 0.5% per year. The final value of the project was omitted in the analyzes due to its negligible value. Investment flows also include the expense of PLN 10,000 for repairing the installation in the middle of the investment period.

According to the manufacturers, the lifespan of photovoltaic cells is estimated at 40 years, and this is the project lifespan assumed in the analysis. It is worth adding that many products available on the market have a warranty of up to 25 years, covering at least 80% of the output power obtained from photovoltaic cells. Auto consumption was also assumed to be 12%. This value was obtained by analyzing the production and delivery of electricity to the power plant.

Table 1.
Study of the profitability of a photovoltaic installation

Year	**2022**	**2023**	**2024**	**2025**	**2026**	**2059**	**2060**	**2061**	**2062**
Energy price [PLN/kWh]	0,75	0,75	0,75	0,75	0,75	0,75	0,75	0,75	0,75
Energy production by a photovoltaic installation [kWh]	10 416	10 364	10 312	10 261	10 209	8 653	8 610	8 566	8 524
Own energy consumption [kWh]	1 250	1 250	1 250	1 250	1 250	1 250	1 250	1 250	1 250
Savings due to the operation of the PV installation	6 437	6 406	6 375	6 344	6 313	5 379	5 353	5 327	5 302
Capital expenditure including:									
Photovoltaic installation	-49 000								
Energy storage									
Subsidy for energy storage									
Tax benefits from the thermal modernization relief		15 680							
Flows	-42 563	22 086	6 375	6 344	6 313	5 379	5 353	5 327	5 302
Discount factor for discount rate = 2%	1,000	0,980	0,961	0,942	0,924	0,481	0,471	0,462	0,453
Discounted flows	-42 563	21 653	6 127	5 978	5 832	2 585	2 522	2 461	2 401
NPV [PLN]	125,254.56								
IRR	21,0%								
NPVR	225%								
Return period	4 years		3 months						
Discounted payback period	4 years		6 months						

Note. NPV – Net Present Value; IRR – Internal Rate of Return; NPVR – Net Profit Value Ratio.

Source: own research.

Table 1 presents the results of research on the profitability of a photovoltaic investment without energy storage. The discount rate was assumed to be the interest rate on deposits. The net present value (NPV) of the investment is positive, which means that it is more advantageous to make such an investment than, for example, investing cash in a bank deposit

with an interest rate of 2%. The internal rate of return (IRR) indicates a project profitability of 21 percent, but one should remember the limitations of this method, as it assumes reinvestment of surpluses according to the obtained rate of return, which in this case will be rather impossible.

The payback periods of the tested investment are 4 years and 3 months and 4 years and 6 months for the discounted version of this method.

Table 2.
Study of the profitability of a subsidized photovoltaic installation, including energy storage

Year	**2022**	**2023**	**2024**	**2025**	**2026**	**2059**	**2060**	**2061**	**2062**
Energy price [PLN/kWh]	0,75	0,75	0,75	0,75	0,75	0,75	0,75	0,75	0,75
Energy production by a photovoltaic installation [kWh]	10 416	10 364	10 312	10 261	10 209	8 653	8 610	8 566	8 524
Own energy consumption [kWh]	6 250	6 250	6 250	6 250	6 250	6 250	6 250	6 250	6 250
Savings due to the operation of the PV installation	7 187	7 156	7 125	7 094	7 063	6 129	6 103	6 077	6 052
Capital expenditure including:									
Photovoltaic installation	-49 000								
Energy storage	-50 000								
Subsidy for energy storage	16 000								
Tax benefits from the thermal modernization relief		16 960							
Flows	-75 813	24 116	7 125	7 094	7 063	6 129	6 103	6 077	6 052
Discount factor for discount rate = 2%	1,000	0,980	0,961	0,942	0,924	0,481	0,471	0,462	0,453
Discounted flows	-75 813	23 643	6 848	6 685	6 525	2 946	2 876	807	2 741
NPV [PLN]	113,999.8								
IRR	11,00%								
NPVR	108%								
Return period	8 years		4 months						
Discounted payback period	9 years		4 months						

Note. NPV – Net Present Value; IRR – Internal Rate of Return; NPVR – Net Profit Value Ratio.

Source: own research.

Table 2 shows the situation in which the investment also includes energy storage. The expenditure needed to install the warehouse was assumed to be PLN 50,000 and a subsidy for its purchase was assumed in the amount of PLN 16,000. Thanks to the energy storage, auto consumption should increase to 60% energy generated.

From those carried out in 2019 surveys among households showed, among other things, that the most frequently expected payback period in the case of building a home photovoltaic power plant is 4-5 years. The analysis of the two situations presented in tables 1 and 2 indicates that such a payback period is achievable in the case of an installation without energy storage. However, both cases are profitable taking into account both the NPV and IRR methods. However, it seems that a quick payback period is more important for households than a holistic view of the investment, as is the case with the NPV and IRR discount methods. The first factor that will popularize energy storage among them must be greater public funding. The second factor that will increase interest in energy storage will be the decline in their prices. Unfortunately, this decline has not occurred recently, which has also stopped the growth of interest in electric cars. Technological progress is expected in this area, which in the case of households may be easier than in the case of cars, as the size and weight of warehouses is of little importance for them.

In the current reality, for an investment with a warehouse to have the same payback period as one without it, the price of the warehouse would have to be only PLN 21,500 (table 3). The net cost of such a warehouse for a household would be PLN 5,500. The analysis based on such a low price of the warehouse showed that the profitability of the investment using the NPV method is the highest of all the considered variants.

Table 3.
Assessment of the profitability of a photovoltaic investment for a household, taking into account the reduced price of the warehouse

Year	**2022**	**2023**	**2024**	**2025**	**2026**	**2059**	**2060**	**2061**	**2062**
Energy price [PLN/kWh]	0,75	0,75	0,75	0,75	0,75	0,75	0,75	0,75	0,75
Energy production by a photovoltaic installation [kWh]	10 416	10 364	10 312	10 261	10 209	8 653	8 610	8 566	8 524
Own energy consumption [kWh]	6 250	6 250	6 250	6 250	6 250	6 250	6 250	6 250	6 250
Savings due to the operation of the PV installation	7 187	7 156	7 125	7 094	7 063	6 129	6 103	6 077	6 052
Capital expenditure including:									
Photovoltaic installation	-49 000								
Energy storage	-21 500								
Subsidy for energy storage	16 000								
Tax benefits from the thermal modernization relief		16 960							
Flows	-47 313	24 116	7 125	7 094	7 063	6 129	6 103	6 077	6 052
Discount factor for discount rate = 2%	1,000	0,980	0,961	0,942	0,924	0,481	0,471	0,462	0,453
Discounted flows	-47 313	23 643	6 848	6 685	6 525	2 946	2 876	2 807	2 741

Cont. table 3.

NPV [PLN]	141,940.99								
IRR	21%								
NPVR	184%								
Return period	4 years		3 months						
Discounted payback period	4 years		7 months						

Note. NPV – Net Present Value; IRR – Internal Rate of Return; NPVR – Net Profit Value Ratio.

Source: own research.

The last option considered in this publication is the nowadays sensitive topic of electricity prices and their impact on the profitability of investments. It is obvious that the price increase improves the efficiency of photovoltaic investments both with and without storage. The reference point in the analysis was again the payback period expected by the household, ranging from 4-5 years. Data for calculations, assumptions and results are presented in table 4.

Table 4.

Assessment of the profitability of a photovoltaic investment for a household, taking into account the increase in electricity prices

Year	**2022**	**2023**	**2024**	**2025**	**2026**	**2059**	**2060**	**2061**	**2062**
Energy price [PLN/kWh]	1,32	1,32	1,32	1,32	1,32	1,32	1,32	1,32	1,32
Energy production by a photovoltaic installation [kWh]	10 416	10 364	10 312	10 261	10 209	8 653	8 610	8 566	8 524
Own energy consumption [kWh]	6 250	6 250	6 250	6 250	6 250	6 250	6 250	6 250	6 250
Savings due to the operation of the PV installation	12 649	12 594	12 539	12 485	12 431	10 787	10 742	10 696	10 651
Capital expenditure including:									
Photovoltaic installation	-49 000								
Energy storage	-50 000								
Subsidy for energy storage	16 000								
Tax benefits from the thermal modernization relief		16 960							
Flows	-70 351	29 554	12 539	12 485	12 431	10 787	10 742	10 696	10 651
Discount factor for discount rate = 2%	1,000	0,980	0,961	0,942	0,924	0,481	0,471	0,462	0,453
Discounted flows	-70 351	28 975	12 053	11 765	11 484	5 184	5 061	4 941	4 824
NPV [PLN]	255,108.02								
IRR	22%								
NPVR	241%								
Return period	4 years		3 months						
Discounted payback period	4 years		6 months						

Note. NPV – Net Present Value; IRR – Internal Rate of Return; NPVR – Net Profit Value Ratio.

Source: own research.

Using the method of subsequent substitutions in the Excel sheet, the value of the hypothetical electricity price was obtained, which should be PLN 1.32. This price, although much higher than the current price for households, occurs on the market, for example in settlements between energy companies and business entities.

To sum up the study of the profitability of four investment variants, it should be stated that photovoltaic investments, including energy storage, can be implemented on a large scale if two conditions are met. The first is even greater support for this type of investment with government programs, and the second is a decline in the purchase prices of energy storage facilities. The likely increase in electricity prices will also stimulate an increase in households' interest in energy storage. These warehouses can be implemented at the stage of construction of a new installation, as well as added to existing ones. The life expectancy of photovoltaic installations and the improvement in their efficiency make them even more profitable than in the research conducted by the author in other publications.

5. Summary

There are systemic problems in the supply of electricity resulting from the low stability of solar energy producers. The increase in energy prices is the result of the need to maintain increased power, caused, among other things, by the dynamic increase in the number of new photovoltaic installations. It is impossible to avoid the costs of this increase for households, because as a result of the increase in energy prices, the products purchased by consumers will become more expensive. Currently, the only solution supporting the development of photovoltaic installations in the context of energy system capacity limitations are energy storage facilities. As was the case with the development of photovoltaic installations, their widespread use may result in a decrease in prices while increasing the quality and durability of such storage facilities. In the future, the need to use energy storage seems to be a necessity. The lifespan of photovoltaic installations is becoming comparable to the lifespan of houses, which indicates that such installations should be taken into account when constructing new buildings. Such a long service life is mainly important for young people, because they can take full advantage of the savings in electricity consumption. It is worth considering whether to build a nuclear power plant, the cost of which exceeds USD 10 billion, or to develop technologies for building modern energy storage facilities. Today, the solution is to diversify production and solutions that maintain the power of the energy system. Energy storage alone will not be a sufficient solution to maintain the stability of the energy system, it is necessary to diversify solutions. However, for further intensive development of solar energy, solutions supporting the construction of solar energy storage facilities seem necessary. An optimal warehouse is one that provides complete energy independence for a household; such a solution, although

technically possible, is completely uneconomic in today's economic conditions. Research has shown that when auto-energy consumption increases from 12% to 60%, expenditures are required that cannot be balanced by the benefits resulting from energy storage. It is worth noting, however, that the total profitability of the investment measured by the NPV method, also taking into account energy storage, is positive.

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THE QUALITY OF THE TRANSPORT SERVICES PROVIDED BY THE OPERATORS OF THE TRI-CITY PUBLIC TRANSPORT

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Purpose: The purpose of the paper is to present the factors that shape the quality of the services provided by the operators of mass public transport in the Tri-City from the point of view of people using that transport.
Design/methodology/approach: The main method used for the research was Kano. Thanks to this method, factors shaping the quality of services provided by public transport entities were examined.
Findings: It was established that the main factors shaping the transport service are: factors directly oriented to the customer – adaptation of means of transport to the transport of disabled people, communication on changes in timetables, information on schedules, as well as environmental factors – adaptation of means of transport to sustainable energy sources, transport infrastructure.
Research limitations/implications: Research may be developed in the future with further factors adapted to the strategies of public entities after 2024.
Practical implications: The factors shaping the transport service are included in the development strategy of the company providing public transport. As a result of the research, it was proved that respondents actually pay attention to the same factors. Hence the conclusion for companies that these factors should continue to be strengthened and invested in modern means of transport.
Originality/value: The article examines the social feelings of factors partially included in the strategy of companies providing public transport. Factors focused on the customer, on the relationship between the employee and the customer, on environmental protection. The feelings of transport users as to the hierarchy of these factors and the importance of their occurrence were examined.

Keywords: Quality of service, public transport.

Category of the paper: Research paper.

1. Introduction

At every stage of their life, people need a sense of independence, and mobility is an important part of it. One of the prerequisites for a good quality of life is easy access to other people and the possibility to achieve a variety of goals, which in turn requires adequate means of transportation. It is therefore important to ensure that people are able to move to different places regardless of the reasons for their need for transportation as well as of the means of travel. This allows the public to maintain the possibility of mobility, resulting in a great sense of independence (Sipa, 2014, p. 190).

According to the Poland 2030 Strategy, transport in Poland by 2030 is expected to be friendly to its users, to improve the economic efficiency of production and distribution in spatial terms, and to improve the country's territorial accessibility. On the other hand, in terms of environmental protection, it will not reduce nature's ability to regenerate and, by controlling energy consumption and gas emissions, it will have less and less negative impact on living conditions (Przybyłowski, 2015, p. 333).

The purpose of the paper is to present the factors that shape the quality of the services provided by the operators of mass public transport in the Tri-City from the point of view of people using that transport.

2. The quality of service in the public transport market

Transportation needs arise from the need to travel at a certain point in time, from a starting point to a destination. The whole range of needs has a quantitative dimension that comprises the number and length of trips, a spatial dimension in the form of the vector of movements, and a temporal dimension defined by the date of travel, the duration of travel, and the time schedule of the trips. Mass public transport plays an important role in meeting the transportation needs of the society (Sipa, 2014, p. 190).

Mass public transport is a service characterised by:

- accessibility for all, whether traveling individually or in groups,
- public advertising,
- a fixed schedule and period of operation,
- fixed routes and stops, or specific places of departure and destination, or a specific territory of operation; and
- published fare tariffs (Gramza, 2011, p. 128).

According to the law, mass public transport is the responsibility of operators, organisers, and carriers.

The operation of mass public transport in a given area is ensured by either the minister in charge of transport or the relevant competent local government unit (Act of 2010, art. 4).

The operator of mass public transport is a budgetary entity of the local government and an entrepreneur who has been authorised to conduct business in the field of passenger transportation and entered into a contract with the organiser of mass public transport for the provision of mass public transport services on the transportation line specified in the contract (Act of 2010, art. 4).

A carrier is an entrepreneur authorised to conduct business in the field of passenger transport on the basis of a confirmation of notification of transportation (Act of 2010, art. 4).

The Metropolitan Transport Association of the Gulf of Gdansk (MZKZG), established in 2007, is an entity that deals with the problem of integration of public transport. The MZKZG was formed by: the City of Gdańsk, the City of Gdynia, the Kolbudy Commune, the Szemud Commune, the Kosakowo Commune, the Luzino Commune, the Pruszcz Gdański Municipality, the City of Pruszcz Gdański, the City of Reda, the City of Rumia, the City of Sopot, the Wejherowo Municipality, the city of Wejherowo, and the Żukowo Commune. The objective of the Association is to jointly develop a transport policy and manage local public transport in the territory of the communes and municipalities that are members of the Association (Hartenberger-Liszek, 2014. p. 42).

Within the MZKZG, in the territory of the Tri-City, public transport services are provided by public transport companies, which include two municipal organisers operating in the form of authorities, namely the Public Transport Authority of Gdańsk (ZTM) and the Public Transport Authority of Gdynia (ZKM), and the Fast Municipal Railway (SKM) and Municipal Transport Company in Wejherowo (MZK), which are organisers as well as carriers.

The Public Transport Authority of Gdynia introduces modern technical solutions that indirectly enable it to improve the quality of its services for passengers. The operators in Gdynia's public transportation organised by the ZKM of Gdynia are:

- Przedsiębiorstwo Komunikacji Autobusowej w Gdyni Sp. z o.o.
- Przedsiębiorstwo Komunikacji Miejskiej w Gdyni Sp. z o.o.
- Przedsiębiorstwo Komunikacji Trolejbusowej w Gdyni Sp. z o.o.
- EUROMATPOL Sp. z o.o.
- Przedsiębiorstwo Wielobranżowe 'BP Tour' Piotr Brewczak.
- IREX 3 Sp. z o. o.
- PKS Gdynia S.A.
- Pomorska Komunikacja Samochodowa Sp. z o.o.
- Przewozy Autobusowe 'Gryf ' Marian Kotecki.

Transport services for the ZTM of Gdansk are provided by the following operators:

- Gdańskie Autobusy i Tramwaje Sp. z o.o.
- Przedsiębiorstwo Komunikacji Samochodowej Sp. z o.o. in Gdańsk.
- Przedsiębiorstwo Wielobranżowe 'BP Tour' Piotr Brewczak (Hartenberger-Liszek, 2014, p. 43).

Nowadays, human activity is strongly linked to the need to move people, cargo, and information. In urban areas, the implementation of the smart city concept is served, among other things, by modern and efficient mass public transport, which binds together large urban agglomerations. This transport should meet customer expectations in terms of quality.

Quality is treated as a characteristic that is collective, unmeasured and unmeasurable, but describable and quantifiable as the resulting intensity of the most significant factors that affect it.

The determination of the requirements for the quality of mass public transport is not easy, as the requirements are associated with various aspects of evaluation of the performance of the transport system from the point of view of its components. Other criteria for the evaluation of the quality of transport will be identified by the passenger, the municipal transportation company, and the person living in the vicinity of the transportation system. In addition, a set of criteria can be defined for the environmental impact of transport. It is not always possible to meet the quality requirements for public transport to the same extent due to social, environmental, technical, and economic factors. It can be said with a broad generalisation that the operation of an urban transport system is based on a certain trade-off between what needs to be done, what can be done, and what pays off (Gramza, 2011, p. 129).

3. The KANO method as an example of service quality research

The Kano quality research method involves translating general customer expectations and opinions about a service or product into specialised language. This makes it possible to focus on the development of a product or service and promotes future rationalisation of resources. The respondent answers the questions included in a questionnaire, which are formulated in two versions (positive and negative): when a characteristic is present and fulfills its task correctly, when a characteristic cannot be extracted or possibly does not occur in a satisfactory manner (Janocha, Dubis, 2023, p. 163).

Each of the questions (whether positive or negative), has a list of five options, namely: *"I like it that way***"** (like), *"It must be that way"* (must-be), *"I am neutral"* (neutral), "I can *live with it that way"* (live with), *"I dislike it that way*" (dislike). After the survey, the result is tallied and totaled to show how the majority of users/customers expressed their requirements, and this is categorized into 6 types of characteristics (Hussain, Mkpojiogu, 2016, p. 173).

The method distinguishes 6 types of characteristics that affect customer satisfaction:

- M – must-be characteristics – must be included as a standard in the product or service, because without them its function cannot be performed. Nor are they important to achieving satisfaction – their existence in the product is taken for granted, and their absence translates into loss of a customer.
- O – one-dimensional characteristics – have the greatest importance for customer satisfaction with a product or service, because they shape the quality. These are the characters sought by the customer; the more there are of them, the higher the chance of meeting the requirements. Their absence causes dissatisfaction to increase, but not as sharply as in the case of mandatory characteristics.
- A – attractive characteristics – are designed to attract the customer to a product or service, as they are supplementary to his or her requirements. When these features are absent, they might cause only a loss of interest in a product or service. On the other hand, when they are present, customers can be delighted by them. They are difficult to identify and even more difficult to define, and their popularity is very short-lived. Poorly designed attractive characteristics may go unnoticed by the customer.
- I – indifferent characteristics – are those whose existence the customer does not care about and is does not care whether they are present or not.
- Q – questionable, skeptical characteristics – are those whose importance to the customer is difficult to predict, especially with respect to the time when the importance emerges.
- R – reverse characteristics – are those which conflict starkly with what the customer feels is important. Their absence pleases the customer, while their presence arouses dissatisfaction (Malinowska, Wiśniewska, Grudowski, 2014, pp. 238-239).

The Kano method helps find the characteristics that are the most important in a particular service or product and that influence customer satisfaction. The order of importance of the characteristics is the following: M, O, A, and I.

4. Mass public transportation in the Tri-city in the light of research

An important issue in the shaping of transport services is the correct identification of customer expectations and service providers' capabilities. In order to achieve the adopted goal of the study, a survey was conducted with 67 respondents. The survey was addressed to the residents of the Tri-City urban agglomeration and its surrounding areas who are undergraduate and graduate students of the Faculty of Economics at the University of Gdańsk and use public transportation at least occasionally. Thirty-five first-cycle program (bachelor's degree) students and 32 second-cycle (master's degree) students participated in the survey. A large majority of the respondents, 41 people, were part-time students (41 people), while the number of full-time

students was 26. Sixty-one people were students of economics and 6 were students of health care technology (HCT).

The questions in the questionnaire were intended to gain information about mass public transport in the Tri-City. They concerned the following issues:

1. Frequent traffic delays in mass public transport.
2. Provision of a sufficient number of connections by public transport organisers.
3. Cleanliness of mass public transport vehicles.
4. Friendly and helpful staff operating mass public transport.
5. Ready availability of schedule and fare information and ease of reading them.
6. Facilities for people with disabilities in mass public transport.
7. Adequate facilities for passengers, such as places to carry strollers, prams, or bicycles.
8. Sufficient communication between public transport operators and passengers in case of schedule changes.
9. Public transport providers offering of a variety of ticket options that meet the needs of the passengers.
10. Amenities such as USB charge ports and free Wi-Fi access on means of transportation.
11. Possibility to file complaints concerning travel.
12. Public transport organisers taking measures to reduce greenhouse gas emissions and negative environmental impacts.
13. Adapting the means of transportation to sustainable energy sources, such as electricity or hydrogen.
14. Sufficient investment in the development of infrastructure (bike paths, bus lanes) for low-emission means of transportation, such as bicycles and electric buses.
15. Public transport operators informing passengers about the environmental impact of the means of transportation and encouraging informed choices by passengers.

4.1. The survey results for all students of the Faculty of Economics

The survey results for all respondents are shown in Table 1. A total of 67 people answered the questions.

Table 1.
The factors shaping the quality of service in Tri-City's mass public transport as identified by students of the Faculty of Economics

Factor no.	Item	Number of votes cast for a given factor						Total number of votes	Assessment category
		M	O	A	I	Q	R		
6	Facilities for people with disabilities	33	20	4	10	-	-	67	M
11	Complaints concerning trips	27	20	5	15	-	-	67	M
8	Communication on schedule changes	26	22	3	16	-	-	67	M
5	Clear information about schedules	25	17	9	16	-	-	67	M
9	Various ticket options	15	36	13	3	-	-	67	O
1	Trip delays	22	34	5	2	3	1	67	O
2	Sufficient number of connections	23	31	9	4	-	-	67	O

Cont. table 1.

3	Cleanliness of the means of transport	25	28	7	7	-	-	67	O
13	Adaptations of the means of transport to energy sources	9	24	14	19	-	1	67	O
14	Investment in infrastructure	17	24	10	15	-	1	67	O
12	Reduction of gas emissions	17	22	6	22	-	-	67	O
4	Friendly staff	13	19	21	14	-	-	67	A
7	Possibility to carry strollers, prams, and bicycles	15	18	7	27	-	-	67	I
15	Information about the impact of the means of transport on the environment	8	19	12	27	-	1	67	I
10	USB charge ports and Wi-Fi	9	14	21	23	-	-	67	I

Note. Prepared by the author.

According to the survey, four characteristics are mandatory and must be included as a standard in the transportation services provided. The first is amenities for people with disabilities, which was indicated by 33 people. The next three characteristics are the possibility to file complaints regarding trips, efficient communication about schedule changes, and easy-to-read schedule and fare information. These characteristics are provided on most lines and stops in the Tri-City thanks to the information boards of the TRISTAR Traffic Management and Control Center and cell phone applications (Trojmiasto.pl and jakdojadę). In addition, during the ride, passengers are informed about where they currently are and what the next stop will be.

Another group of characteristics comprises those that are most important for customer satisfaction with the transportation service and that shape its quality. One of them is the various ticket options that meet the needs of the passengers. As many as 36 people indicated this characteristic. This is a very important issue in the Tri-City, where it is possible to purchase single-trip tickets, timed-limited tickets, and tickets combining different modes of transport (bus, tram, trolleybus, and Fast Urban Railway). Another feature is the lack of traffic delays and the number of connections. This feature was indicated as important by 34 of the respondents. In the past year, many bus lines have been closed in the Tri-City and others have been shortened or lengthened. The cleanliness of the means of transportation is also an important factor that affects the quality of the services provided. As it turns out, more and more passengers are also paying attention to features associated with environmental protection, because as many as 24 persons indicated the desirability of the adaptation of the means of transportation to sustainable energy sources, such as electricity or hydrogen, and of investments in infrastructure development for low-emission means of transportation, such as bicycles, bike paths, and electric buses. In the Tri-City, there is an increasing emphasis on the reconstruction of roads and construction of bus lanes. Measures are also taken to reduce greenhouse gas emissions and negative environmental impacts by public transport organisers (by introducing electric buses and buses that use natural gas as the fuel).

The only attractive characteristic identified by the respondents is friendly and helpful staff.

The indifferent characteristics that the customers using the service do not ask for are the carriage of strollers, prams, and bicycles (this is due to the fact that the spots for such purpose are commonly found on buses), information about the environmental impact of the means of transportation, and USB charge ports and Wi-Fi.

4.2. The results of the survey for the group of first-cycle and second-cycle students

An analysis of the different groups of students makes it possible to notice small differences in the order of the characteristics depending on whether they are students of the first- or second-cycle programs and whether they are full-time or part-time students.

The results of the survey for students of full-time and part-time first-cycle programs are shown in Table 2.

Table 2.
The factors shaping the quality of service in Tri-City's mass public transport as identified by first-cycle students

Factor no.	Item	Number of votes cast for a given factor						Total number of votes	Assessment category
		M	O	A	I	Q	R		
6	Facilities for people with disabilities	19	11		3	-	-	35	M
8	Communication on schedule changes	14	13	3	5	-	-	35	M
11	Complaints concerning trips	14	11	2	8	-	-	35	M
2	Sufficient number of connections	13	13	7	2	-	-	35	M/O
5	Clear information about schedules	11	11	6	6	-	-	35	M/O
9	Various ticket options	8	21	5	1	-	-	35	O
1	Trip delays	12	17	4	-	1	1	35	O
3	Cleanliness of the means of transport	11	17	5	2	-	-	35	O
14	Investment in infrastructure	10	15	5	4	-	1	35	O
13	Adaptations of the means of transport to energy sources	5	12	6	11	-	1	35	O
4	Friendly staff	8	11	10	6	-	-	35	O
10	USB charge ports and Wi-Fi	6	8	13	8	-	-	35	A
7	Possibility to carry strollers, prams, and bicycles	6	10	4	15	-	-	35	I
15	Information about the impact of the means of transport on the environment	5	11	4	15	-	-	35	I
12	Reduction of gas emissions	8	11	3	13	-	-	35	I

Note. Prepared by the author.

Responses to the survey questions were provided by 35 first-cycle students. The partial results differ slightly for this group compared to the entire study group. The group of factors whose existence is taken for granted and whose absence could translate into a lack of customers continues to include amenities for people with disabilities, communication about schedule changes, and the ability to file complaints concerning trips.

The next two factors are both necessary and important to satisfaction, according to the respondents, and include clear information on schedules (11 people gave that response) and sufficient connections (11 people). This is a significant difference from the results for the entire study group.

The features sought by customers include: the availability of a variety of ticket options, lack of traffic delays, cleanliness of the means of transportation, investments in infrastructure, adaptations of the means of transportation to sustainable energy sources, and friendly staff (which was an attractive characteristic for all respondents).

The attractive characteristic is availability of USB charge ports and Wi-Fi on the means of transportation. The respondents were 22-23 years old and had an interest in technological innovation. The choice of this factor as an attractive factor was mainly voted for by full-time students. This answer was indicated by 13 people out of 35.

The indifferent characteristics indicated by the respondents were the ability to transport strollers, prams and bicycles, information about the environmental impact of the means of transportation, and the reduction of gas emissions from the means of transportation.

The results of the survey for students of full-time and part-time second-cycle programs are shown in Table 3.

Table 3.
The factors shaping the quality of service in Tri-City's mass public transport as identified by second-cycle students

Factor no.	Item	Number of votes cast for a given factor						Total number of votes	Assessment category
		M	O	A	I	Q	R		
3	Cleanliness of the means of transport	14	11	2	5	-	-	32	M
5	Clear information about schedules	14	6	3	9	-	-	32	M
6	Facilities for people with disabilities	14	9	2	7	-	-	32	M
11	Complaints concerning trips	13	9	3	7	-	-	32	M
8	Communication on schedule changes	12	9	-	11	-	-	32	M
2	Sufficient number of connections	10	18	2	2	-	-	32	O
1	Trip delays	10	17	1	2	2	-	32	O
9	Various ticket options	7	15	8	2	-	-	32	O
13	Adaptations of the means of transport to energy sources	4	12	8	8	-	-	32	O
12	Reduction of gas emissions	9	11	3	9	-	-	32	O
4	Friendly staff	5	8	11	8	-	-	32	A
10	USB charge ports and Wi-Fi	3	6	8	15	-	-	32	I
7	Possibility to carry strollers, prams, and bicycles	9	8	3	12	-	-	32	I
15	Information about the impact of the means of transport on the environment	3	8	8	12	-	1	32	I
14	Investment in infrastructure	7	9	5	11	-	-	32	I

Note. Prepared by the author.

Thirty-two second-cycle students participated in the survey. An analysis of the survey results for this group of respondents indicates that the situation is very similar to the overall results. The first difference is the indication of bus cleanliness as the first factor in the group of M factors (14 votes), i.e., the factors that are mandatory for the transportation service. The second difference is that the weight of the factor of investment in infrastructure was shifted from essential to indifferent.

4.3. The survey results for full-time and part-time students

An analysis of the results of the survey for full-time students, which are shown in Table 4, also indicates a similarity of the results to the overall results.

Table 4.
The factors shaping the quality of service in Tri-City's mass public transport as identified by full-time students

Factor no.	Item	Number of votes cast for a given factor						Total number of votes	Assessment category
		M	O	A	I	Q	R		
6	Facilities for people with disabilities	14	6	2	4	-	-	26	M
8	Communication on schedule changes	13	7	2	4	-	-	26	M
5	Clear information about schedules	9	5	5	7	-	-	26	M
1	Trip delays	7	15	3	-	-	1	26	O
9	Various ticket options	7	11	7	1	-	-	26	O
11	Complaints concerning trips	7	10	-	9	-	-	26	O
2	Sufficient number of connections	9	10	5	2	-	-	26	O
3	Cleanliness of the means of transport	9	10	5	2	-	-	26	O
14	Investment in infrastructure	4	10	2	9	-	1	26	O
4	Friendly staff	6	6	12	3	-	-	26	A
10	USB charge ports and Wi-Fi	3	6	9	8	-	-	26	A
15	Information about the impact of the means of transport on the environment	1	7	3	15	-	-	26	I
12	Reduction of gas emissions	7	3	3	13	-	-	26	I
13	Adaptations of the means of transport to energy sources	3	5	7	10	-	1	26	I
7	Possibility to carry strollers, prams, and bicycles	5	8	4	9	-	-	26	I

Note. Prepared by the author.

Among full-time students, minor changes can be seen in the order of the factors. A significant difference is the ability to file complaints, which was moved from the group of mandatory factors to the group of those that are the most important to the customers (as was indicated by 10 out of 26 respondents). This may be due to the fact that this group of respondents consists mainly of full-time first-cycle students, for whom public transportation is often the only means of transportation to travel between home and university or to work.

The second difference is that equipping the means of transportation with Wi-Fi and USB charge ports was qualified as an attractive factor (9 indications).

The final change is that the factors relating to the reduction of gas emissions by the means of transportation and their adaptation to sustainable energy sources were moved from the group of important factors to the group of neutral factors.

The results of the survey for part-time students are shown in Table 5.

Table 5.
The factors shaping the quality of service in Tri-City's mass public transport as identified by part-time students

Factor no.	Item	Number of votes cast for a given factor						Total number of votes	Assessment category
		M	O	A	I	Q	R		
11	Complaints concerning trips	20	10	5	7	-	-	41	M
6	Facilities for people with disabilities	19	14	2	6	-	-	41	M
5	Clear information about schedules	16	12	4	9	-	-	41	M
9	Various ticket options	8	25	6	2	-	-	41	O
2	Sufficient number of connections	14	21	4	2	-	-	41	O
1	Trip delays	15	19	2	2	3	-	41	O
12	Reduction of gas emissions	10	19	3	9	-	-	41	O
13	Adaptations of the means of transport to energy sources	6	19	7	9	-	-	41	O
3	Cleanliness of the means of transport	16	18	4	2	-	-	41	O
8	Communication on schedule changes	13	15	1	12	-	-	41	O
14	Investment in infrastructure	13	14	8	6	-	-	41	O
4	Friendly staff	8	13	9	8	-	-	41	O
15	Information about the impact of the means of transport on the environment	7	12	9	12	-	1	41	O
10	USB charge ports and Wi-Fi	6	8	12	15	-	-	41	I
7	Possibility to carry strollers, prams, and bicycles	10	10	3	14	-	-	41	I

Note. Prepared by the author.

It would seem that part-time students use mass public transportation more sporadically. However, there are no significant differences between part-time and full-time students in the factors indicated. This group included 41 respondents.

To the students in this group, no factor qualifies as 'attractive'. Friendly staff is a mandatory factor, as is communication on schedule changes.

On the other hand, one can see an increase in environmental awareness among the part-time students, as information about the environmental impact of the means of transportation is an important factor for them. Part-time students often use their own means of transportation to travel, so environmental aspects are important and relevant to them, not only in their decisions related to the purchase of their own cars, but also for the means of mass public transport.

5. Conclusion

Assessing the quality of urban public transport is a complex issue. The selection of the main criteria for evaluating quality in passenger transport is influenced by the passengers' preferences. It is essential to improve the quality of the services provided in order to convince people to abandon individual transportation in favor of mass public transport. It is therefore necessary to identify problems and needs in the organisation and management of public

transportation in order to facilitate and encourage as many people as possible to use public transportation.

As part of the Tri-City's sustainable development strategy, it is fundamental to strive for a reasonable range of services provided by the public transportation system. Success in this endeavour requires:

- adjusting the quantity and quality of public transportation services to the preferences and expectations of the passengers, including accessibility for people with disabilities;
- providing high-quality public transportation services that create a viable alternative to travel by privately-owned car;
- coordinating the local transportation development plan with regional and national transportation development plans and local spatial development plans;
- reducing the negative impact of transportation on the environment;
- economic and financial efficiency of specific solutions in shaping the transportation services and infrastructure (Plan…, 2021, p. 3).

The survey results show that students who use mass public transport think alike, as they indicated similar characteristics as important and relevant to the formation of the quality of transportation services. They emphasised the adaptation of the means of transportation for use by people with disabilities and the reduction of negative environmental impacts of the means of transportation. In addition, communication between transport operators and passengers about the possibility of filing complaints or informing about schedule changes were indicated as important factors.

Other factors indicated by the respondents were the courtesy of the staff and the cleanliness of the means of transportation, as well as equipping the latter with Wi-Fi and USB charge ports.

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ENGAGEMENT OF PUBLIC ADMINISTRATION EMPLOYEES – AN EXAMPLE OF THE SOCIAL INSURANCE INSTITUTION

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Purpose: The article measures the level of employee engagement in the Social Security unit and identifies the factors that determine this engagement.
Design/methodology/approach: Both quantitative and qualitative methods were used in this study. Expert interviews and surveys were conducted using a modified questionnaire of the WIGOR method. The survey was conducted in March 2023 and covered 148 employees in a selected ZUS unit.
Findings[1]**:** The survey found that the level of engagement among employees is unsatisfactory. It also found that fair compensation and positive relationships with managers and colleagues are strong determinants of engagement. However, there is still untapped potential among the institution's staff.
Research limitations: The most important limitation of the survey is that it is only conducted in one branch of Social Security, and in the future, the survey should be expanded to other units throughout the country.
Practical implications: The results of our study provide practical implications for executives. We indicate what actions should be taken to enable an increase in the level of involvement.
Originality/value: The study fills the gap in determining the level of commitment among public administration employees. The WIGOR model was first used in public administration units.

Keywords: work engagement, employee engagement, public administration, engagement models.

Category of the paper: research paper.

[1] The analysis was carried out based on the results of final diploma paper: Goj, Grabowska, Małoszyc.

1. Introduction

Employee engagement is a key factor in the effectiveness of any organization. Regardless of whether it is a commercial enterprise, a public administration unit or an educational unit, the success of any organization is impossible without committed employees (Borst et al., 2020a). In the literature on the subject, we can find many theoretical studies and research on engagement and related aspects, such as well-being (De-la-Calle-Durán, Rodríguez-Sánchez, 2021; Juchnowicz, Kinowska, 2022; Kadir, Broberg, 2020; Kahtani, 2022), work efficiency (Al-dalahmeh et al., 2018; Borst et al., 2020b; Kim, 2017), work motivation (Hysa, Grabowska, 2014; Król, Zdonek, 2020; Riyanto et al., 2021).

Kinowska (2021) in her research confirmed the existence of a relationship between the commitment and well-being of working Poles (Kinowska, 2021). In particular, employee well-being is positively influenced by vigour and dedication to work. In turn, Mostafa and Abed El-Motalib (2020) and Ashfaq, et al. (2021) draw attention to the role of good, ethical leadership as a factor influencing the involvement of public administration employees. Researchers claim that by treating employees fairly and caringly, ethical leaders increase public administration employees' commitment to work (Ashfaq et al., 2021; Mostafa, Abed El-Motalib, 2020). Appropriate leadership and good communication with the direct superior are important factors motivating employees to work, which is confirmed by research by Hysa and Grabowska (2014), Juchnowicz and Kinowska (2018a) or Jonek-Kowalska, et al. (2021) (Hysa, Grabowska, 2014; Jonek-Kowalska et al., 2021; Juchnowicz, Kinowska, 2018a). In turn, Khusanova et al. (2021) indicate that work engagement plays a mediating role between job meaningfulness and performance (Khusanova et al., 2021). Employee engagement has a direct impact on their work performance and, therefore, on the results and success of the entire organization (Borst et al., 2020a). Of course, employee engagement and their motivation to work are influenced by many factors, which is the subject of many studies (Al-dalahmeh et al., 2018; De-la-Calle-Durán, Rodríguez-Sánchez, 2021; Juchnowicz, Kinowska, 2018b; Kim, 2017; Riyanto et al., 2021; Saks, 2022; Sanborn et al., 2017).

However, despite numerous studies available in the literature, there is still a certain gap related to research on involvement in the area of public administration (Borst et al., 2020a; Juchnowicz et al., 2020; Khusanova et al., 2021). This study will fill the gap in determining the level of commitment, especially since the WIGOR model will be used, which has not yet been used in public administration units. Moreover, an important value of the research will be the fact that it will be carried out in the same public administration unit and mostly among the same employees where the authors examined employees' motivation (Hysa, Grabowska, 2014) to work, their knowledge and competences (Hysa, Grabowska, 2017).

The main objective of the study is to assess the level of engagement of employees of the Social Security unit and to identify the factors determining this engagement. The article is structured in three sections: a theoretical background of the essence and research models of employee engagement, a section devoted to the methodology of empirical research, and a section presenting the results of the analyses and discussion, ending with conclusions.

2. Employee engagement- definition and models

Researchers agree that engagement is not a homogeneous phenomenon (Cook, 2008; Juchnowicz, Kinowska, 2018b; Rakowska, Mącik, 2016; Wziątek-Staśko, Michalik, 2019), is a multidimensional category, and therefore difficult to study. The very definition of engagement becomes problematic, explained, as a mental state, an attitudinal attribute, a set or system of behaviours, a relationship, a role, an emotional construction or energy (Cichorzewska et al., 2020; Juchnowicz et al., 2020; Juchnowicz, Kinowska, 2018a).

In the English-language literature, engagement is understood in three ways: commitment, engagement and involvement (De-la-Calle-Durán, Rodríguez-Sánchez, 2021; Leask, Barron, 2021; Rakowska, Mącik, 2016; Riyanto et al., 2021). In addition, engagement can relate to different areas: commitment to the organization (Lampropoulos et al., 2022), teams, leaders (Juchnowicz, Kinowska, 2018a; Nikolova et al., 2019), profession, goals or personal career (Kahtani, 2022; Saks, 2022). Compared to other constructs, such as job satisfaction work, job involvement, and organizational commitment, employee engagement is a broader construct that includes a more holistic and complete dedication of oneself to the performance of a task or duties (Rakowska, Mendryk, 2017; Saks, 2022). This point of view was adopted in the work.

The issue of engagement can thus be studied in the context of various criteria for the development of the engagement concept and its milestones such as (Rakowska, Mącik, 2016):

- concepts and definitions of engagement (including differentiating the terms commitment, engagement, and involvement, and distinguishing between types of engagement, e.g. job engagement, and organizational engagement),
- factors that influence the level of commitment,
- measuring engagement,
- effects of engagement.

Nevertheless, different approaches to the issue of involvement have in common that they bring beneficial results for the organization. Employee involvement is becoming an extremely important factor in stimulating the development and competitiveness of the organization (Gruszczyńska-Malec, Waligóra, 2019; Juchnowicz, Kinowska, 2021). An engaged employee focuses on work, is more enthusiastic about doing it and achieves or even exceeds business goals, acting in the interest of the company (Gruszczyńska-Malec, Waligóra, 2018). Moreover,

an engaged employee speaks positively about his or her organization, declares his or her willingness to stay in the company, works for its success and is ready to make additional efforts for it. The concept of employee engagement is often confused with satisfaction or happiness. However, the true definition is deeper in meaning. Employee engagement is defined as *the level of an employee's psychological investment in their organization* (Sanborn et al., 2017).

Lewicka and Rakowska (2016), in their research, demonstrated the significant impact of Human Resource Management (HRM) practices on employee engagement (Lewicka, Rakowska, 2016). This is especially true for practices related to development, which is very important for young employees. In addition, Rakowska and Mendryk (2017) proved that work engagement is clearly related to satisfaction with interpersonal relationships in the workplace (Rakowska, Mendryk, 2017). In contrast, some studies show that work engagement is more a result of personality traits and values than organizational factors (Kahtani, 2022; Lampropoulos et al., 2022; Riyanto et al., 2021).

Engagement also requires a specific approach to motivation. It involves the ability of an engaged leader to inspire in particular (Nikolova et al., 2019). Traditional motivation involves consciously influencing employees to achieve the motivator's goals. Inspiration is about setting mutually beneficial goals. The condition is a partnership between the organization and employees. Inspiration leads to unleashing the creative potential of employees. Managing by involvement means creating conditions in which work is a source of satisfaction and employees are aware that their contribution matters to the organization.

Many researchers agree that engagement includes three interrelated factors: cognitive, emotional and behavioural (Cichorzewska et al., 2020; Juchnowicz, Kinowska, 2018a, 2021):

- emotional job involvement – indicates how much the employee is interested in his or her job, whether he or she creates relationships at work, how much the employee likes his or her job,
- cognitive job involvement – indicates how much the employee wants to participate in making decisions regarding his work, how aware he is of his role in the work environment,
- behavioural job involvement – indicates how often employees take additional actions, such as participating in after-hours activities that develop new needed skills, making additional effort and taking initiatives for the organization.

A variety of engagement models and methods for measuring engagement can be found in the literature (Cook, 2008; Juchnowicz, 2012; Robinson et al., 2004; Sanborn et al., 2017; Seligman, 2012):

- model PERMA developed by Seligmann (2012),
- Robinson, Perryman and Hayday model (2004),
- Cook's WIFI model (2008),
- a three-component model of organizational commitment, Meyer and Allen (1997),

- Aon Hewitt model (Sanborn et al., 2017),
- WIGOR model developed by the Juchnowicz team (2012).

The PERMA model presented by the representative of positive psychology and the term *happiness at work*, Seligman, (2012, pp. 57-59) within the framework of well-being theory distinguishes five elements that make up human well-being, which directly translate into personal life and professional engagement: P – Positive emotions, E – Engagement, R – Relationships, M – Meaning, A – Accomplishment/Achievement.

Authors Robinson, Perryman, and Hayday (2004) give special attention to two factors: employee involvement in the sense of interfering, insight, and feeling valued. The authors also identified five additional factors that determine whether employees feel valued and included in the affairs of the organization (Robinson et al., 2004, pp. 34-36).

A slightly different model was presented by Cook (2008), who makes commitment dependent on four factors: employees' good feelings about the organization (well-being), employees' good understanding of the organization's goals and values (information), fair treatment of employees (fairness), and employees' participation in communicating and responding to their opinions (involvement). According to Cook (2008), ensuring these four elements makes employees feel valued, and respected and that management has confidence in them. This, in turn, translates directly into the behaviour of employees, who give their best at work. In addition, they go above and beyond the call of duty and are loyal, motivated and enthusiastic (Cook, 2008, pp. 75-79).

One of the most widely used models of commitment is Meyer and Allen's (1997) three-component model of organizational attachment. According to them, attachment is a psychological state that implies, first, the relationship occurring between the employee and the organization and, second, the employee's decision toward staying or leaving the organization (Meyer, Allen, 1997). Organizational attachment consists of three components: affective commitment, which refers to the employee's emotional attachment and identification with the organization, continuance commitment, which is described as the intention to stay due to the anticipated costs resulting from leaving the organization, normative commitment, which stems from a sense of duty, loyalty to the organization (Cichorzewska et al., 2020). The above components result from a psychological state that shows up in desire (affective attachment), need (continuance attachment) and obligation (normative attachment) to maintain employment with the organization.

Another model developed by consulting firm Aon Hewitt (Sanborn et al., 2017, pp. 12-14), emphasizes the behavioural dimension as the most important in work engagement. It manifests itself in three levels of employee behaviour (Say, Stay, Strive):

- expressing positive opinions about the organization in contact with colleagues, clients and other stakeholders,
- demonstrating a deep desire to remain a member of the organization,
- and demonstrating above-average efforts and dedication to work to contribute to the success of the organization.

The highlighted variables in the Aon Hewitt model (2017, pp. 2-4) are supervisors, career and employee development, collaboration, autonomy and influence, job security, ensuring employee supply, work organization, infrastructure, communication, acceptance of diversity, brand, reputation, and social responsibility.

The WIGOR model is a model for measuring employee engagement developed by a team of Polish researchers led by Juchnowicz and presented in the form of an equation:

$$WIGOR\ (Engagement) = Knowledge + Identification + Gratification + Organization + Cooperation$$

where:

Knowledge – means knowledge of the vision, mission, strategic goals and objectives of the work performed.

Identification – means a sense of unity with the organisation, loyalty, initiating improvements, taking responsibility and initiative, willingness to make sacrifices, acceptance of the organisation's goals, values and culture, trust in management and employees, a strong corporate brand as an attractive employer.

Gratification is a system of remuneration, the total benefits received by an employee as a result of employment should be comprehensive but at the same time individualised.

Organisation – organisational and technical support, appropriate management system, including human capital management tools.

Cooperation – the desired nature of the relationship between partners in an employment relationship is cooperation, not a conflict of interest, which requires appropriate behaviour of superiors (motivating, not manipulative) and employees (colleagues, not competitors or rivals).

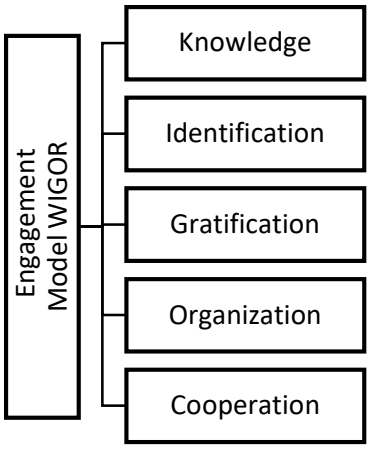

Figure 1. Own work.

Source: based on (Juchnowicz, 2012).

To achieve the main goal of the research, which is to assess the involvement of public administration employees, the WIGOR model was adopted because it is adapted to the work environment and culture of Polish employees (Figure 1).

To meet the main purpose, three research questions were formulated:

1. What is the level of engagement in the selected Social Security unit?
2. Which group has the greatest engagement?
3. What key factors determine the employee engagement?

3. Methods and data collection

The research was conducted in a selected public administration unit of the Social Insurance Institution (ZUS). The Social Insurance Institution (ZUS) is the state organisational unit with legal personality and the main element of the administration of the Polish social security system. Currently, the ZUS has over 300 field units and employs over 43,000 people. The original Juchnowicz method was used to measure the level of employees' commitment to the organisation and the level of commitment to work, the theoretical basis of which is the WIGOR model (Juchnowicz, 2012). The study consisted of two stages. In the first stage, interviews were conducted with experts in the field of management and public administration to adapt the Juchnowicz (2012) questionnaire to the specificity of this field. In the second stage, survey research was carried out. Data were collected in March 2023 through a survey conducted on a sample of employees of the ZUS unit (n = 148) using the PAPSI (Paper and Pencil Self-administered Interview) method.

The survey contained a total of 50 questions. The first part of the 30 questions concerned respondents' opinions on specific aspects of employees' involvement in the organization (19 questions) and commitment to work (11 questions). The questions covered cognitive, behavioural, and emotional aspects. Respondents rated statements on a 5-point Likert scale, where 1 represented *strongly disagree* and 5, *strongly agree.* Another part of the 20 questions related to the aspect of engagement like work organization, development opportunities, principles and mechanisms of remuneration, relations with the direct superior, and relations with colleagues [2]. In the third part of the survey, respondents were asked to rank the factors influencing their level of engagement. Ten factors had to be ranked in order of importance from 1 very important factor, 2 less important factor, etc. to 10 least important factor (each number from 1 to 10 could only appear once). The structure of the survey sample is shown in Table 1.

[2] For editorial reasons, not all aspects of the research are presented.

Table 1.
Structure of the survey sample

Item		%
Sex	male	7
	female	93
Age	up to 25	1
	26-35	15
	36-45	39
	46-60	41
	above 61	3
Education	secondary but still studying	2
	secondary	28
	higher	70
Seniority (experience)	up to 2	7
	3-5	7
	6-10	16
	11-20	28
	above 21	42

Source: own study (N = 148).

The survey was dominated by female respondents (93%). Almost three-quarters of respondents had higher education (70%), a third had secondary education (28%) and only 2% had secondary education but were still studying. The largest number of respondents, 42%, are employees with more than 21 years of experience, followed by employees with 11 to 20 years of experience (28%), 16% of respondents with 6 to 10 years of experience and 7% of respondents with up to 2 years of experience and between 3 and 5 years of experience.

4. Result and discussion

4.1. Level of engagement in a selected unit of the Social Insurance Institution

To determine the level of involvement in the the organization, employees' opinions on nineteen different aspects of commitment were analyzed and the employee engagement to the organization index according to Juchnowicz (2012) was calculated (Table 2).

Table 2.
Involvement in the organization (IZPO)

	Item
1	I believe that our company has a good reputation as an employer
2	I would recommend the company to a friend looking for a job without hesitation
3	Employees' suggestions and opinions are taken into account when decisions are made in the company
4	I work overtime or on days off if required by the job or the company's situation
5	I am very satisfied with my workplace
6	There would have to be serious reasons for me to leave the company.
7	If necessary, I can count on the help of my colleagues or superiors
8	I am proud to work in my current workplace
9	I contribute ideas and suggestions for changes whenever I see an opportunity to improve the company's results

Cont. table 2.

10	The company provides training to help me develop valuable skills
11	I feel used/abused and undervalued at work
12	I am willing to take on any additional tasks required to achieve the objectives of my workplace
13	I am well-informed about important changes in our company
14	The tools and technology available allow me to do my job properly
15	My manager gives me the support I need to do my job effectively
16	I want to change the workplace where I currently work
17	I accept the company's values, standards, behaviours and practices
18	I am happy to share my knowledge at work
19	I know and can explain the main objectives of the workplace where I work

Source: Own work based on Juchnowicz, 2010.

The indicator of employee engagement in the organisation (IZPO), the percentage of employees who answered at least 80% of questions from this group positively (definitely *strongly agree* and *agree*), was 21%. Compared to Juchnowicz's (2012) research (44%) from commercial organisations, it is twice as low. This may be due to poor earnings and limited trust in a credible employer brand, which effectively reduces the commitment of public administration employees.

Analyzing all 19 statements regarding involvement in the organisation (Figure 2), 99% of employees responded that they *know and can explain the main objectives of the workplace where I work.* This means that employees receive clear and concise communication regarding the organization's strategy and primary objective. Whilst executing their responsibilities, they endeavour to achieve the goals assigned to them by management, which demonstrates a strong identification with the goals and, in a broader perspective, with the organisation. Similar to Cook (2008) and Hevit (2017) (Cook, 2008; Sanborn et al., 2017).

As many as 98% of employees said *I am happy to share my knowledge at work.* This result is undoubtedly influenced by the organisational culture, which is based on values such as trust, honesty and respect. The atmosphere among employees is based on mutual friendliness, openness and cooperation.

In contrast, however, it is surprising that 86% of employees responded positively to the desire “to change the workplace where I currently work”. The research indicates that the employer must take measures to establish a trustworthy employer brand to attract job seekers and retain talent. The brand represents a commitment and guarantee not only to job applicants but also to employees. The employer brand comprises various facets, including the organisation's culture, benefits package, the scope for advancement, communication, training, and the correlation between remuneration and staff engagement and job contentment.

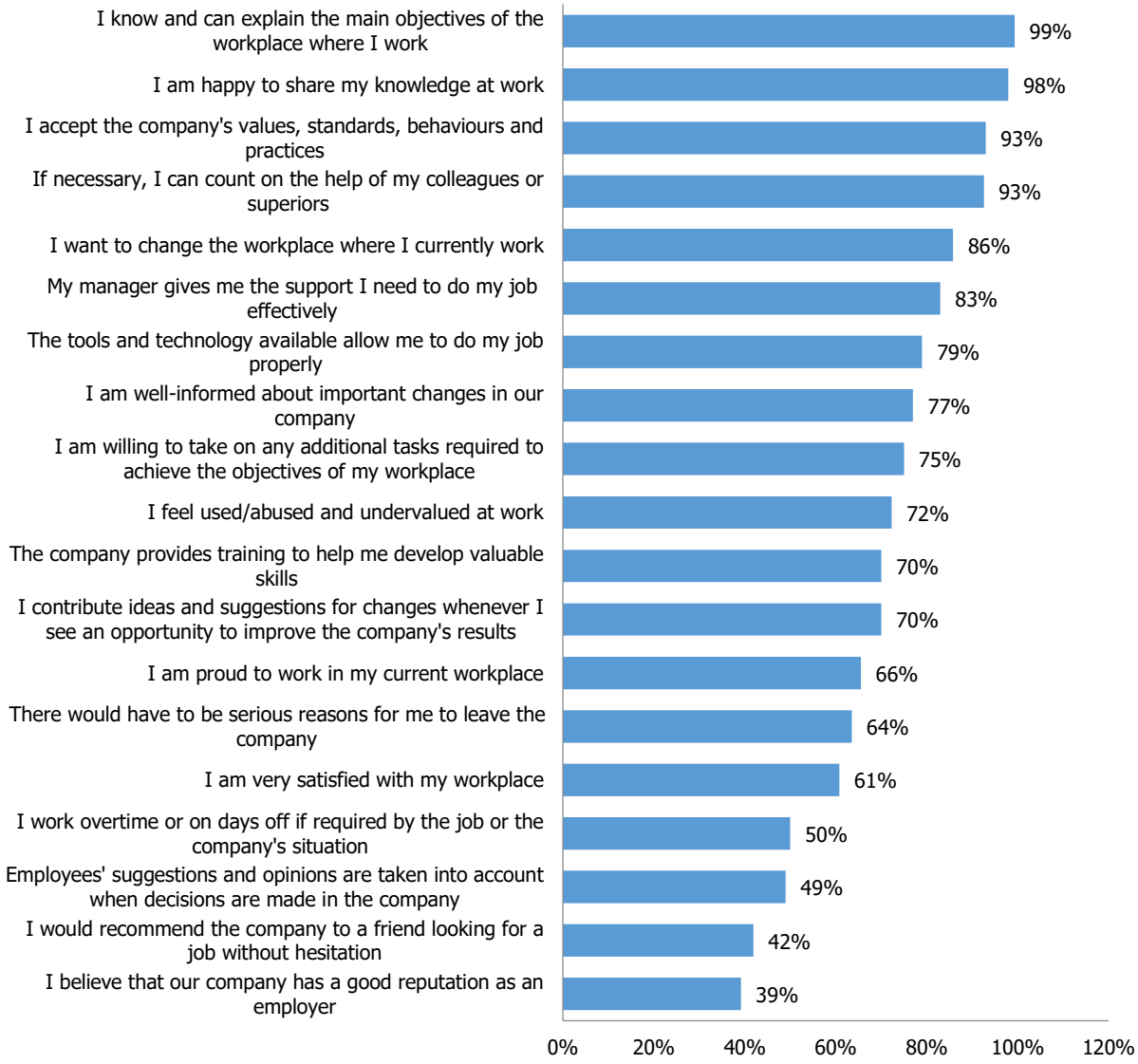

Figure 2. Involvement in the organization. Answers "strongly agree" and "agree".

Source: Own work.

Based on eleven other statements, the work engagement index was calculated (Table 2).

Table 2.
Commitment to work

	Item	Aspect
1	I know and can explain the goals of my work	cognitive
2	I am fairly rewarded for the work I do	cognitive
3	The work I do creates opportunities to use my knowledge and skills	cognitive
4	The work I do gives me the freedom to act	cognitive
5	My opinions/opinions are taken into account at work	behavioural
6	My work necessitates me to enhance my skills, develop and take on challenges	behavioural
7	I am satisfied with my work. I feel good about it	emotional
8	Professional work is an overwhelming duty for me	emotional
9	I go to work every day with pleasure	emotional
10	My work gives me satisfaction	emotional
11	I am proud of the tasks I perform	emotional

Source: Own work based on Juchnowicz, 2010.

The work engagement index (IZP) determines the percentage of a company's employees who express a positive opinion on 80% of the questions related to work engagement. In the examined sample, the rate stands at 29%, slightly less than the figure calculated for commercial organisations (34%) (Juchnowicz, 2012).

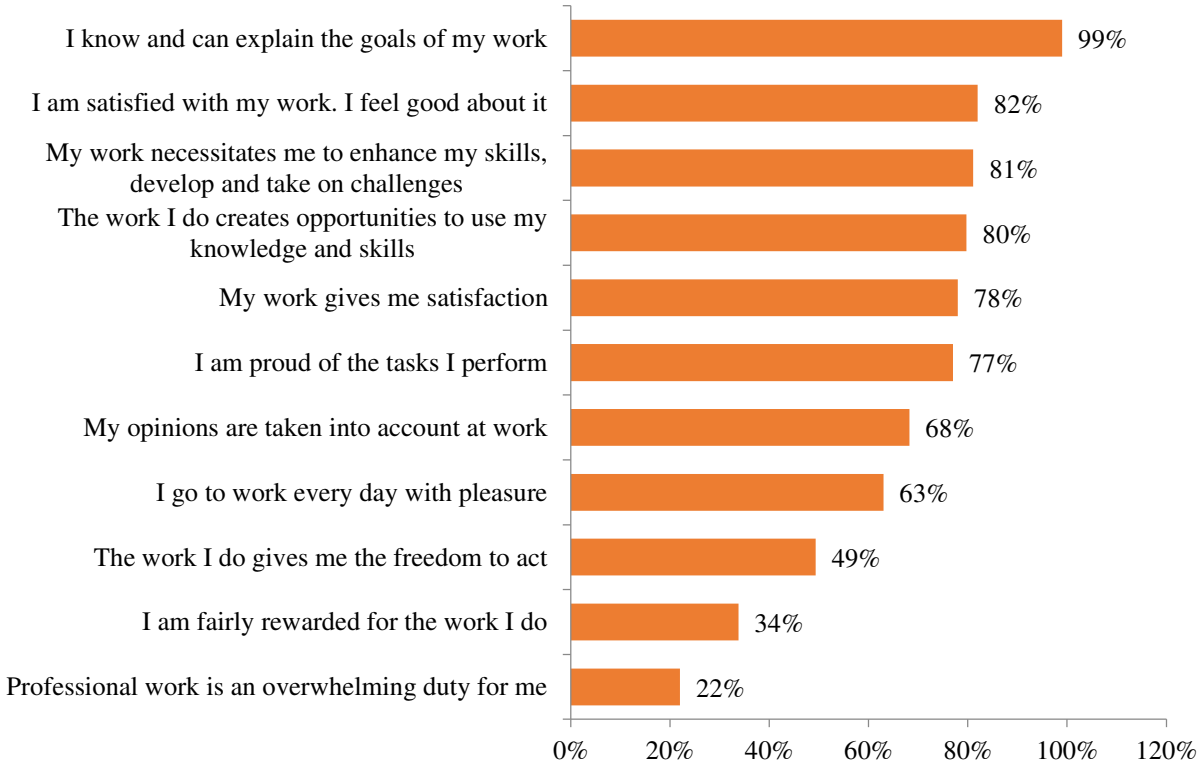

Figure 3. Commitment to work. Answers "strongly agree" and "agree".

Source: Own work.

Analyzing 11 statements related to work commitment, as many as 99% of employees answered that they knew and could explain the goals of the work they do. Thus, conveying that awareness regarding the company's goals corresponds to an understanding of the objectives of employee duties. This is not surprising, since the Social Insurance Institution monitors the implementation of the ZUS strategy on a semi-annual basis, which includes an assessment of the degree of achievement of the adopted strategic goals, as well as programmes and initiatives, based on defined metrics. Furthermore, the substantial number of positive responses to the statements *my job necessitates me to enhance my skills, develop and take on challenges* (81%) and *the work I do creates opportunities to use my knowledge and skills* (80%) shows that employees are aware of the need to improve their qualifications and continuous training. These results are consistent with the research conducted by Lewicka and Rakowska (2016). This requirement stems from the necessity to possess adequate knowledge of relevant laws, the implementation of appropriate procedures, and the proper interpretation of legal provisions. These findings align with those of Hysa and Grabowska's (2014) study, where common motivators cited by respondents include frequent use of access to training and further education (74%) and utilizing pre-existing skill sets (71%).

The employee engagement index (IZPO) was assessed according to length of service and age. Employees with a seniority of 3-5 years have the highest level of the IZPO index (18%), while employees with a seniority of up to 2 years have the lowest level (5%). The age group of 26-35 years (21%) has the highest IZPO index, while the age group of over 61 years (8%) observes the lowest IZPO index. In commercial organisations' involvement levels (Juchnowicz, 2012), a distinct difference is observed, with the lowest involvement rate noted in the 26-35 group and the highest in the 36-45 group.

Analysing the responses according to the aspects included in the WIGOR model (knowledge, identification, gratification, organisation, cooperation), it can be indicated that employees have the necessary **knowledge** to make decisions, are *well informed about important changes in our company* (77%) and are *willing to share my knowledge* (98%).

When it comes to **identification** with the company, employees *accept the company's values, standards, behaviours and practices* (93%). Moreover, 75% indicate their willingness *to perform additional tasks beyond their role requirements to achieve workplace objectives*. However, 86% express a desire *to leave their current workplace*, which contrasts with the findings of Gruszczyńska-Malec & Waligóra (2018). These findings may be explained by the fact that their organisation does not have a good reputation as an employer (39%), as only 42% of respondents *would recommend the company to a friend looking for a job without hesitation.*

On the other hand, another motivation for wanting to change jobs could be inadequate **gratification**, as only 34% of respondents said that they were *fairly rewarded for the work they do*. This issue with appropriate gratification was already visible in 2012, when Hysa & Grabowska (2014) examined motivational factors among employees in the same department (Hysa, Grabowska, 2014). In these studies, 88% of respondents indicated that the remuneration system was inappropriate and unfair. The issue of fair remuneration in the Social Insurance Institution for work performed, adequate to the work contribution, has not lost its relevance since 2012. Employees have positive opinions about the **organisation**, the company's ability *to provide tools and appropriate technology to enable them to do their jobs properly* (79%), and *training that helps develop skills that are valuable to them* (70%).

To achieve a sense of integration with the organisation, and tasks, taking responsibility and **cooperation**, trust in management and colleagues is important. The majority of respondents (84%) stated that their *managers provide them with adequate support for productive work*. Also, they can *rely on their colleagues (93%) or superiors in case of personal or professional problems*. If we compare the above results with the research conducted by Hysa and Grabowska (2014) in the same workplace, we can see a significant improvement in relations with colleagues. In addition, all respondents (100%) identified a lack of cooperation on the part of co-workers and subordinates as a factor negatively impacting work conditions. The introduction of the "Code of Ethics for ZUS Employees" at the plant a few years ago may have significantly enhanced relationships and cooperation. The Company's primary values when dealing with clients, superiors and colleagues are trust, honesty and respect. The principles that should guide all employees at the plant, regardless of their position and type of contract, include loyalty to

the employer and promoting its interests, fostering healthy relationships and a welcoming environment, and denouncing corruption and deceptive behaviour. According to the results, employees identify with the company's goals, values and principles. They trust not only their superiors but also each other.

4.2. Factors determining the level of engagement among employees

Additionally, to identify the factors that influence employee engagement, respondents rated ten factors, including financial rewards, non-financial recognition from supervisors, collegial atmosphere, quality of contact with supervisor, working conditions, opportunity for professional development, willingness to avoid punishment, additional nonwage benefits associated with the job, ability to act independently, and clear criteria for employee evaluation and promotion rules. Each factor was rated only once on a scale from 1 (most important) to 10 (least important)

63% of employees ranked *financial reward (salary increase or bonus)* as the most important factor in determining their level of engagement at work. 13% placed *atmosphere among the employees* at first position, 23% at second position and 27% at third position. As can be observed, similar to Rakowska and Mendryk's (2017) study, work engagement is linked to contentment with interpersonal relationships at work. A further significant factor influencing work commitment is *non-financial recognition from superiors*. As indicated by 3% of employees in first place, 22% in second, and 11% ranking third, such recognition is highly valued. This aligns with previous studies by Robinson et al. (2004) and Cook (2008), which emphasize the importance of appropriate motivation to employee engagement.

A hierarchy of important engagement indicators can be identified by aggregating the responses of all respondents. Figure 4 shows the proportion of employees who ranked a particular factor as the most important (rank 1, 2 or 3).

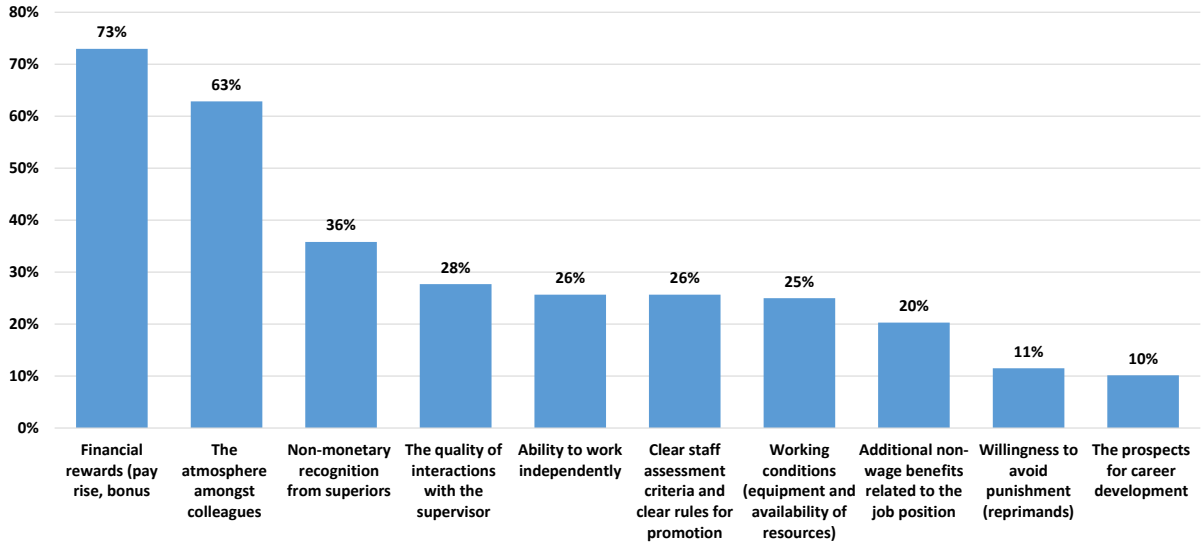

Figure 4. Key engagement factors. (most important priorities 1, 2 and 3 combined).

Source: Own source.

73% of employees considered *financial rewards (pay rise, bonus)* to be an important determinant of their commitment to work. Subsequently, *the atmosphere amongst colleagues* held second place with 63%, whereas *non-monetary recognition from superiors (praise, congratulatory letter)* was placed third with 36% of respondents in agreement. *The quality of interactions with the supervisor* is crucial (28%), as shown by the studies of Juchnowicz and Kinowska (2018a), Jonek-Kowalska et al. (2021), (Mostafa, Abed El-Motalib, 2020, 2020) and Nikolova et al. (2019). Only 10% the employees considered *the prospects for career development* to be important for their loyalty to the job, which is in contrast to the findings of Lewicka and Rakowska (2016).

5. Conclusion

The success of the Social Insurance Institution is the result of many factors. The most important of these are the committed employees who create the organisation. To develop and fully utilise their potential, the management must take comprehensive measures to ensure a high level of employee involvement, regardless of the position held. Unfortunately, according to the research conducted, the level of employee involvement is not satisfactory (IZPO 21%, IZP 34%). The level of employee involvement in the organisation and work depends on many factors, mainly on the working conditions created by the employer and the resources provided (Juchnowicz et al., 2020; Mostafa, Abed El-Motalib, 2020). The research conducted showed that the most important factors that determine the level of involvement of public administration employees are fair remuneration, non-financial recognition from superiors, as well as an appropriate atmosphere among employees.

The presented research has significant implications for both theoretical and practical achievements in the field of employee engagement. First, we have framed our study in the context of Juchnowicz's (2012) WIGOR theoretical model of engagement, which has not yet been used in public administration.

The results of our study also have several practical implications for managers. First of all, the survey results indicate which actions should be taken to increase the level of engagement. The most important recommendations are:

1. Build the image of an attractive employer among employees. One way to do this is to build a reward brand. Employees will appreciate the employer if it recognises and respects the value they bring to the organisation, rewards them appropriately and communicates its pay practices clearly.
2. Mechanisms for changing employee pay levels, which should take into account the impact of work and the appropriate competencies of employees.

3. Introduction of professional human resources management, i.e. reform of the current bonus system, reward for good results, implementation of a career management process and a transparent vision of employee development.
4. Supporting the individual development of employees through line managers and creating an appropriate working atmosphere.

The presented research has some limitations. The most important thing is to conduct research only in one ZUS branch; in the future, the research should be extended to other units throughout the country.

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CHANGE LEADER AS KEY TO IMPLEMENTING INNOVATION IN THE ORGANIZATION

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Purpose: The main objective of the article is to demonstrate the importance of the leadership role in the e implementation of innovation in the company.
Design/methodology/approach: The article's conclusions and findings are based on an extensive analysis of the literature. This was followed by a verification of the documentation of innovative projects implemented under the INNOVATION IN THE ECONOMY operational programme (Priority Axis I). The next stage was to conduct interviews with project leaders. On this basis, conclusions were clarified and directions for further research were established.
Findings: The research carried out made it possible to define the most important attributes of change leaders. The importance of the leader in the implementation of innovation was highlighted. The functioning of the leader in the team, its importance for the success of the project was presented. Also described are the ways in which leaders deal with conflict, pressure and resistance. The interviews conducted are an excellent foundation for further research.
Research limitations/implications: The main limitation of the research is the small number of leaders taking part in the interviews. The research is one-sided, based on the leaders' point of view. In the next stage, observation of the work in selected teams is carried out in order to also take into account the opinions of the other team members and to avoid subjective feelings of the interviewees.
Practical implications: The research has the potential to create a set of good practices in the implementation of innovation projects. The characteristics of a change leader are the basis for educating modern managers, so necessary in today's demanding market.
Originality/value: The main value of the article is the opportunity to find out what leaders think about the principles, problems, success factors of leading innovation projects. An attempt has also been made to define a change leader in order to identify the market requirements for executives.

Keywords: innovation, change, leader, team, project.

Category of the paper: Research paper.

1. Introduction

In today's volatile, challenging environment, the importance of the role of the leader in an organization is increasing. Lack of stability, and at the same time emerging opportunities require from the leader not only unique competencies and skills, but the implementation of modern management models, a new approach to management.

Leadership plays an important role in the functioning of organizations, often determining their survival and enabling proper development. Its purpose is to effectively schedule tasks, give employees the competence and provide the necessary support, constantly improve the efficiency and quality of the team's activities. It should also be noted that it is the leader who is responsible for the process of implementing change, especially creating innovation.

The article characterizes the roles of a leader in an organization, the required leadership competencies, and the management model of the innovation process. Also presented are the results of a pilot study on the role of the leader in the implementation of innovation in the Opole Province.

2. Literature review

The current times, turbulent, full of change and, consequently, bringing numerous threats and opportunities, require a new management approach from organizations. The new style of management is all about peculiar working conditions, rules of coexistence, culture and, above all, intelligent, charismatic and creative leadership.

Nowadays, a leader is largely responsible for creating the organizational culture, plays an important role in organizing work, helps resolve unexpected conflicts, responds to the needs of his or her subordinates and supports them in their daily activities. To meet these challenges, a leader must have certain competencies, flexibility in action, the ability to take legitimate risks (Gergen, 2022).

To meet the indicated tasks and responsibilities, a leader must possess a number of qualities, skills and qualifications. The ability to lead, to effectively motivate team members to achieve the company's mission and goals is a key factor, but the requirements for a leader are much broader. We should mention organizational skills that guarantee harmonious cooperation with subordinates and effective planning of activities, the ability to cooperate with people, the right choice of ways and tools to motivate teams and individual employees (Haldeman, Henke-Cilenti, 2022). Good relations with customers or partners of the enterprise are equally important. In addition, the leader should be characterized by the ability to think globally, to see the organization as a whole. He or she should understand how the individual elements

contribute to the collective success, perceive the relationships between the various factors that create a specific solution. The leader should have a high degree of creativity in decision-making and problem-solving, as this increases the possibility of developing innovative solutions. Table 1 presents a set of characteristics of the leader's role.

Table 1.
Characteristics of a leader

No.	Quality	Description
1.	The ability to create a vision	Clear vision, accepted mission support efficient management, create "team spirit". It is the vision that creates a kind of roadmap for success of the company.
2.	Effective communication	Effective communication is the key to the success of any venture, any organization. It creates bonds, creates an atmosphere of understanding, support. It is the foundation of creativity and the determinant of motivation.
3.	Ability to assess the situation	Having knowledge of the mistakes and success factors of previous ventures, about the conditions shaping the current situation. It is also fairness in assessing the situation.
4.	Motivation	Motivation has a direct impact on the effectiveness of completed tasks. The leader knows the team, and is able to select tools and methods of motivation that effectively affect its members. He or she creates a desire for self-motivation and self-development among team members.
5.	Optimism	Positively thinking people are a source of inspiration and ideas for colleagues. They give meaning to action and improve relationships among people working together. Having this trait facilitates its spread and propagates enthusiasm.
6.	Generosity	The best leaders are generous. They show trust and give out enthusiastic praise. They treat the success of their subordinates as their own.
7.	Emotional stability	A leader's ability to find psychological balance, realistically assess the situation and act in a principled way. The ability to function under stress.
8.	Self-confidence	Only a self-confident, self-aware person can convince others of his or her own ideas, gain respect. It does not exclude dialogue, but implies making decisions based on the leader's own convictions
9.	Determination	A leader must be characterized by courage, decisiveness and patience. He or she must be a determined, motivated person. The leader is expected to be involved at all stages of the team's activities.
10.	Responsibility	Responsibility for their own decisions, but also for the actions of the entire team.
11	Ability to distribute tasks	A leader has the knowledge to estimate the duration of individual tasks. Skills and competence to accurately allocate tasks and the necessary resources to complete them. When allocating tasks, they take into account the competence, skills and experience of individuals. A leader is guided simultaneously by logic, intuition and the good of the team.
12.	Pursuit of knowledge	Leaders learn from diverse experiences. Leaders know that they must constantly update their skills and knowledge to succeed. Knowledge helps minimize risks and make confident decisions. A leader must know and understand the organization's processes.
13.	Empathy	The art of empathy, the ability to take the point of view of others and making judgments in this way. The ability to read the feelings of co-workers enables a leader to choose the right tools and methods of motivation, but also to create an atmosphere of trust and respect.
14.	Charisma	It gives a leader the ability to explain, to convince. Charisma makes a leader unique compared to other people. Remarkably, research shows that charisma is a competence that can be consciously built and developed.
15.	Ability to build a team	A leader should have the ability to inspire a team, create a positive atmosphere, build an effective system of communication between its members. A leader through his or her actions should be the one who leads the organization forward, but at the same time look for possible directions of development.

Cont. table 1.

16.	Out-of-the-box approach to problems	An out-of-the-box approach to various problems, the ability to look for relations between concepts and facts. Being original, creating innovative solutions. A leader not only needs to be creative, but also needs to foster creativity and innovation throughout the team.
17.	Openness	A leader should be open to ideas, other point of view, discussion and communication.

Source: own elaboration based on Hao, Yazdanifard, 2015; Borgelt, Falk, 2007; Gill, 2002; Mansaray, 2019.

The main role of a leader in a team is to inspire or stimulate what is in people, so as to release the energy necessary to carry out changes, overcome difficulties and perform tasks. His or her job is to help people believe in their own abilities, which is the key to achieving results. A leader does not give team members ready-made solutions but motivates people to seek and find them on their own (Manfred, Kets de Vries, 2022).

A true leader is full of passion, drive, enthusiasm and charisma. He or she inspires and motivates the team to strive and grow. They take the time to get to know their own people, to determine their strengths, priorities and needs. They make team members feel valued and appreciated.

According to J. Adair (2010), the actions of an effective leader regarding the team are:

- building a team maintaining its spirit,
- creating working methods to ensure the smooth operation of the team,
- setting standards and maintaining discipline,
- establishing a system of communication,
- training the team.

On the other hand, the most important functions of a leader in the areas:

- definition of tasks,
- definition of objectives,
- planning the work of the team,
- allocating resources,
- providing answers,
- monitoring progress and controlling performance,
- quality control.

It should be noted that everyone can develop their own leadership qualities, to become a good leader it is necessary to learn: to listen (and hear), build relationships, positive reinforcement.

In the implementation of individual projects, each leader faces different types of challenges and opportunities, unleashing the potential of team members, so that the synergy of knowledge, skills, competencies will enable the achievement of the set goal. A leader is responsible for the results achieved by the team. The leader's actions should lead to the greatest possible efficiency and to the professional development of team members.

One of the most sensitive functions of a leader is to lead change. Incentives for change can include factors within the organization, as well as those arising from the environment. Figure 1 presents examples of sources of changes.

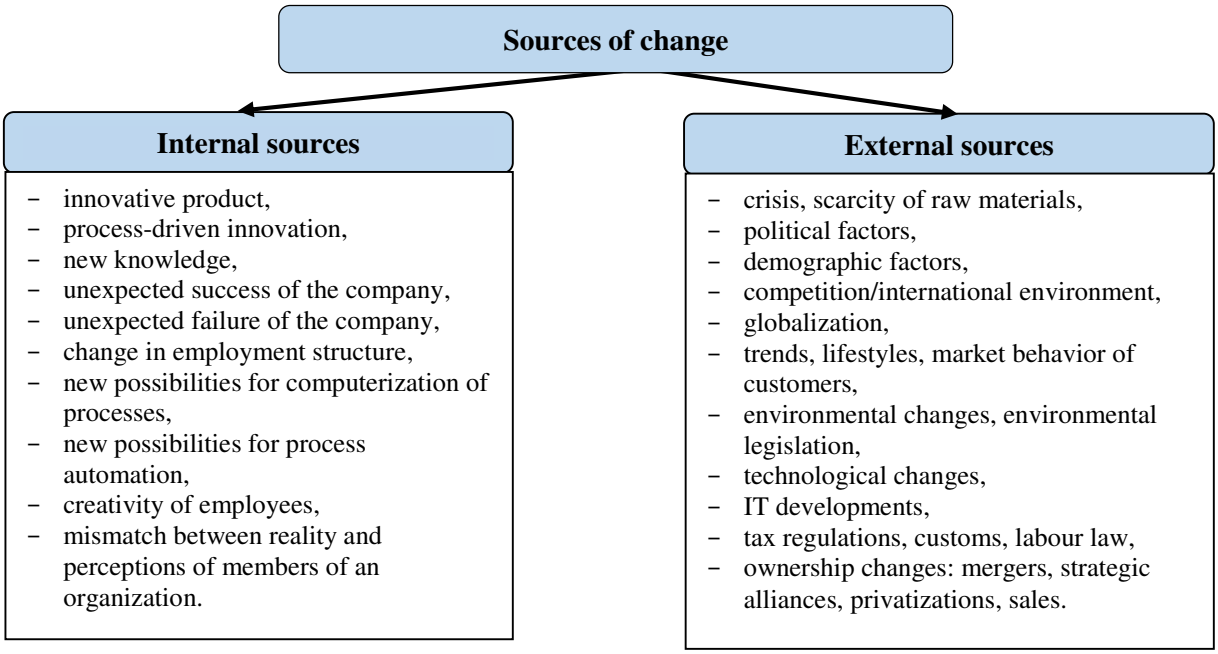

Figure 1. Sources of changes.

Source: Own elaboration based on Highsmith, 2005; Paulsen, Maldonado, Callan, Ayoko, 2009) Al-Ali, Singh, Al-Nahyan, Sohal, 2017.

A special source of changes are those that result from the desire for self-development. Change management involves making decisions about the best, effective use of one's physical, capital and human resources to accomplish specific tasks (Mayle, 2006).

When changes result from the desire to improve or develop the organization, they are usually more widely accepted, arousing less resistance among employees, than those resulting from changes in the broader environment (Sońta-Drączkowska, 2018).

It should be remembered that the goal of change management in an enterprise is not only to introduce change effectively, but also to constitute it regardless of its source. As there are many sources of change, there are also many scenarios for dealing with it. After all, implementation should be adapted to the structure of the organization, the nature of the change, the needs of the company or even the time available.

Among the sources, the impetus for change in the organization is a business concept - reengineering. This is a special type of change in a company, as it involves making radical changes to business processes. The goal of the changes is to achieve maximum efficiency of the organization and reduce costs. Business Process Reengineering, due to the agility and comprehensiveness of its course, requires a lot of attention, knowledge, commitment and often expert support (Orridge, 2009). However, its effects contribute to a significant increase in the

competitiveness of the company in the market. The main objectives of reengineering include (Tidd, Bodley, 2002):

- increase in efficiency,
- increase in competitiveness,
- reduction of costs (general running of the business and/or individual departments),
- increase in the quality of manufactured products or provided services,
- improvement of customer relations, increase in the quality of customer service.

The process of reengineering, i.e. the implementation of specific organizational changes, is therefore similar to the process of change management, but its ubiquity in the enterprise and forward-looking intent should be noted:

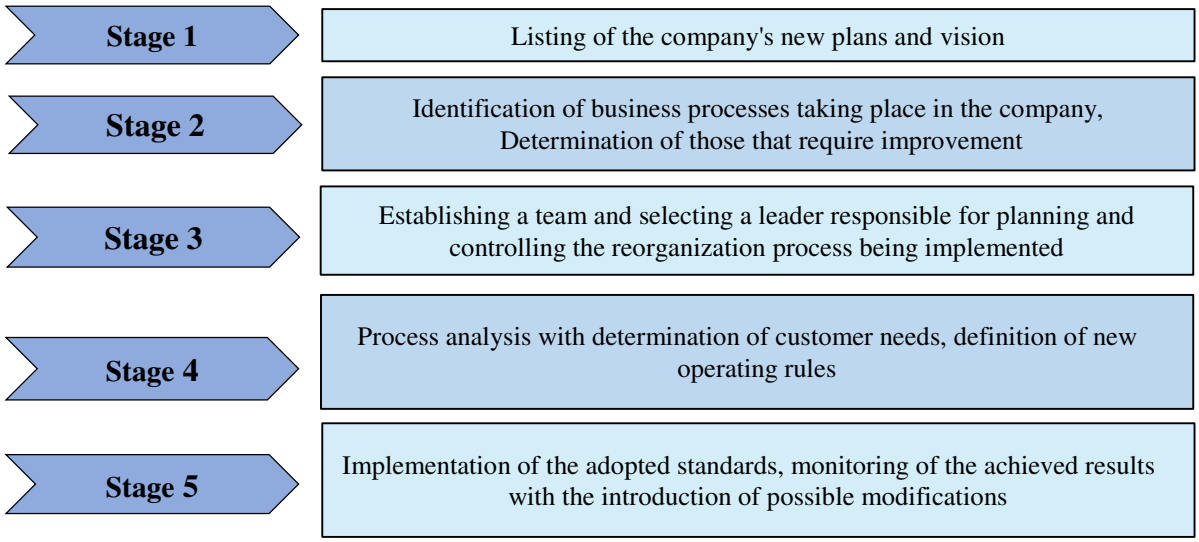

Figure 2. Reengineering – the process of implementing strategic changes.

Source: Own elaboration.

However, it cannot be overlooked that reengineering also involves a very high risk for the company. The most common risks include (Salerno et al., 2015):

- resistance to change, boycotting ideas,
- downsizing which results in dissatisfaction, may lead to late revealed deficiencies in employee skills,
- uniqueness of the enterprise, there is no way to predict the exact course of the process, each organization and change is unique.

Seeking opportunities for change and adapting to a turbulent environment is the impetus for change in any thriving organization. However, change is a process that must be managed. Change should be led by a leader who will not only implement it efficiently, but also perpetuate it. A leader who will see change as an opportunity to develop, improve, increase efficiency in operations, and not as an unpleasant chore.

Change management is a process that demonstrates the maturity of an organization. Readiness for change, willingness to seize opportunities and agile response to threats allow a company to survive and to grow. Change can in many cases be considered synonymous with innovation. Hence, it is worth quoting after Krzywicka-Szpor (2020) the division of change into:

- structural changes - changes in functional, overall scope,
- cost reductions - elimination of unnecessary activities, more efficient use of resources,
- process changes - changes within the selected process, improvement of its course,
- cultural changes - changes within the organization's culture, values, organizational environment.

Knowing the type and characteristics of the change and the expected result, it is necessary to prepare for the process of implementing and managing it effectively.

Proper management of the change implementation process is a fundamental factor that determines the success of the entire operation. One major factor that disrupts the process is employee resistance to change. Therefore, the basic condition for change is correct diagnosis. That's the reason for the proposal to expand the process into further phases.

The model presented below focuses more on the nature of the organization itself. This is because the process begins with the identification of its needs, the exploration of opportunities and the establishment of goals.

Management does not follow ready-made schemes or scenarios. Each entity studied makes changes around its system. However, change management should always lead to the previously assumed results of the change, which is why correct diagnosis is a basic prerequisite for change.

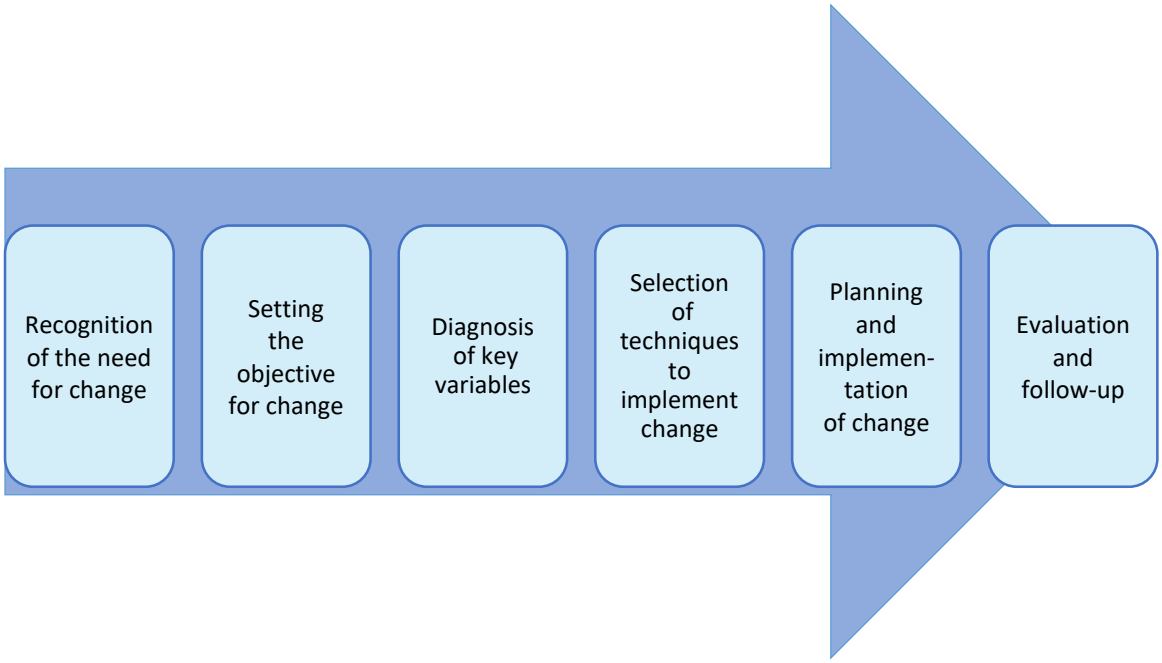

Figure 3. Stages of the change implementation process.

Source: Own elaboration based on Serrat (2020).

A common mistake in the change implementation process is to skip the final step. Failure to cement the change can lead the organization to revert to old habits before long. Lack of evaluation and feedback will discourage future efforts to implement further changes.

In conclusion, the change implementation process is fraught with risk. When managing change, one must be prepared for various adversities and turbulence. Anticipating difficulties, preparing for them in advance will enable quick and effective responses to them. And once implemented, the change should be consolidated and become the beginning of the next stage of self-development.

Ineffective change management in the company will not produce the desired effects, resulting in a negative impact on the operation of the company. It may prove to be unnecessary effort and high cost. It can also lead to strained relations among employees and their dissatisfaction. Incorrectly implemented change in the future may result in increased resistance among the team to make further modifications.

It is worth noting that in today's competitive market, making changes in companies is mandatory. New products, solutions, strategies, computerization and automation require rapid and efficient implementation of changes. What is more difficult is that the rapid pace of these changes in the environment requires a virtually flawless response to them. Failure to keep up with the needs of modification can result in a company's failure to survive in the market (Okoń-Hordyńska, 2010).

Effective change management not only takes into account the requirements of the organization's environment, but also its characteristics and culture.

Effective change management must be linked to the competencies of the leader, his or her ability to lead. The leader's task is to examine the attitudes of the workforce and respond appropriately to their concerns. The leader should properly mobilize employees, prepare them substantively to implement new solutions. Employees should feel that they are participating in the implementation of the change, that they are understood, that they can share concerns and ask for support at any stage (Kopczyński, 2014).

The following figure may be helpful as it shows the successive stages of implementing the change in relation to the leader's message to their team members.

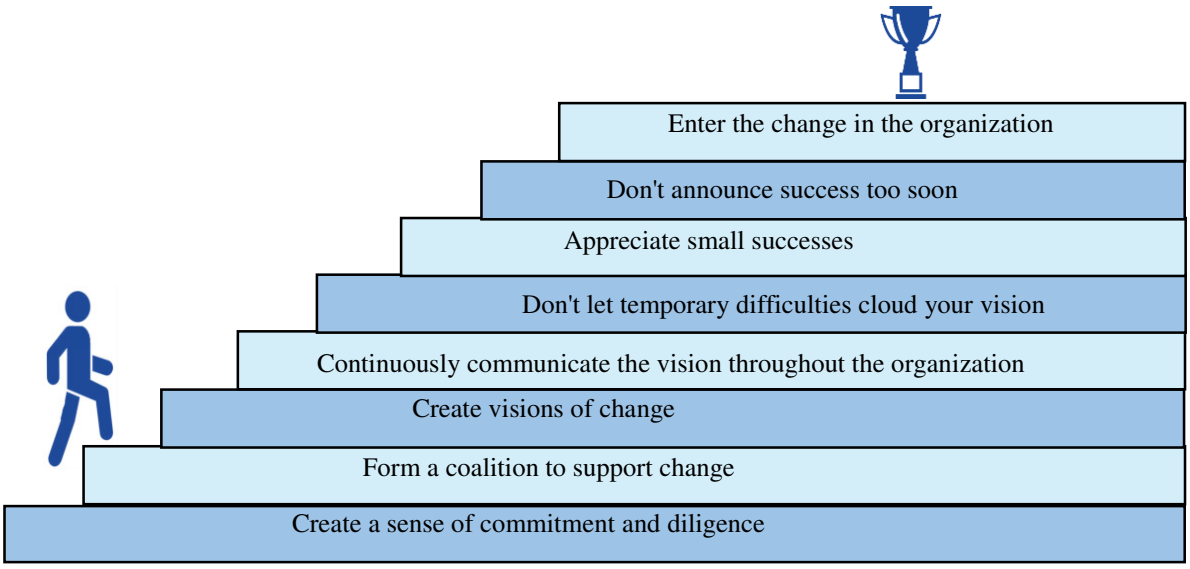

Figure 4. Model for change.

Source: Kotter (2012).

The following most important guidelines have been collected to indicate recommendations for change management practice:

1

Communication and more communication - ensuring a proper information flow system is key to implementing change. Employees must have quick access to up-to-date information provided by authorized persons, and not learn about planned changes through rumors. It should be remembered that it is what is new and unknown that causes the most anxiety. Warning employees about the planned change, presenting the stages of its implementation, allaying fears will result in employee involvement and greater understanding in the event of errors or difficulties.

2

Motivation - designing a motivation system for people who will support the change management process with their attitude and commitment. Motivation should also be based on identifying and rewarding change leaders who, with their optimism, inspire other employees to be active in the change process. Motivation is nothing more than the promotion of behavioral patterns such as openness, creativity, fierceness, desire to improve.

3

Vision of change - creating a document that will synthesize the change. As many employees as possible should participate in its development. The development of the document will help convince employees of the benefits and the need for change. The vision of change should be understandable and acceptable.

4

Team - leaders of change, a group of people who will lead the change. These professionals should have the right qualifications and character. They should inspire action. However, they themselves need support, providing the necessary resources and authority.

5

Delegation of authority and power - change leaders, those responsible for implementing the change should have the tools and authority to lead employees. They should have access to resources, most importantly information. Delegation should go all the way down to the lowest ranks of the organizational structure. Employees involved with the change, being part of the change process, will more easily emphasize it and make an effort to its implementation.

6

Positive attitude - employees should be infected with a positive thinking style, an open attitude. Change should be associated as something good, providing opportunities for development, the prospect of a great future.

7

Following the example - when outlining the vision of change, creating an open attitude of employees, it is worth using positive examples from the past. It is necessary to present positive aspects of change, its important results, It is worth showing that change is a challenge that has already been taken more than once and turned into a success for the organization.

Following the principles presented, it is important to remember that each organization has its own characteristics and culture. The implementation of change should be tailored to it, and the right selection of the team leading the change will be the key to success.

3. Research methodology

The research initiated aims to identify the key characteristics and competencies of a change leader that enable him or her to effectively implement innovative solutions.

The pilot research stage has now been completed, involving leaders implementing innovative projects subsidized under Priority Axis I Innovation In The Economy, Measure: 1.1 Innovation In Businesses. Enterprises in the Opolskie Voivodeship received support for the implementation of innovative solutions as part of the call for proposals organized by the Opolskie Centre for Economy Development.

Some of the project leaders (24 out of 126) implemented between 2016 and 2020 agreed to take part in the researches. Due to the number of people participating, but also the detailed and specific nature of the research, it was decided to use a personal interview for the pilot study. The leaders were selected according to 3 criteria:

- diversity criterion - the leaders represent different industries,
- diverse types of innovative solutions - product, process, organizational,
- the criterion of data availability - the leaders had to express their willingness to participate in the research.

The following data sources were used in the research: available domestic and foreign literature, available documentation of the surveyed companies and the results of interviews. In the next stage, the research will be complemented by participant observation in individual organizations, which will allow an in-depth examination of team-leader interactions and elements such as, culture, communication, work environment, creativity development.

It should be noted, however, that already after the first stage of the research, interesting conclusions and recommendations can be drawn, which will be presented in the article (Fig. 5).

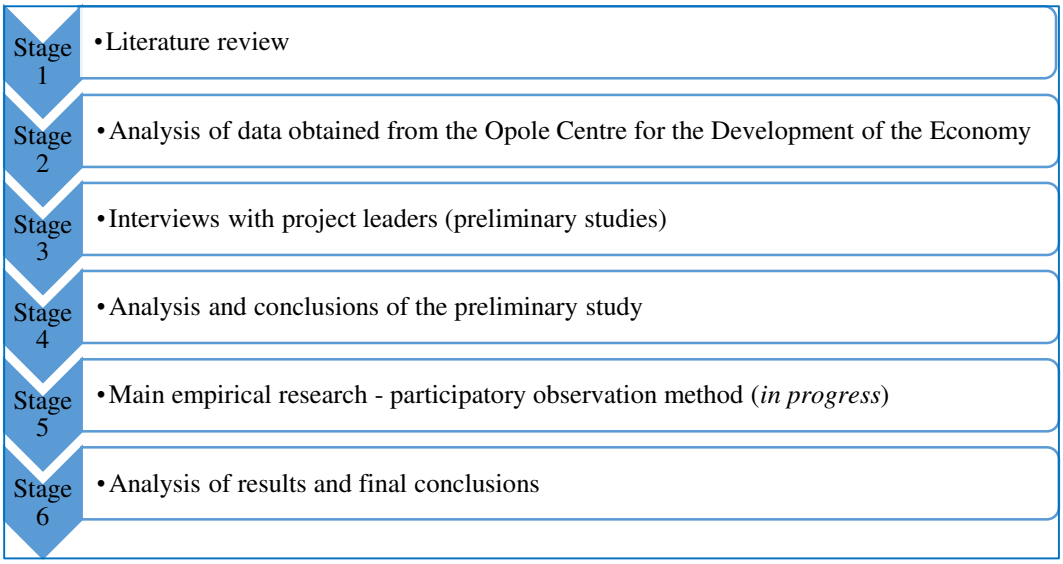

Figure 5. The research scheme.

Source: Own elaboration.

4. Research process

Interviews with individual project leaders lasted between 2 and 3 hours. To structure the interview process, main and auxiliary questions were prepared. Special attention was paid to the leader's freedom of expression, insights, emotions, personal reflections.

Main questions

1. What is your experience in implementing projects, especially innovative projects?
2. Where did the idea for the innovative solution come from?
3. what are the main success factors in innovation projects?

4. What are the main risks in the process of designing and implementing an innovation?
5. Which character traits of a leader are most important in the implementation of innovation projects? What competencies, education, experience should a leader in innovation projects have?
6. How did the leader-team communication work?
7. How do you overcome resistance, encourage employees to implement change and innovation?
8. What should be done, what methods should be used when conflicts arise?

Supporting questions

1. What other ideas have been analyzed related to the implementation of innovative solutions?
2. What sources of innovation would you identify as the most valuable and why?
3. List, describe difficult situations, emerging problems during the implementation of the innovation project.
4. Which of your competences and qualities proved to be crucial during the implementation of the project? Give examples.
5. How did the team communicate - describe. Was communication always effective? If not, what were the most common noises?
6. Describe an example of the use of motivational tools. Were they effective?
7. Describe situations of employee resistance to change. How did you deal with it?
8. Characterize an example of a conflict situation in a team. How did you deal with it?

Analysis of the results

All participating project leaders showed commitment and professionalism. They justified their statements with examples. Each of the leaders had more than 5 years of experience in project implementation, only 9 of them had previously implemented innovations.

As a source of ideas for innovations, they indicated mainly the organisation's own resources: research departments, employees, business owners and management.

Only in two cases did the idea come from consumers. Importantly, consumers were not later involved in the product design process itself. Demand-side innovations are therefore sporadic in the surveyed group, and it would be worth paying attention to this extremely valuable source of ideas. Innovations implemented according to the concept of user-driven innovation are characterised by lower risk, often also lower costs associated with promotion.

In their statements, the leaders paid particular attention to the coherence of the concept, adaptation of solutions to current trends and customer types. Among the main success factors, they mentioned: speed and agility, use of new technologies (not only in the innovation itself, but also e.g. in the communication process or promotion), a creative team, openness to change, and a flexible working system.

As main sources of risk, they mentioned above all: bad budgeting (underestimation), faster and more agile competition, mistakes in communication, shortcomings in the competences of team members, incompatibility of the innovation with the client's expectations.

Project leaders unanimously indicated the importance of their role in the team. They stressed repeatedly, the need for authority, charisma and strong intrinsic motivation.

Among the key qualities a leader should possess, they mentioned: interdisciplinary knowledge, speed of learning, experience, communication skills, seeing connections and relationships (between people, events), strategic thinking, adapting to change, flexibility in action, energy.

In addition, leaders mentioned empathy, openness, creativity as some of the important personality traits.

None of the leaders indicated the need to have a degree in a field, but the need for continuous development was emphasized.

The topic of communication was the most widely discussed issue. It was adapted to the team members, the situation. Interestingly, in 19 cases virtual communication tools were used in addition to traditional communication. Leaders unanimously pointed out that communication became easier with the duration of the project, there was less noise.

The following were identified as communication noises: language problems related to working in international teams, inactivity of some team members (especially in online meetings), intergenerational differences.

Attention was also drawn to the different working styles and priorities of team members, which not only hindered communication, but contributed to conflicts.

The most common situations of conflict and so-called employee resistance to change are collected below. In the statements of the leaders, these situations were combined and intermingled, hence the collective compilation.

Table 2.
Dysfunctions in the team

Reasons for conflict and resistance	Methods of proceeding
inconsistency between the manager's vision and the employees' vision	strategy building workshop, reminder talk on project plans, objectives and targets
miscommunication, failure to pass on information	removal of communication noises, reminder of rules related to the communication process, exercises on effective communication methods, team integration
a feeling of unequal sharing of responsibilities	participation of team members in the distribution of tasks
inaccuracy of task performance	reminder of team rules, warning, no bonus, disciplinary conversation
a feeling of favoritism towards employees	participation of team members in the division of tasks and decision-making, frank discussion
gossiping	admonition, confrontation
miscommunication, transmission delay	use of new tools to support the communication process, removal of communication noises, reminder of rules related to communication

Cont. table 2.

lack of empathy and understanding	integration of team members
failing to see the bigger picture, "focusing on oneself", not understanding the principles of teamwork	co-creation of team rules, integration, discipline talks
negative attitude towards new solutions	demonstrating the benefits of new solutions, training, creating a support team - leading change
short term, template thinking	creative sessions and training
time pressure	incentive bonuses, flexible schedules, modern tools to support work

Source: own elaboration.

The study preliminarily showed the importance of the role of the leader in the process of implementing innovative solutions. It should be noted that the conclusions are based solely on the feelings, experiences of the project leaders. Hence, it is necessary to expand the research by observing the performance of entire project teams.

5. Summary

Implementing innovation projects requires team commitment, flexibility and speed activities and a charismatic leader. It is the leader who carries out the management functions, in particular inspiring and motivating the team members. He or she creates a shared vision, strategies, team cohesion. He is the inspiration for the creation of new concepts. Leadership is a success factor towards building a permanent change in the environment and operating culture.

A leader should both promote and enable change. He or she should motivate employees, ensure that they understand the need for change and the benefits of continuous improvement. Example from the top has a positive effect on creating a sincere desire for change. The last task is to provide opportunities, needed resources such as time, tools, access to knowledge.

The research carried out was aimed at outlining the characteristics of a change leader, creating a catalogue of competences that he or she should possess. They are an excellent introduction to further extensive research on the role of the leader in implementing innovative solutions. They provide a rationale for creating a learning or development programme for change leaders, the future.

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MANAGEMENT OBJECTIVES AND CAPITAL EQUILIBRIUM IN MUNICIPAL COMPANIES

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Purpose: This study aims to present the research findings regarding the final stages of a new concept for managing municipal companies. The need for a new management concept for municipal companies arises from the ever-present dilemma that managers face, torn between the commercial nature of the company and its responsibilities related to public utility and improving residents' lives.
Design/methodology/approach: In contrast to the previous concept, the research described in this article focuses on a modified and simplified version of capital equilibrium developed within the past year and based on a point system. The previous concept, which the authors piloted in municipal companies in previous years, was based on a rather complex and labor-intensive valuation of specific capital components in monetary terms to balance them. The study was carried out in eight municipal companies using a research tool—a point-based questionnaire about the state of their capital. A description of the methodology used and the study's findings is preceded by a review of the current knowledge and papers related to previous attempts to implement the concept in previous years.
Findings: The study's results indicate that managers correctly assess the capital levels, which is a prerequisite for implementing the concept. However, several conditions may hinder its implementation in some companies, the most significant being the issue of limited knowledge about the company's capital.
Originality/value: This concept combines the achievement of mandatory management objectives in municipal companies in Poland (effectiveness) with capital balancing (efficiency) and offers an alternative to the widely used profit-driven approach. Primarily, the goal is to find an alternative to the outdated profit metric, which has become a management objective in these companies due to recent changes in legal regulations, leading directly to increased fees for water, sewage, thermal power, waste, and transportation.

Keywords: management objectives, municipal company, capital equilibrium.

Category of the paper: research paper.

Introduction

One of the fundamental problems that municipal company[1] managers encounter there is a specific dichotomy when it comes to making decisions based on two distinct regulations that regulate the operation of these entities and their strategies for carrying out their missions. One of these regulations is the Act of 1996 on Communal Economy (Act, 1996), which stipulates that these companies generally undertake tasks of a public utility nature[2].

The concept of "public utility" was defined in the 1990 Act on Local Self-government (Act, 1990), which specified that public utility duties, as defined in the law, are the inherent responsibilities of municipalities that seek to continually satisfy the public's needs through the provision of services that are accessible to everyone. In the literature, public utility is defined in various ways, but most authors tend to highlight a shared characteristic: the absence of a profit-oriented approach (Pyziak-Szafnicka, Płaszczyk, 1997). From this, it can be concluded that a company's goal should be to improve the accessibility and quality of services offered to improve the quality of life for citizens and the operation of businesses, with less emphasis on making a profit. On the other hand, municipal companies, like all other commercial companies, are subject to the provisions of the Commercial Companies Code, which does not differentiate municipal companies from other commercial entities. These companies typically operate in competitive markets and aim to generate profits. The Commercial Companies Code does not mention public utilities, and the most common form of municipal company, such as a limited liability company (sp. z o.o.), can operate for any legally permissible purpose (Act, 2000).

In the early stages of Poland's transformation, there were ideas aimed at preventing future conflicts by creating "public utility companies" from former public utility enterprises operating under the State Enterprises Act (Act, 1981) or by introducing a new legal form called a "municipal company" to the reactivated 1934 Commercial Code in 2000 (Act, 2000). However, these initiatives remained in the project phase (Klimek, 2017). Establishing distinct legal structures for municipal companies that would not be solely driven by profit as the primary criterion for their operations continued to surface in later years within academic discourse (Bachor, 2009). Notably, scholars like E. Wojciechowski from the University of Łódź advocated for the practicality of creating an intermediary legal framework that bridges the gap between a budgetary institution and a commercial enterprise. Furthermore, auditors from the Supreme Audit Office (NIK) consistently highlighted the inherent tension between the duty to address societal needs and the imperative of profit maximization, emphasizing that "a municipal enterprise may either generate profits at the expense of its residents or, conversely, be perceived as inefficient even when effectively meeting their needs" (Challenges, 2015).

[1] In Polish law, there is no specific definition for a municipal company. Therefore, for this research, it has been assumed that a municipal company is a company in which one or more local government units hold 100% of the shares or stocks.

[2] The performance of tasks of a public utility nature can apply to only some municipal companies. According to the law, separate municipal companies operate outside the sphere of public utility. See: Wronkowska, 2015, p. 117; Rakoczy, 2010, p. 27.

In 2016, a fundamental change occurred and municipal companies could finally define and pursue their management objectives, not necessarily based solely on profit. In the Act of June 9, 2016, on the principles of remuneration for persons managing certain companies, it was specified that the total remuneration of members of the management board of, among others, municipal companies consists of a fixed part, which constitutes a monthly basic remuneration defined in a specific amount, and a variable part, which serves as supplementary remuneration for the company's fiscal year. The variable portion of the remuneration depends on the achievement of management objectives (Act, 2016). It is worth mentioning that the new law's provisions at that time applied to a significant number of entities. Besides state-owned companies covered by the provisions of the law, as of December 31, 2015, Poland had 2324 limited liability companies and 273 joint-stock companies in which local government units held shares or stocks, respectively (Information, 2016). To facilitate the founding bodies of these companies in formulating management objectives, the legislator, in Article 4(6) of the law mentioned above, provided examples of management objectives applicable to entities covered by the law. These objectives could include, in particular: 1) an increase in net profit or profit before interest, taxes, and depreciation, or a positive change in the growth rate of either of these; 2) reaching or changing the amount of production or sales; 3) increasing revenue value, especially from sales, operational activities, other operational activities, or financial activities; 4) reducing losses, lowering management or operating costs; 5) implementing a restructuring strategy or plan, 6) reaching or changing specific indicators, especially profitability, financial liquidity, management efficiency, or solvency; 7) implementing investments, taking such factors into account as the investment's scale, return rate, innovation, and timeliness; 8) Changing the company's market position, which is measured by market share or other criteria, or its relationships with key counterparties as defined by certain criteria; 9) implementing human resources policies and increasing employee engagement.

Between 2017 and 2018, a significant number of municipal companies published (on their websites) their founding bodies' resolutions containing management objectives, making it easy for researchers to access this data. In 2018, one year after the law mentioned above was passed, investigations into the management objectives of 103 municipal companies yielded the following conclusions:

- Only seven out of 103 municipal companies examined did not mention profit as a criterion for assessing the board's or the company's performance.
- Among the 484 management objectives across these 103 companies, there was a clear dominance of financial goals (over 53.5%), primarily related to profit, revenue, or costs. There were fewer concrete goals, most of which were related to development or investment plans (over 31.0%), and very few social goals (15.5%) that directly helped improve the quality of life for residents.

- The highest number of economic objectives, including profit, was observed in municipal companies in the following sectors: municipal waste (70.0%), healthcare facilities (60.0%), public transportation (55.6%), and water supply and sewage (55.6%). The fewest were found in social housing companies (23.0%), with varying numbers of objectives. For example, there were ten objectives in Radom Airport and only 2 in the Pomeranian Special Economic Zone.
- Management objectives were copied directly from legal provisions in nearly half of the companies examined. Although this might not be a problem if the objectives were appropriate for each company, concerns were raised because the same management objectives were repeated across multiple municipal companies in a single city, regardless of their industry, size, or probably different economic situations and investment needs (Klimek, 2018a, 2018b, 2019a).

Our examination of management objectives revealed another issue: competing objectives. Before implementing the new law's provisions, many municipal company directors were adept at balancing public utilities and the Commercial Companies Code. They undertook actions that, in addition to generating profits, at times included tasks that were not necessarily associated with beneficial profitability (such as building sewage systems in sparsely populated areas or launching bus routes in rural areas) but aimed at improving the quality of life for residents and the working conditions for local businesses. However, when the new management objectives require the company's board of directors to, for example, increase service accessibility by increasing revenue while simultaneously decreasing costs, it may not always be feasible.

These issues prompted us to seek an alternative approach to managing municipal companies that would reduce the conflict between the public utility and commercial nature of these companies. The primary goal was to eliminate profit as the primary objective of municipal companies. This alternative approach is called "sustainable capital management", which combines capital balancing (efficiency) with the achievement of management goals (effectiveness). After conducting pilot studies in several municipal companies, this new concept was first described in a paper in 2019 in Polish (Klimek, 2019b) and in 2020 in English (Klimek, 2020).

The concept of capital balancing draws on several scientific theories and methods. One of its foundational elements is undoubtedly the systemic approach, which emerged and developed in science in the 1950s and 1960s. The essence of this approach is to treat the objects being studied as sets of interconnected elements in such a way that they form a new whole, distinguishing it within a given environment. Additionally, the theory of resources and competencies played a significant role, suggesting that a company's strength primarily arises from its people's knowledge and technological potential. Equally important were the following concepts: 1) the concept of corporate equilibrium, developed as part of the Anglo-American supply theory, 2) the notion of intellectual capital, which argues that a company's human resources are just as necessary as its physical assets like buildings, machinery, and cash,

3) the theory of social capital, whose comprehension and, more significantly, the development of techniques for measuring it, were essential for the development of the proposed approach.

Furthermore, the concept shares much in common with the well-established literature and managerial practice of several decades, known as Management by Objectives (MBO). This approach involves building a cohesive set of objectives for all units and participants within an organization and assessing their achievement level.

While developing the concept of capital balancing presented below, we shared the views of H.A. Simon, who significantly contributed to changing how we understand rational thinking in human activity. This shift moved away from the notion of a person with unlimited computational abilities who comprehends all available decision options and maximizes all utilities toward the idea of decision-making processes based on "satisficing" rather than optimizing, guided by imperfect rules. For companies in particular, Simon argued that it is reasonable to assume they strive for satisfactory solutions rather than maximizing, or, in other words, they aim for outcomes that are good enough but not necessarily the best. Simon's theory of bounded rationality has been further developed not only by Simon himself but also by other behavioral economists and theorists (Simon, 1957, 1959, 1979; Cyert, March, 1963).

The new concept of capital balancing represents an ongoing process aimed at attaining one or more objectives while simultaneously maintaining equilibrium among the various forms of capital within an enterprise. This entails striving to ensure that the value of each capital type approaches an optimal level while preserving the proportional relationships among these capital forms. The effectiveness of an enterprise is measured by its ability to achieve its predetermined goals successfully. At the same time, efficiency is associated with the ability of managers to rapidly approach a state of equilibrium between current capital levels and their ideal states. It is essential to maintain this equilibrium across all types of capital for an extended period. It is worth noting that managers should recognize that the effectiveness of achieving objectives and capital equilibrium often present conflicting demands.

Therefore, an enterprise's primary task is to achieve strategic and operational objectives with the highest possible efficiency, defined as the pursuit of equilibrium. In other words, when pursuing its goals, an enterprise should be practical and, at the same time, strive for equilibrium among its various forms of capital (physical, structural, financial, market, human, social, and possibly natural). This equilibrium can be understood in two ways:

1) as the difference between each capital's current value and its target value for a specific period, as specified by the objectives, or
2) as the disparity between different forms of capital (all forms of capital interact with each other, but not equally and with the same strength).

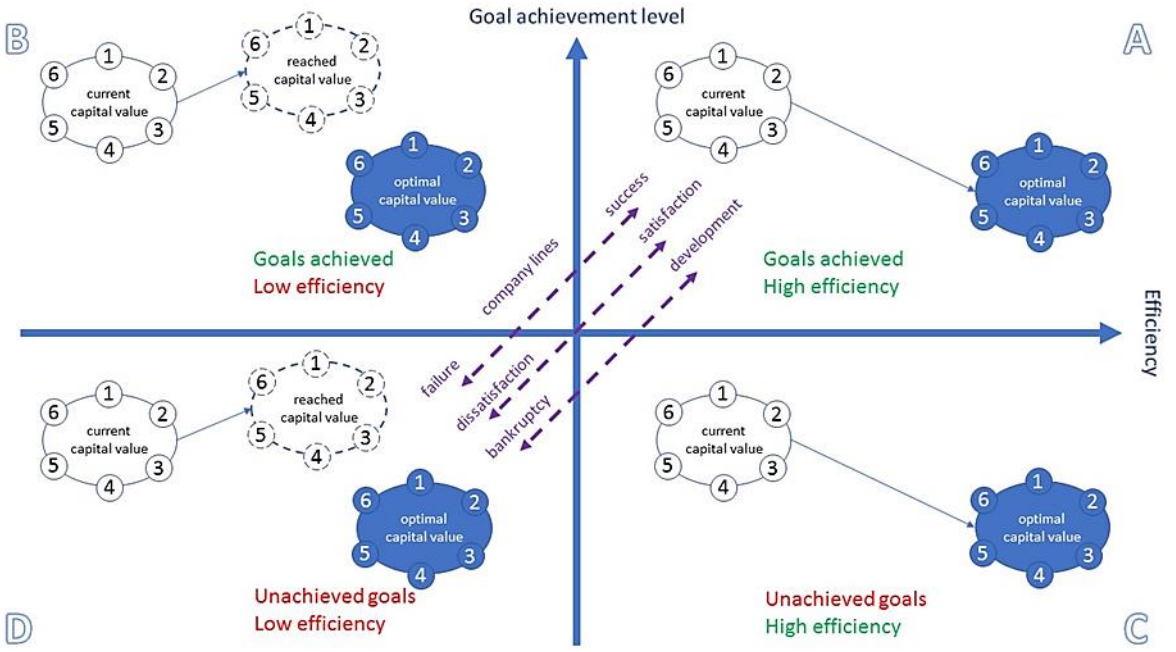

Figure 1. Zones for goal achievement level.

Source: Klimek, Jędrych, 2021.

The most effective management outcomes occur when a company is in zone A, achieving its goal(s) via the highest concentration of capital (physical, structural, financial, market, human, and social) (Figure 1). Zone B represents a situation where the company achieves its goal(s), but its efficiency is low (low capital balance). Failure to align capital levels can result in underutilization (waste) and unnecessary costs. It is vital to remember that while the underutilization or misutilization of physical and structural capital is quite visible, the underutilization or misutilization of market and financial capital is also visible but tends to receive less attention during the management process. The worst scenario, though, occurs regarding social and human capital. These are often referred to as hidden capital and are rarely measured, and managers usually receive only incomplete or incidental information about them. Zone C could appear less favorable (depending on the company's strategy and ownership priorities) than Zone B because, even though the business is effective (its capital is balanced), its objectives still need to be met. This hampers the company's development, not to mention the legal, financial, or staff-related consequences associated with failure to achieve goals. Zone D has the worst circumstances. It denotes both poor capital efficiency and failure to meet objectives. As a result, it not only symbolizes failure but also has the potential to lead to a crisis or even bankruptcy. Finding a company in this zone undoubtedly indicates that significant changes are needed.

These two terms, effectiveness (in achieving goals) and efficiency (balancing capital), are fundamental principles that every manager should follow. When achieved simultaneously, they lead to success, satisfaction, and the company's development. In reality, this implies that the decisions made by managers and the business's financial standing will be evaluated based on effectiveness (the degree to which goals are met) and efficiency (the amount of equilibrium between the company's capital).

A balance between a company's capital should never be equated with equal monetary value; balance usually occurs between capitals with varying values. Sustainable management is not only about balancing various forms of capitals but also between capitals and goals. In other words, when setting goals, it is essential to consider to what extent achieving these goals will create an imbalance in different capitals and whether it is possible, at what pace, and with what effort and resources to balance the capitals while attaining goals.

For this concept, two new metrics have been developed: the average percentage difference of capitals and weighted capital differences. These coefficients range from 0 to 1 and provide insight into whether the company is proceeding in the intended course and how close it is to accomplishing its objective of an ideal capital distribution. Balancing capital aims to achieve the most efficient utilization of the company's resources.

2. Methods

The tests to implement the sustainable capital management approach in several companies in Poland conducted in 2018–2021 have shown that it can be implemented (Jędrych, Klimek, Rzepka, 2021). However, the tests have also pointed out numerous factors that can hinder its implementation in specific instances. In addition to managers' lack of knowledge of capital, which was expected at this point in the study, the pilot studies showed that putting the concept into practice takes time. It calls for immediate assistance from outside professionals and, without developing a software program (an app), is practically impossible to implement for the present management requirements. The most significant problems were related to the valuation of individual capitals (Jędrych, Klimek, 2018a; Klimek, 2018c). The current valuation techniques proved overly complex, requiring them to be modified. Another significant area for improvement was the imprecise nature of valuation techniques and how valuations can be compared over time. Internal social capital raised questions regarding the validity of the responses given (as long as no outside interviewers were involved and employees were not given assurances that their opinions were anonymous), as well as the fact that nearly every comparatively straightforward question required a detailed explanation by the interviewer, especially among production workers (Jędrych, Klimek, 2018b; Jędrych, Klimek, Rzepka, 2022).

This led to the development of a simplified capital balance system. The primary distinction is the shift from a thorough monetary evaluation of individual capitals to a point-based evaluation of their levels. The approach allows for significant flexibility, and the process of such assessment may vary from one company to another. The basic framework for implementing the simplified method should include:

- Determining annual management goals for the company by the founding body and possibly long-term goals. This action may involve collaboration with the management team, where the mayor or city council approves the goals developed by the management and reviewed by the company's supervisory board. It's essential that these goals are measurable and attributed to specific capitals: physical, structural, financial, market, human, and social. Within each capital, there can be multiple goals, or there may not be any, but for balance, it is desirable to identify at least one goal within each capital. Goals should be assigned weights in accordance with legal provisions, although these weights are not of significant importance for management purposes. However, they are necessary for determining the remuneration of the company's management.
- A point-based assessment of the level of individual capitals carried out by the management and approved by the supervisory board. These evaluations should be performed with regard to the current level of each capital and the target level of capitals derived from the established goals. Double evaluation occurs only in the initial year; the level of capital achieved in the year before becomes the starting level of capital in the year after. Knowledge in this regard is crucial for the proper capital balancing process, and a subsequent section of the article is dedicated to exploring this aspect.
- A point-based assessment of the level of individual capitals by the management and approved by the supervisory board following one year of operation. It is crucial because the capitals level determines the degree to which management objectives have been met, which serves as the basis for the variable component of the company management's remuneration. These assessments can be conducted more frequently to meet present needs as they do not require extensive and costly measures.

One of the fundamental prerequisites for carrying out capital balancing in management is knowledge about the levels of capitals, which enables a proper assessment of their current condition. The results described below pertain to the study's final stage before training and implementing sustainable management principles in a simplified form in selected municipal companies. The study focused on the knowledge of municipal company managers regarding the levels of individual capitals. The study results answer the query if it is possible to apply the principles of sustainable management in practice without significant external help from experts.

The study was conducted in eight selected municipal companies located in the Mazowieckie, Łódzkie, and Śląskie voivodeships. Each of the businesses was medium-sized, with between 115 and 340 employees, operating in one or several municipalities, and representing various industries including water supply and sewage, heating, public transportation, and municipal waste management. Three of them were multi-industry businesses covering several different sectors of municipal business in the cities they served. The study consisted of four stages:

1. Defining the components constituting the various capitals of a municipal company (physical, structural, financial, market, human, and social) and establishing the criteria for assessing the level of these capitals. At this point, particular focus was placed on the fact that municipal companies have unique characteristics compared to other economic entities, which significantly impacted how components were allocated to capitals. Differences are often mentioned in the literature primarily based on technical and economic-social criteria. The technical criteria included characteristics such as high capital intensity (especially in network companies like water supply, sewage, and energy providers), technical indivisibility, the inability to store provided services, services being produced, delivered, and utilized simultaneously, a frequent shortage of supplier options, and service substitutability. The technical criteria also included the service-oriented nature. Although it is not a characteristic that is unique to municipal companies, it is worth noting because these companies typically deliver manufactured goods such as water or heat. The service-oriented character is only present in municipal companies in the transportation or funeral industries. According to the socioeconomic criteria, these differences arise from natural monopolies (at least in the case of water and sewage or heating provision) or monopolies imposed by local authorities on specific service providers (e.g., municipal waste management). Additionally, service subsidies are frequently required, primarily for public transportation companies but also often for water and sewage fees (Pyziak-Szafnicka, Płaszczyk, 1997; Byjoch, Klimek, 2015). Finally, nearly all authors point out that these entities are not profit-oriented. In almost every capital, this particularity of municipal businesses is evident. In addition to the previously mentioned points, it is critical to emphasize the distinctiveness of municipal businesses in domains like marketing or human capital. Because of their inherent monopoly status, many of these companies do not focus on marketing capital as intensely as businesses operating in highly competitive markets. However, most of these companies still value their relationships with the community and customers, making this an element of social capital. In terms of human capital, these businesses only serve the neighborhood, and many of their staff members are locals. They frequently spend their entire professional lives with one municipal company, and interestingly, they are also customers of the same company because they live in the regions where it conducts business.
2. The second stage involved experts familiarizing themselves with the condition of capitals and assessing their levels in the eight studied municipal companies. The assessment of capital levels was carried out by four experts who were individuals with significant theoretical and practical experience in the functioning of municipal companies and affiliated with universities in Łódź and Warsaw. The assessment included the levels of six capitals within each company (physical, structural, financial, market, human, and social), with the assessment of social capital focusing only on

external and internal aspects. In the end, each capital in a given company received a single score; there was no average of scores. It was decided upon by consensus during the last evaluation phase and resulted from in-depth discussions among the experts. A conventional rating scale was utilized for the evaluation, ranging from 1 (very low level) to 5 (very high level), allowing for intermediate ratings such as 1.5, 2.5, 3.5, and 4.5.

3. The third stage involved a survey that was conducted among 129 people in eight companies, each of which had 13 to 24 people in top managerial positions (including the president, board members, production director, economic director, chief accountant, department managers, deputy production managers, technical department managers, maintenance managers, procurement managers, financial managers, and human resources managers), as well as 36 people who worked in non-management positions. According to the experts' previous methodology, the six company capitals were evaluated using 8 to 11 criteria. For instance, the level of technology, technical condition, sufficiency in size, and completeness, including the ability to promptly address breakdowns, were considered when evaluating physical capital. The evaluation of structural capital considered things like the organizational structure and information flow, licenses and certificates held, approved tariffs, and the company's information system and security. Marketing capital was assessed based on the customer support system and the company's reputation in the marketplace. Human capital was evaluated based on variables such as the number of employees with the necessary competencies and the system for replenishing knowledge. Three variables—relational, structural, and cognitive—were considered when assessing internal social capital. Two perspectives were used in the assessments of capital levels: the current state of the capitals and the capitals necessary to meet the company's management objectives for the current year. In actuality, the experts and the survey respondents made two assessments for each capital: the current and target levels within a year.
4. The final stage involved the analysis of the gathered information.

3. Results

Figures 2 through 4 show the percentage differences between expert opinions and those of 129 managerial staff members, including the management team (Figure 2), 22 board members and directors who are not board members (Figure 3), and 36 supervisory board members and representatives of local government authorities overseeing the companies (Figure 4). Figures 5-7 show the percentage variations in the assessments of the capital levels the surveyed

municipal companies required to meet management objectives (the target level within one year).

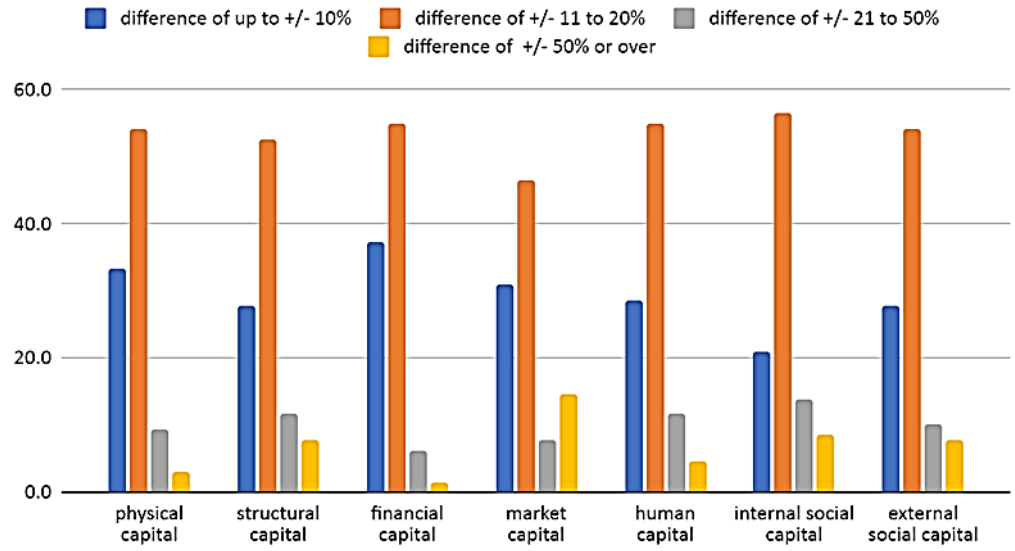

Figure 2. Differences in the evaluation of the present levels of capital among 129 managerial staff members (including the management team) versus the experts' assessment.

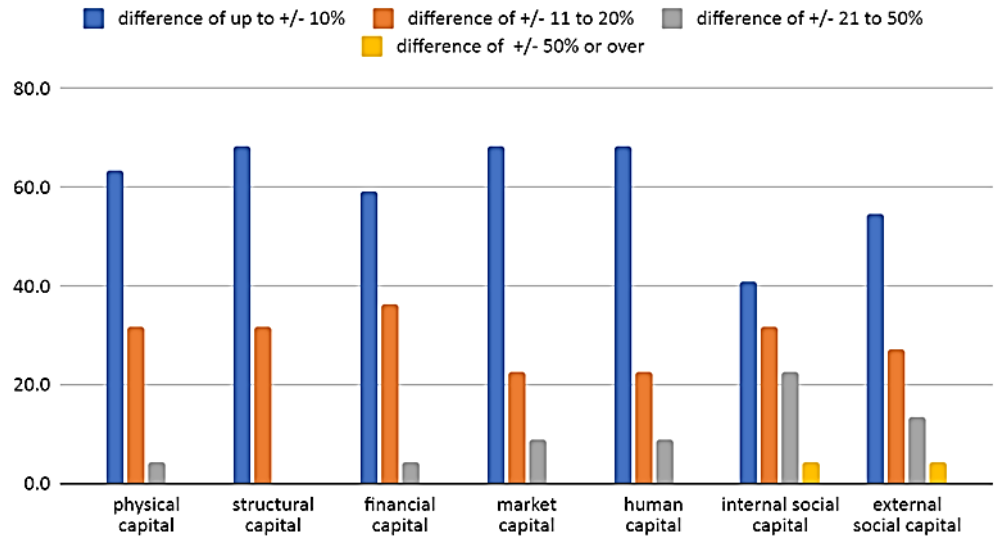

Figure 3. Differences in the evaluation of the present levels of capital among 22 individuals (board members and directors who are not board members) versus the experts' assessment.

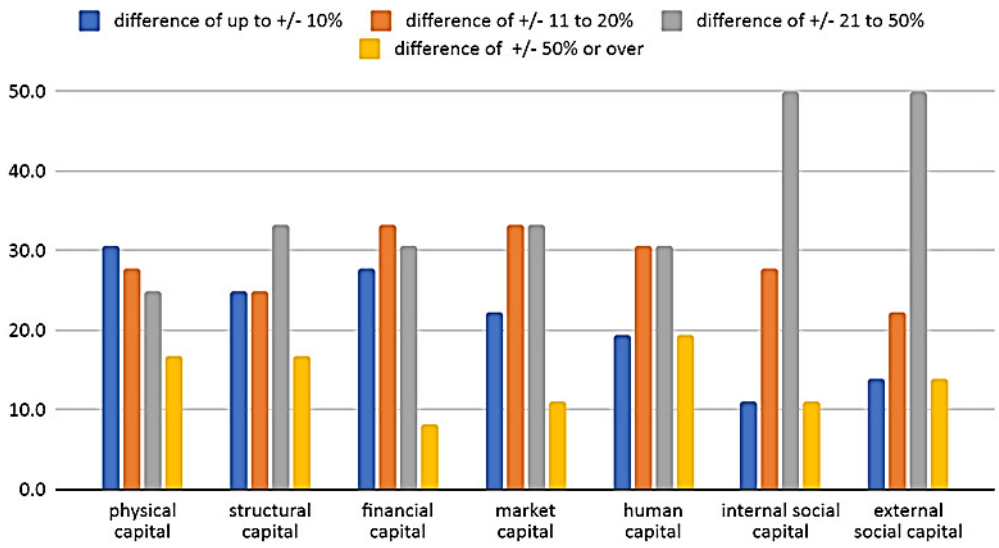

Figure 4. Differences in the evaluation of the present levels of capital among 36 individuals (supervisory board members and representatives of local government authorities overseeing the companies) versus the experts' assessment.

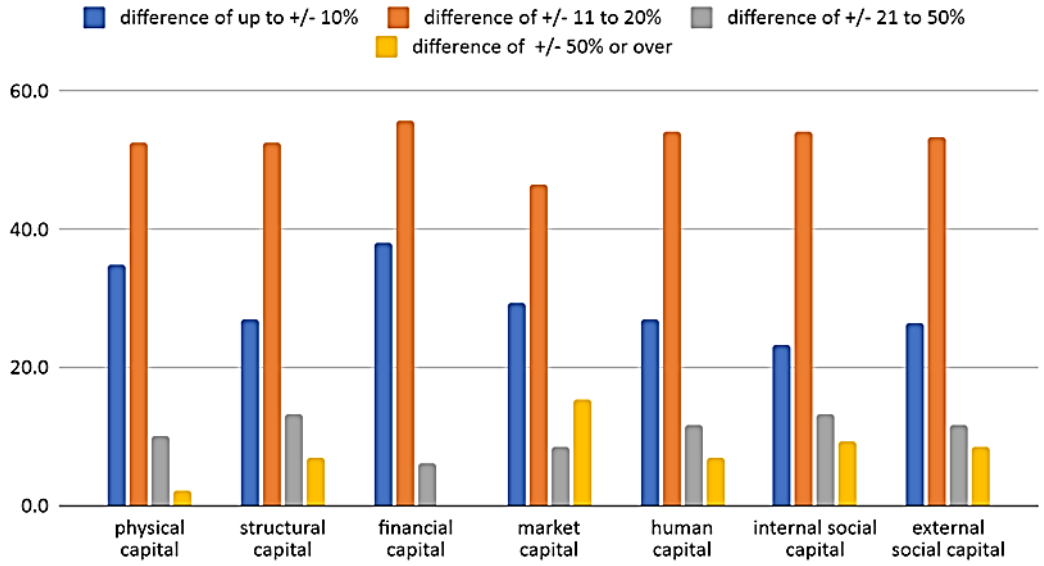

Figure 5. Differences in the assessment of the target levels of capital required to achieve management goals among 129 managerial staff members (including the management team) compared to the experts' assessment.

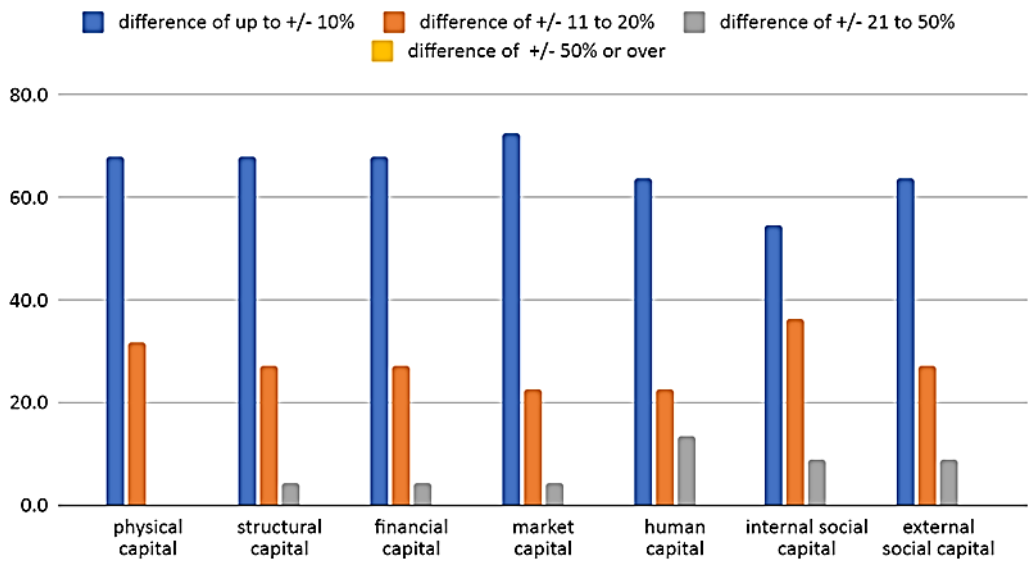

Figure 6. Differences in the assessment of the target levels of capital required to achieve management goals among 22 individuals (board members and directors who are not part of the board) versus the experts' assessment.

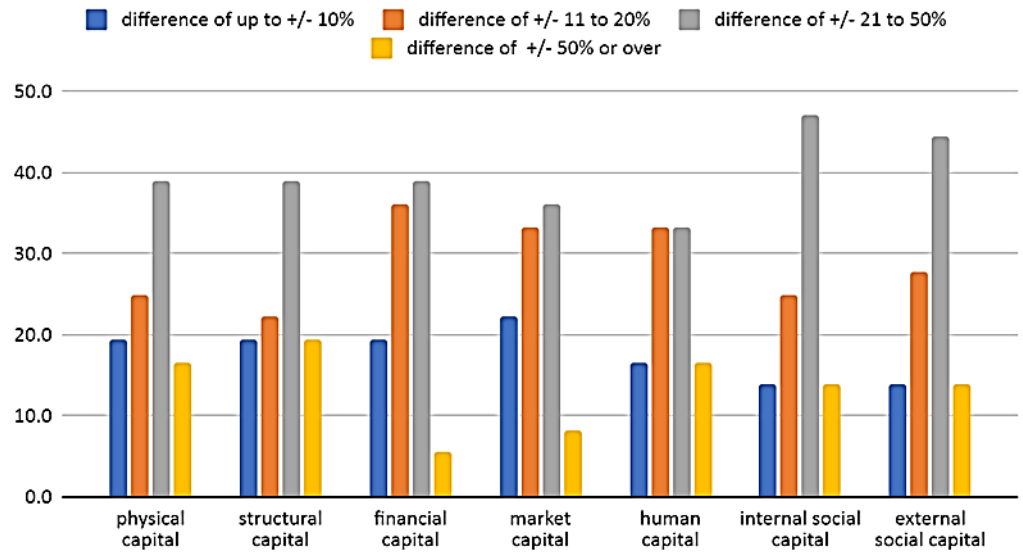

Figure 6. Differences in the assessment of the target levels of capital required to achieve management goals among 36 individuals (supervisory board members and representatives of local government authorities overseeing the companies) versus the experts' assessment.

4. Discussion

The results presented in the tables show that:

- There are relatively few differences when comparing the managerial staff's assessment of the current capital levels to the expert assessment (Figures 2 and 3). This is especially true of top management. For the 129 participants who made up the middle and top management teams, 83.1% of the responses did not deviate more than 20% from the expert evaluation. There was even more agreement between the assessments of the board members and directors (22 people) and the experts. In this case, nearly 90% of responses did not differ by more than 20% from the expert assessment.
- When assessing target capital levels (Figures 5 and 6), these differences rise by about 1% among top and middle management and fall by more than 3% among board members and directors.
- A significantly worse situation exists in the assessment of capital levels in the surveyed municipal companies by supervisory board members and representatives of local government authorities overseeing these companies. In this case, there was a difference of less than 20% in assessments for 50% of current capital levels (Figure 4) and only 46.8% for target capital levels (Figure 7).
- Individual capital assessments revealed differences as well. The surveyed managerial staff (129 individuals) identified financial, physical, human, and social capitals more accurately, but there were more significant differences when assessing market and internal social capital (Figures 2 and 5). More significant differences were observed only in the assessment of internal social capital among responses from board members and directors (Figures 3 and 6). The difficulties in assessing capitals were roughly the same for supervisory board members and representatives of local governments, except for the assessment of both internal and external social capital. Only a maximum of 40% of respondents differed from the expert assessment by less than 20% (Figures 4 and 7).

Differences in the assessment of individual capitals are understandable. Generally, respondents were closer to expert assessments in the case of capitals whose levels can be assessed more quantitatively, such as financial and physical capital. The most significant differences occurred in the area of social capital, with many respondents having a more positive perception of its level, while others viewed it negatively.

It is also important to note that the tables present average results. Unfortunately, the results obtained among companies varied significantly. Because the study included only eight companies from various industries, it is difficult to draw unequivocal conclusions regarding the causes of the significant variations. The only thing that is certain is that such studies should be conducted before the implementation of the concept, and attention should be given to it during training in companies where the managerial staff struggles to determine the level of capital.

It should be emphasized that the study was carried out under the assumption that the expert assessment of capital levels, which was used as a comparison, was correct. This assumption can be supported by the effort and time put into the expert assessment, the consultants' experience, and—most importantly—the fact that the consultants had the opportunity to compare capital levels in numerous companies, giving them a competitive advantage over respondents who typically assessed the level without a second reference point.

5. Summary

The research results, although conducted on a relatively small group of enterprises, have shown that the ability of the managerial staff to assess the levels of capital is good. This means that municipal companies can independently, or with minimal expert support, implement balanced capital management. The authors' ability to assess capital levels was the most significant concern, and the research confirmed that the implementation and management processes can be carried out in line with the concept.

The capital level assessments were more comparable to those of experts among the directors and board members (Figures 3 and 6). This implies that, in practice, capital level appraisals should be conducted by a small group of managers, possibly relying solely on middle management's expertise when no data is available or defining the level proves difficult.

A less favorable situation occurred for supervisory board members and representatives of local authorities. To some extent, this can be justified and stems from a lack of knowledge about the specific company rather than a lack of skills. It should be noted, though, that these people will be in charge of the capital management procedures.

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EXPECTATIONS OF GENERATION Z REPRESENTATIVES TOWARDS THE FEATURES AND COMPETENCIES OF THEIR DIRECT SUPERVISORS (MANAGERS) – RESULTS OF OWN STUDY

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Purpose: The goal of the study was identification of the features and competencies of direct supervisors, considered desirable for Generation Z.
Design/methodology/approach: The study was conducted among students in Poland and Great Britain in 2023. The study used survey method, in particular the CATI survey technique. To analyze the study data descriptive statistics measures were used.
Findings: The conducted research allowed to identify the features and competencies of direct superiors, desirable for Generation Z. The researchers examined also correlations between the respondents' answers, their gender, and place of residence. In several cases, gender and place of residence significantly differentiated the analyzed variables. The results also allowed to indicate the differences in the expected features and competencies of direct superiors, desired by Generation Z in Poland and in Great Britain.
Research limitations/implications: The use of surveys is associated with limitations, which include: the possibility of a superficial knowledge of the studied phenomena or being given false answers by the respondents. Relatively small number of respondents does not allow the obtained study results to be acknowledged as representative. Future research should be conducted on a larger sample, and quantitative research should be complemented by qualitative research. Undertaking research in other countries would make it possible to compare the features/competencies of direct supervisors desirable for representatives of Generation Z representing different nationalities, and to determine whether and which of them are mentioned regardless of geographical latitude.
Practical implications: Identification of the features and competencies of direct supervisors, desirable for Generation Z will allow team leaders – after taking them into account – to build positive relations with representatives of this generation, which will translate into effective cooperation and employee retention in the organization. The obtained knowledge indicates that the nationality of respondents is an important factor differentiating preferences and values in the Generation Z workplace, which confirms the importance of diversity management. This knowledge is very useful in international teams including representatives of Generation Z.
Originality/value: The paper is addressed to direct supervisors who work or intend to work with representatives of Generation Z. The presented results complement and deepen the knowledge about the features and competencies of direct supervisors, that are desirable for Generation Z, along with the gender and place of residence of the respondent. They also indicate

the influence of the nationality of respondents from Generation Z on the prioritization of their expectations towards the workplace.

Keywords: Generation Z, enterprise, manager, relation, desirable features and competencies of a manager.

Category of the paper: Research paper.

1. Introduction

Currently, representatives of the Z Generation are entering the labor market. In Poland in 2024 one fourth of the employees will be persons born after 1997 (Marszycki, 2022). The digital competencies of the most technologically advanced generation will be increasingly in demand in an increasingly digital labor market (Oxford Economics, 2021). Until now, it was the older generations who passed on their knowledge and experience to the younger generations. We are currently dealing with an opposite situation on the labor market – for the first time it is the youngest generation, who is an authority and has knowledge that other generations do not have. Such unnatural situation on the labor market in the future will change the typical corporate hierarchy (Stillman, Stillman, 2017). And how does Generation Z with its digital leverage on the labor market evaluate its current jobs? A big part of Gen Z is dissatisfied with current job - four out of ten Gen Z representatives would like to quit within two years, and circa a third would do so even without having other job offer. Two out of five Gen Z representatives would turn down a job offer if it didn't align with their expectations and values. A Generation Z representative is willing to stay in a given workplace for more than 5 years only if the employer takes actions that have a positive impact on society and the environment, as well as when he takes actions to create a diverse and inclusive culture in the workplace, which takes into account the expectations and values of Generation Z (Deloitte, 2022). Why are so many representatives of Generation Z thinking about changing jobs? What are the main priorities they take into account choosing their workplace? When choosing a workplace, Generation Z representatives pay attention to respecting their values, supervisors' decision-making process taking their opinion into account, or a positive organizational culture. Almost one-third of Generation Z representatives indicate that decisions in the organizations they work for are made top-down without taking into account the opinions of employees, and assess this situation very negatively (Deloitte, 2022).

Employers and direct supervisors, wanting to attract and retain the talents of Generation Z in their companies, should be able to cooperate with them, implement changes in the workplace and adapt to the expectations of this generation. This means that direct supervisors, who want to effectively and efficiently manage Generation Z representatives, should learn about the expectations of representatives of this group towards their colleagues and the work

environment. The relationship between the Generation Z representatives and their direct supervisor will determine the success of cooperation and the achieved results - if an employee feels that the supervisor respects and appreciates him/her, and his/her opinion is important, he/she feels more connected to the company and is more loyal to it. Knowing what Generation Z expects from the workplace, it is worth pointing out what features and competencies will enable the direct supervisor to build positive relations with Generation Z employees. The aim of the paper is to identify the features and competencies of their direct supervisors (managers) desirable for Generation Z.

In recent years, research on Generation Z, and in particular, their values in the workplace, has become more and more popular. However, comparative analyzes of Generation Z living in different countries are still limited. The study conducted by the authors extends the knowledge also in terms of determining the impact of the nationality of the Generation Z respondents on the prioritization of their expectations towards the workplace.

2. Who are Gen Zers?

Who is a Generation Z representative? The literature on the subject indicates various years of birth of Generation Z representatives. The authors adopted 1995 as the first year of birth of Generation Z representatives (Bassiouni, Hackley, 2014, Priporas, Stylos, Fotiadis, 2017; Hampton, Keys, 2017; Francis, Hoefel, 2018; Kamenidou et al., 2019) and 2009 as the final year (2010 marks the birth of the first persons belonging to the next generation, known as Generation Alpha) (McCrindle, 2014). Generation Z representatives differ from representatives of other generations in many ways. These differences and, at the same time, the features of Generation Z representatives are well reflected in the 7 factors shaping this generation (McCrindle, 2014):

- demographic changes – Generation Z representatives start their professional careers in times of massive aging of societies, which means that they will live longer, work longer and have higher retirement benefits. Single-person households will become the fastest-growing type of household,
- the times they live in – Generation Z is the most materially equipped, technology-saturated, globally connected, formally educated generation of all previous generations,
- digitization – Generation Z grew up in a digital world, using new technologies from an early age. This is why this generation is called digital integrators, who from an early age has seamlessly integrated technology into almost all areas of life,
- globalization – no other generation was as global as Generation Z. Modern technology allowed music, movies, fashion, trends, communication and even memes to have global nature,

- visualization – in times of information overload, more and more companies are moving away from using words in messages in favor of colors and images, which are very well received by Generation Z,
- reformed education – for Generation Z students education is no longer related to the stage of life they are at, but is a reality that accompanies them throughout their lives,
- social aspects – comparing to other generations, Generation Z has the largest number of friends and acquaintances. The opinions of friends greatly shape the Generation Z assessment and opinions.

Generation Z representatives, unlike previous generations, are not afraid of globalization, automation and changing work standards, seeing them as an opportunity to obtain flexible work and the opportunity to participate in projects of great importance. They feel technologically proficient and show a high degree of self-sufficiency (EY & JA Worldwide, 2021). The level of functional digital competencies of Generation Z in the sphere of work and professional development, which are a multi-factor construct, is determined by gender, age and level of study (Kowalczyk, 2022). They are willing to engage in cooperation and problem solving. Thinking about achieving their professional goals, Generation Z representatives want to build relationships with people from other environments through participation of government and business representatives in the education system. They expect practical opportunities to learn through experience, and they perceive the knowledge and skills of business representatives as allowing them to better prepare for work (EY & JA Worldwide, 2021).

3. Features of the direct supervisor – review of the literature

Defining the direct supervisor in an organization is not conclusive. A person appointed as a direct supervisor is often wrongly identified with an employer or a person employed in a given organization. When looking for an answer to the question of who the immediate supervisor is, we should follow the provisions of the Labor Code, according to which the employer is "an organizational unit, even if it does not have legal personality, as well as a natural person if they employ employees", and "for the employer being an organizational unit, actions in matters relating to labor law are performed by a person or body managing this unit or another person designated for that purpose" (Labor Code, Art. 3, 3^1 §1). This provision indicates that a person appointed as a direct supervisor not only does not have to be a member of the management of a given organization, but also does not have to be a person employed in it. The authors assumed that a direct supervisor is a person appointed by the employer who remains in direct contact and relations with employees, and who also directly delegates them tasks in the field of labor law. The direct supervisor can be the employer himself (in case of small businesses), the manager or any other person, etc.

What are Generation Z representatives like at work? What do they expect from their direct supervisors (managers)? Generation Z representatives make decisions very quickly and do not fear risk. From the employer they expect high salary, effective non-financial motivators, and opportunities for personal development, skillful use of their potential and good atmosphere. At the same time, they want to be respected in the workplace (Wiktorowicz et al., 2016). Generation Z wants to work in places where it can shape the organizational culture of the company, as well as openly discuss various topics with their supervisors (Deloitte, 2022). They expect that the supervisor/manager will not only share their value system, show understanding of their life priorities, but also support them in their non-professional activities: social, civic and charitable. They are open to changes and highly mobile. Contrary to many stereotypical opinions, Generation Z representatives are not closed to building social relationships, and they even declare the need to create and develop such relationships in the workplace, as well as the need to base these relationships on the principles of ethics, mutual openness, respect and understanding. The matters most important for Generation Z are: 1. Respect for themselves, relationships, environment; 2. Work based on values; 3. Building relationships on various levels – private and professional; 4. Work-life balance; 5. Openness to diversity; 6. Assertiveness; 7. Clearly formulated expectations towards employees and candidates; 8. Creativity; 9. Care for the environment; 10. Developing passion (Humanitas, 2023). Supervisors who want to attract and retain representatives of Generation Z in the company should: be empathetic; build trust by communicating goals, actions and progress backed by data and science; be genuinely committed to the sustainable development and equality goals, making them crucial to the company's goals and strategy; offer dynamic and engaging career paths, as well as innovative and collaborative forms of work, as well as opportunities for continuous learning and development (EY & JA Worldwide, 2021).

Generation Z representatives have their own, different from representatives of other generations, expectations regarding the characteristics and behavior of their direct supervisors/managers. First of all, they want their direct supervisor to have the ability to listen carefully, communicate and cooperate (Sladek, Grabinger, 2014). They want him/her to be honest and righteous, to learn and be interested in their problems and passions, treat them individually, meet them often and discuss the effects of their work, give them the opportunity to develop and prove themselves, support them in difficult situations (White, 2022). Generation Z representatives expect a positive, communicative leader who will provide ambitious team members with support, mentoring and other development opportunities. They expect the direct supervisor to provide a friendly working atmosphere based on fair competition, stability and security, to reduce uncertainty and risk, and to offer employees a variety of opportunities to engage, and establish rewards for such engagement. The desired form of communication is primarily communication via computer (Gabrielova, Buchko, 2021), which allows using social media for business contacts (Karasek, Hysa, 2020). Generation Z representatives expect their supervisor to support them in developing interpersonal skills that will help them build social

interactions. They are open for participation in any events integrating colleagues. To sum up, the quality of the relationship between the supervisor and Generation Z representative, as well as the attitude and quality of the work performed, is influenced by the ability to listen, understand, share one's own experiences, stories, and consequently joint setting of development goals (Gabrielova, Buchko, 2021).

The results of the study conducted by A. Rybowska indicate that employees expect from their supervisors honesty, dynamics, positive thinking, assertiveness, strong personality, openness and fairness. The least important features turned out to be charisma and self-criticism. The assessment of men who had lower expectations towards managers than women, differed from the assessment of women – men considered loyalty to employees as the most important feature, while dynamism was not important to them. The highest rated interpersonal skills included the ability to work with a team of people, the ability to inspire social trust and establish contacts (Rybowska, 2016). According to the results of study conducted by J. Gajda, in the opinion of the Generation Z representatives a perfect supervisor should: treat his subordinates fairly and as partners, support their development, keep his/ her word, mitigate conflicts, not favor any of his/her subordinates, help in difficult situations, be open to their needs, respect the time of their subordinates, provide support in developing skills relevant to the labor market during work (Gajda, 2017). The results of the research conducted by J.T. Jensen are consistent with the research results presented above. Generation Z representatives expect their supervisors to create a *fair-play* workplace, providing them with a high level of support and representing an engaging and authentic leadership style. The immediate supervisor should be fair, honest, direct, open and trustworthy. The expected way of communication – whenever possible – is face-to-face communication (Jensen, 2021).

Based on the results of a study conducted, among others, by the employees of the Humanitas University, it is possible to indicate the features and behavior of the employer/direct supervisor most valued by Generation Z. These include: showing respect, individual treatment, kindness, tolerance, readiness to help, openness, partner treatment. The indicated features show how important social relations are for Generation Z. The desired features and behaviors related to the professional competencies of employers/direct supervisors, e.g. professionalism, reliability, are of lesser importance to the respondents. General social values, which are part of the organizational culture of the workplace, are of great importance to the representatives of Generation Z. Justice, respect, tolerance, equality, fairness, and freedom are important (Humanitas, 2023).

Based on the analysis of the literature on the subject, the authors built a catalog of features and competencies, which was used in the conducted study aimed at identifying the features and competencies of their immediate supervisor (manager) desired by Generation Z. Also based on the analysis of the literature on the subject, the authors formulated the following research questions:

1. In the opinion of Generation Z representatives – what features and competencies should a direct supervisor have?
2. Is there a correlation between the choice of desired features/competencies of a direct supervisor/manager and the gender of a Generation Z representative?
3. Is there a correlation between the choice of desired features/competencies of a direct supervisor/manager and the place of residence of a Generation Z representative?
4. Is there any difference between the desired features/competencies of a direct supervisor/manager of Generation Z representatives in Poland and Great Britain? If yes, what is it?

4. Methods

The research on Gen Zers' attitudes towards brands on social media is a part of a broader study conducted by the authors among students in Poland and Great Britain in 2023. The research employed a combination of qualitative and quantitative approaches, utilizing survey research as an indirect measurement method. It employed survey as the research technique and survey questionnaire as the research tool. The selection of variables used in the study was based on a critical analysis of relevant literature (Gummerus et al., 2012; Gregor, Kubiak, 2014). Regarding the birth year of Generation Z representatives, there is no consensus in the literature. The most frequently cited date is the year 1995, which the authors of the paper adopted as the cutoff year for their study.

The authors also assumed that the independent variable in their study is the specific group of respondents being tested, rather than the entire population of Generation Z. Due to the challenge of definitively determining the age range of Generation Z, it becomes problematic to treat this variable as independent. However, the authors found that utilizing Generation Z as a heuristic is valuable, as generational profiling is now prevalent in popular media and popular culture, providing a descriptive framework.

Prior to commencing the main research, the authors conducted a pilot study in 2018, enabling them to identify and rectify any errors in the survey questionnaire before proceeding with the main study. For the first time, comparative studies of representatives of Generation Z in Poland and Great Britain were conducted by the authors between 2020 and 2021 (Korombel, Ławińska, 2023). In 2023, 322 students (166 women and 156 men) in Poland and 318 students (199 women and 119 men) in Great Britain were surveyed. The research employed the CAWI (Computer-Assisted Web Interviewing) technique. In Poland, an online survey questionnaire was administered through the Webankieta.pl platform, while data collection in Great Britain was outsourced to an external institution specializing in survey administration. It is important to note that the sampling method used in both studies was non-probabilistic. While utilizing

non-probabilistic sampling, the authors employed statistical inference as an opportunity to identify relationships within the studied groups, as descriptive statistics alone would not allow for such analysis.

Based on the research results, the authors calculated the number and frequency of respondents' responses to each question in the survey. The authors are aware that the sampling technique employed does not allow for the estimation of errors that may arise when generalizing the observed patterns in the sample to the entire population. To identify potential relationships within the studied groups, the authors utilized statistical inference, for which they adopted a certain level of significance, as descriptive statistics alone cannot provide such analysis. Statistical inference was conducted with a predetermined significance level set at $\alpha = 0.05$, and a p-value was calculated for each test. The authors compared the p-value with the level of statistical significance to determine whether there was sufficient evidence to reject the null hypothesis (H_0) in favor of the alternative hypothesis (H_1) ($p < \alpha$), or not ($p \geq \alpha$). All analyses were performed using Statistica software, version 13.

The authors acknowledge that survey research has certain limitations, such as providing only a surface-level understanding of the phenomena under study and the possibility of respondents providing inaccurate answers. One potential criticism of the presented research results is that the study was conducted on a small group of participants. While small sample sizes can raise methodological concerns, such as limitations in generalization, they can still provide valuable insights when proper statistical tests are applied for inference (Yates, 1934; Nachar, 2008).

5. Results

The presented results are part of the study conducted by the authors in Poland and Great Britain at the beginning of 2023. One of the questions in the survey concerned the features of managers, desired by Generation Z. Respondents were asked the following question: *Please, read all the following features first. Then indicate the 5 most important qualities that you would like your ideal boss/manager to have.* A catalog containing 35 features selected on the basis of literature analysis was presented. The obtained response frequencies (in %) of the most and least desired features selected by respondents in Poland are presented in Figures 1 and 2.

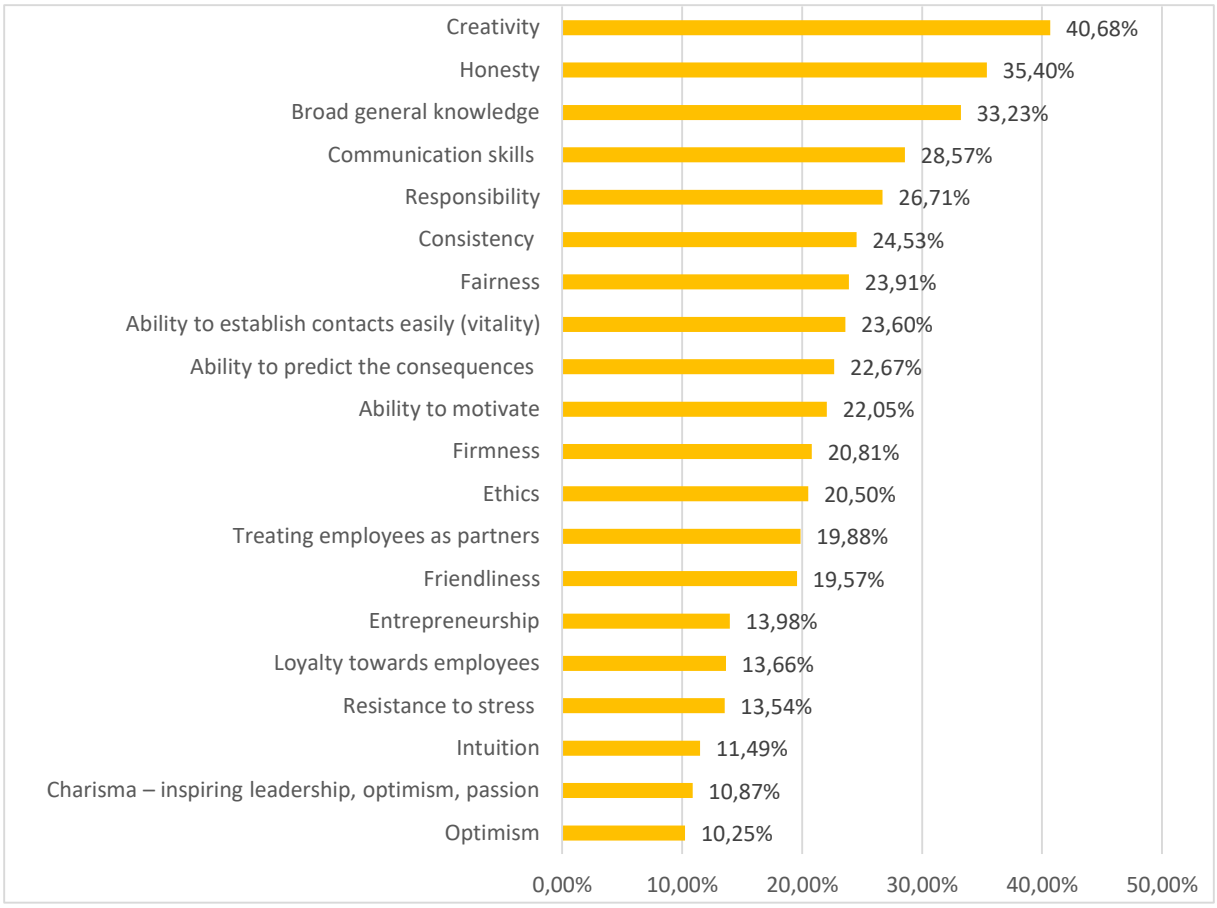


Figure 1. Response frequencies (in %) on the features of a direct supervisor (manager) most desirable for the respondents in Poland in 2023.

Source: own study.

The results of the survey conducted among the Generation Z representatives in Poland (Figure 1) allowed to identify the three features and competencies of the direct supervisor (manager) most desirable by the respondents: *creativity, honesty and broad general knowledge.* Each of these features/competencies was indicated by 30% or more of the respondents.

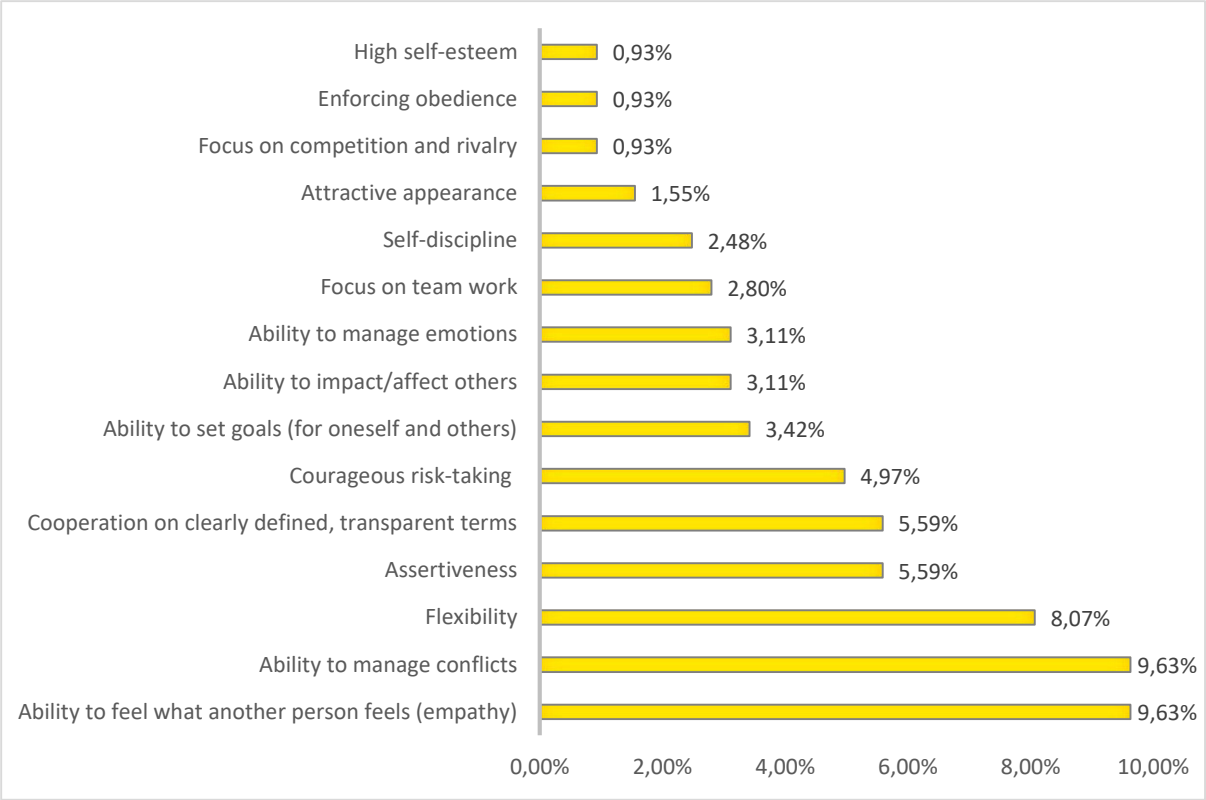


Figure 2. Response frequencies (in %) on the features and competencies of a direct supervisor (manager) least desirable for the respondents in Poland in 2023.

Source: own study.

At the same time, the surveyed Generation Z representatives in Poland in 2023 (Figure 2) indicated the following as the least important features and competencies of the direct supervisor (manager): *high self-esteem*, *forcing obedience, focus on rivalry and competition, and attractive appearance.* All these features/competencies were indicated by less than 2% of the respondents.

Next Figures (3 and 4) show obtained response frequencies (in %) of the most and least desired features selected by respondents in Great Britain.

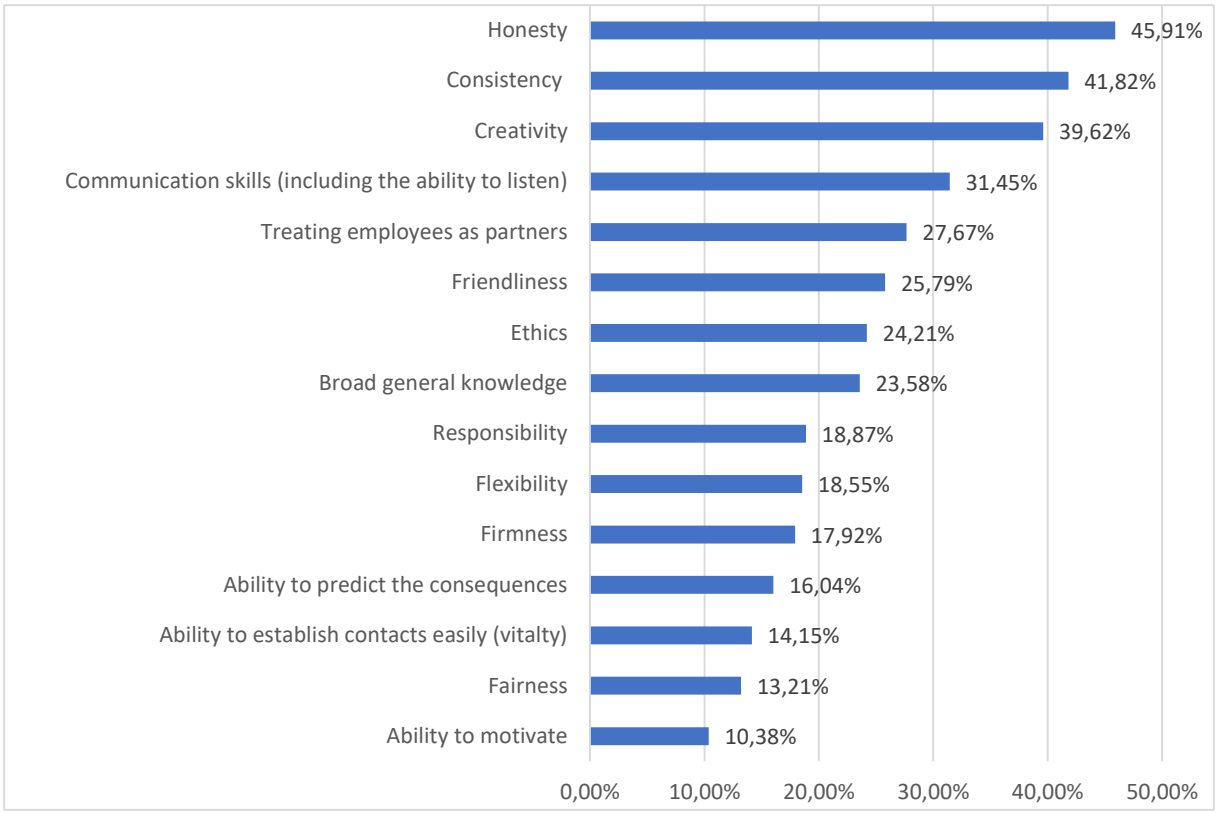


Figure 3. Response frequencies (in %) on the features and competencies of a direct supervisor (manager) most desirable for the respondents in Great Britain in 2023.

Source: own study.

The results of a study conducted in Great Britain in 2023 (Figure 3) revealed one feature of a direct supervisor (manager) particularly important for representatives of Generation Z: *honesty*, which was indicated by over 45% of respondents. Next, the following were indicated (over 30% of answers): *consistency, creativity,* and *communication skills (including the ability to listen).*

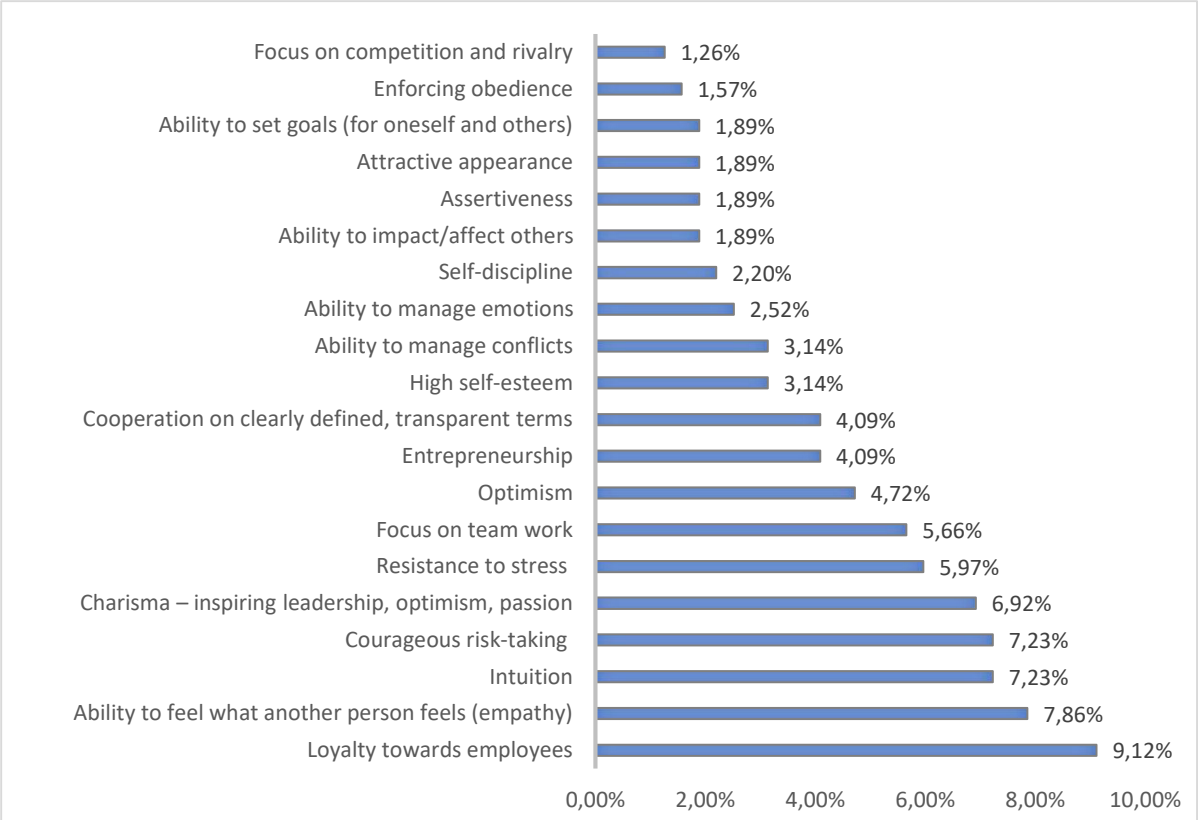


Figure 4. Response frequencies (in %) on the features and competencies of a direct supervisor (manager) least desirable for the respondents in Great Britain in 2023.

Source: own study.

The surveyed Generation Z representatives in Great Britain (Figure 4) indicated the following as the least important features and competencies of a direct supervisor (manager): *focus on rivalry and competition, enforcing obedience, the ability to set goals (for oneself and others), attractive appearance, assertiveness,* and *the ability to impact/affect others.* All mentioned features/competencies were indicated by less than 2% of the respondents.

To sum up, it is possible to indicate the features and competencies of the direct supervisor (manager) most desirable for the respondents both in Poland and in Great Britain: *creativity, honesty*, and *communication skills (including the ability to listen).* The surveyed Generation Z representatives in both countries indicated the following as the least desirable: *enforcing obedience, focus on rivalry and competition,* and *attractive appearance.*

The next stage of data analysis was to verify whether there was a correlation between the variables: the choice of expected features and competencies of the direct supervisor/manager (variable X) and the gender of the respondent (variable Y). For this purpose, a significance test for structure indicators was used (comparison of two structure indicators). It was assumed that in the group of women the fraction indicator of this feature is p_1, and in the group of men – p_2. The null hypothesis was verified:

$$H_0: p_1 = p_2$$

to the alternative hypothesis:

$$H_1: p_1 > p_2$$

Due to the adopted form of the alternative hypothesis, the one-sided critical area was considered. The analysis concerned the answers to multiple-response questions, the indicators were calculated for the general population as well as for women and men, and then it was verified using the test for the structure indicator whether gender significantly differentiates these indicators. Detailed data on the selection of features and competencies of a direct supervisor/manager desirable for the respondents in Poland and Great Britain in 2023 and the result of the significance test for structure indicators by gender of the respondent are presented in Tables 1 and 2.

Table 1.
Selection of the desirable features and competencies of the direct supervisor (manager) for the respondents in Poland in 2023 and the result of the significance test for structure indicators by gender

Characteristics and Competencies	In total		Females		Males		p
	Number	Percentage of cases	Number	Percentage of cases	Number	Percentage of cases	
Ability to establish contacts easily (vitality)	76	23.60%	44	26.51%	32	20.51%	0.1026
Ability to feel what another person feels (empathy)	31	9.63%	18	10.84%	13	8.33%	0.2227
Ability to impact/affect others	10	3.11%	4	2.41%	6	3.85%	0.2284
Ability to manage conflicts	31	9.63%	18	10.84%	13	8.33%	0.2227
Ability to manage emotions	10	3.11%	5	3.01%	5	3.21%	0.4588
Ability to motivate	71	22.05%	40	24.10%	31	19.87%	0.1801
Ability to predict the consequences of own and other people's actions	73	22.67%	37	22.29%	36	23.08%	0.4328
Ability to set goals (for oneself and others)	11	3.42%	8	4.82%	3	1.92%	0.0761
Assertiveness	18	5.59%	9	5.42%	9	5.77%	0.4457
Attractive appearance	5	1.55%	3	1.81%	2	1.28%	0.3300
Broad general knowledge	107	33.23%	56	33.73%	51	32.69%	0.4215
Charisma – inspiring leadership, optimism, passion	35	10.87%	13	7.83%	22	14.10%	**0.0354**
Communication skills (including the ability to listen)	92	28.57%	51	30.72%	41	26.28%	0.1890
Consistency	79	24.53%	32	19.28%	47	30.13%	0.0119
Cooperation on clearly defined, transparent terms	18	5.59%	10	6.02%	8	5.13%	0.3641
Courageous risk-taking	16	4.97%	6	3.61%	10	6.41%	0.1239
Creativity	131	40.68%	69	41.57%	62	39.74%	0.3692
Enforcing obedience (authoritarian attitude to employees)	3	0.93%	1	0.60%	2	1.28%	0.2626
Entrepreneurship	45	13.98%	17	10.24%	28	17.95%	**0.0231**
Ethics	66	20.50%	32	19.28%	34	21.79%	0.2886
Fairness	77	23.91%	38	22.89%	39	25.00%	0.3287
Firmness	67	20.81%	31	18.67%	36	23.08%	0.1650
Flexibility	26	8.07%	15	9.04%	11	7.05%	0.2562
Focus on competition and rivalry	3	0.93%	0	0	3	1.92%	**0.0364**
Focus on team work	9	2.80%	5	3.01%	4	2.56%	0.4032
Friendliness	63	19.57%	33	19.88%	30	19.23%	0.4416
High self-esteem	3	0.93%	1	0.60%	2	1.28%	0.2626
Honesty	114	35.40%	56	33.73%	58	37.18%	0.2588
Intuition	37	11.49%	18	10.84%	19	12.18%	0.3531

Cont. table 1.

Loyalty towards employees	44	13.66%	26	15.66%	18	11.54%	0.1410
Optimism	33	10.25%	17	10.24%	16	10.26%	0.4976
Resistance to stress	43	13.54%	21	12.65%	22	14.10%	0.3511
Responsibility	86	26.71%	48	28.92%	38	24.36%	0.1777
Self-discipline	8	2.48%	3	1.81%	5	3.21%	0.2101
Treating employees as partners	64	19.88%	45	27.11%	19	12.18%	**0.0004**

Source: own study.

The analysis of data collected in Poland (Table 1) gave grounds for stating that gender significantly differentiated the analyzed percentage indicators in four cases. It can be noticed that the surveyed women in Poland significantly more often than men chose: *treating employees as partners.* The surveyed men significantly more often than women indicated the following features/competencies: *charisma (inspiring leadership, optimism, passion), focus on competition and rivalry,* and *entrepreneurship.*

Table 2.

Selection of the desirable features and competencies of the direct supervisor (manager) for the respondents in Great Britain in 2023 and the result of the significance test for structure indicators by gender

Characteristics and Competencies	In total		Females		Males		p
	Number	Percentage of cases	Number	Percentage of cases	Number	Percentage of cases	
Ability to establish contacts easily (vitality)	45	14.15%	27	13.57%	18	15.13%	0.3497
Ability to feel what another person feels (empathy)	25	7.86%	23	11.56%	2	1.68%	**0.0008**
Ability to impact/affect others	6	1.89%	2	1.01%	4	3.36%	0.0682
Ability to manage conflicts	10	3.14%	7	3.52%	3	2.52%	0.3105
Ability to manage emotions	8	2.52%	5	2.51%	3	2.52%	0.4978
Ability to motivate	33	10.38%	21	10.55%	12	10.08%	0.4471
Ability to predict the consequences of own and other people's actions	51	16.04%	24	12.06%	27	22.69%	**0.0062**
Ability to set goals (for oneself and others)	6	1.89%	5	2.51%	1	0.84%	0.1446
Assertiveness	6	1.89%	4	2.01%	2	1.68%	0.4171
Attractive appearance	6	1.89%	5	2.51%	1	0.84%	0.1446
Broad general knowledge	75	23.58%	46	23.12%	29	24.37%	0.3997
Charisma – inspiring leadership, optimism, passion	22	6.92%	14	7.04%	8	6.72%	0.4567
Communication skills (including the ability to listen)	100	31.45%	70	35.18%	30	25.21%	**0.0319**
Consistency	133	41.82%	78	39.20%	55	46.22%	0.1097
Cooperation on clearly defined, transparent terms	13	4.09%	10	5.03%	3	2.52%	0.1371
Courageous risk-taking	23	7.23%	15	7.54%	8	6.72%	0.3924
Creativity	126	39.62%	72	36.18%	54	45.38%	0.0523
Enforcing obedience (authoritarian attitude to employees)	5	1.57%	3	1.51%	2	1.68%	0.4531
Enterprise	13	4.09%	9	4.52%	4	3.36%	0.3065
Ethics	77	24.21%	51	25.63%	26	21.85%	0.2232
Fairness	42	13.21%	25	12.56%	17	14.29%	0.3296
Firmness	57	17.92%	28	14.07%	29	24.37%	**0.0102**
Flexibility	59	18.55%	42	21.11%	17	14.29%	0.0650

Cont. table 2.

Focus on competition and rivalry	4	1.26%	1	0.50%	3	2.52%	0.0588
Focus on team work	18	5.66%	11	5.53%	7	5.88%	0.4480
Friendliness	82	25.79%	55	27.64%	27	22.69%	0.1644
High self-esteem	10	3.14%	9	4.52%	1	0.84%	**0.0344**
Honesty	146	45.91%	92	46.23%	54	45.38%	0.4415
Intuition	23	7.23%	15	7.54%	8	6.72%	0.3924
Loyalty towards employees	29	9.12%	19	9.55%	10	8.40%	0.3652
Optimism	15	4.72%	11	5.53%	4	3.36%	0.1886
Resistance to stress	19	5.97%	13	6.53%	6	5.04%	0.2937
Responsibility	60	18.87%	36	18.09%	24	20.17%	0.3232
Self-discipline	7	2.20%	3	1.51%	4	3.36%	0.1383
Treating employees as partners	88	27.67%	61	30.65%	27	22.69%	0.0623

Source: own study.

The analysis of data collected in Great Britain (Table 2) gave grounds for stating that gender significantly differentiated the analyzed percentage indicators in five cases. It can be noticed that women in this research group significantly more often than men chose the following features/competencies: *communication skills (including the ability to listen), ability to feel what another person feels (empathy)* and *high self-esteem.* In turn, the surveyed men in this research group significantly more often than women indicated the following features/competencies: *ability to predict the consequences of own and other people's actions,* and *firmness.* Comparing the calculated structure indicators (Tables 1 and 2), it should be emphasized that there are no similar results in both surveyed countries.

The next step was an attempt to verify the hypothesis about the independence of two qualitative features: the choice of the desired feature/competencies of the direct supervisor (manager) and the respondent's place of residence. For this purpose, Pearson's Chi-square test was used, which enabled the analysis of the collected data (included in Tables 3 and 4) and providing proof of the correlation between these two variables. Pearson's Chi-square test was a comparison of observed frequencies with expected frequencies assuming the null hypothesis (no correlation between the two variables). The null hypothesis was verified:

H_0: features X i Y are independent

to the alternative hypothesis:

H_1: features X i Y are depended.

The collected data on the selection of the desired features and competencies of the direct supervisor (manager) according to the respondent's place of residence in 2023 and the results of the Pearson Chi-square test and its significance level are presented in Tables 3 (data for Poland) and 4 (data for Great Britain).

Table 3.
Selection of the desirable features and competencies of the direct supervisor (manager) by the respondent's place of residence in Poland in 2023 and the results of the Pearson Chi-square test and the level of its significance

Characteristics and Competencies	Place of residence (% against number of responses = 322)						Pearson's Chi^2	p
	Village	City up to 100 000 residents	City up to 100 000 residents	City up to 250 000 residents	City over 250 000 residents	Row in total		
Ability to establish contacts easily (vitality)	12.73%	3.42%	1.24%	4.35%	1.86%	23.60%	3.4926	0.4790
Ability to feel what another person feels (empathy)	5.28%	0.93%	0.31%	2.48%	0.62%	9.63%	1.8317	0.7667
Ability to impact/affect others	1.86%	0	0.31%	0.93%	0	3.11%	2.9554	0.5653
Ability to manage conflicts	5.28%	1.24%	0.93%	1.86%	0.31%	9.63%	2.7557	0.5995
Ability to manage emotions	1.86%	0.31%	0.31%	0.31%	0.31%	3.11%	1.0030	0.9094
Ability to motivate	12.11%	1.86%	2.17%	4.35%	1.55%	22.05%	3.5668	0.4678
Ability to predict the consequences of own and other people's actions	11.18%	3.73%	0.31%	5.28%	2.17%	22.67%	7.5880	0.1079
Ability to set goals (for oneself and others)	1.55%	0.31%	0.62%	0.31%	0.62%	3.42%	3.5260	0.4739
Assertiveness	1.55%	0.93%	0.31%	1.24%	1.55%	5.59%	7.3056	0.1206
Attractive appearance	0.31%	0.31%	0	0.31%	0.62%	1.55%	5.4679	0.2426
Broad general knowledge	18.32%	2.80%	1.86%	7.14%	3.11%	33.23%	2.3814	0.6660
Charisma – inspiring leadership, optimism, passion	5.59%	1.55%	0	2.48%	1.24%	10.87%	3.2550	0.5161
Communication skills (including the ability to listen)	14.60%	1.86%	2.48%	7.45%	2.17%	28.57%	5.4470	0.2444
Consistency	9.32%	3.42%	2.80%	5.28%	3.73%	24.53%	8.8422	0.0652
Cooperation on clearly defined, transparent terms	3.73%	1.24%	0.31%	0.31%	0	5.59%	7.9342	0.0940
Courageous risk-taking	2.48%	0.31%	0.62%	0.62%	0.93%	4.97%	2.5770	0.6309
Creativity	18.01%	4.04%	4.66%	8.70%	5.28%	40.68%	9.0641	0.0595
Enforcing obedience (authoritarian attitude to employees)	0.62%	0	0	0	0.31%	0.93%	2.6731	0.6139
Enterprise	7.14%	0.62%	1.24%	3.73%	1.24%	13.98%	3.1044	0.5405
Ethics	8.07%	3.42%	0.62%	4.66%	3.73%	20.50%	**10.2624**	**0.0362**
Fairness	13.35%	2.17%	0.93%	5.90%	1.55%	23.91%	4.6608	0.3240
Firmness	10.25%	1.55%	1.86%	4.35%	2.80%	20.81%	1.7309	0.7851
Flexibility	3.73%	0.62%	0.31%	2.17%	1.24%	8.07%	1.5186	0.8233
Focus on competition and rivalry	0.62%	0.31%	0	0	0	0.93%	2.8501	0.5832
Focus on team work	0.93%	0.62%	0.31%	0.62%	0.31%	2.80%	1.9580	0.7435
Friendliness	12.11%	1.86%	1.24%	3.42%	0.93%	19.57%	5.7878	0.2156
High self-esteem	0.31%	0	0	0.31%	0.31%	0.93%	2.2244	0.6946
Honesty	16.46%	3.42%	2.17%	8.07%	5.28%	35.40%	3.0518	0.5492
Intuition	5.59%	0.62%	0.62%	1.86%	2.80%	11.49%	8.1814	0.0852
Loyalty towards employees	7.76%	0.62%	0.93%	2.48%	1.86%	13.66%	2.7450	0.6014
Optimism	5.59%	1.24%	0.93%	1.86%	0.62%	10.25%	1.5543	0.8170
Resistance to stress	6.83%	1.86%	0.93%	2.17%	1.55%	13.35%	1.1795	0.8815
Responsibility	12.73%	2.17%	1.86%	6.83%	3.11%	26.71%	1.7464	0.7823
Self-discipline	0.62%	1.24%	0	0.31%	0.31%	2.48%	**13.9902**	**0.0073**
Treating employees as partners	9.94%	2.17%	0.93%	4.97%	1.86%	19.88%	1.2569	0.8687

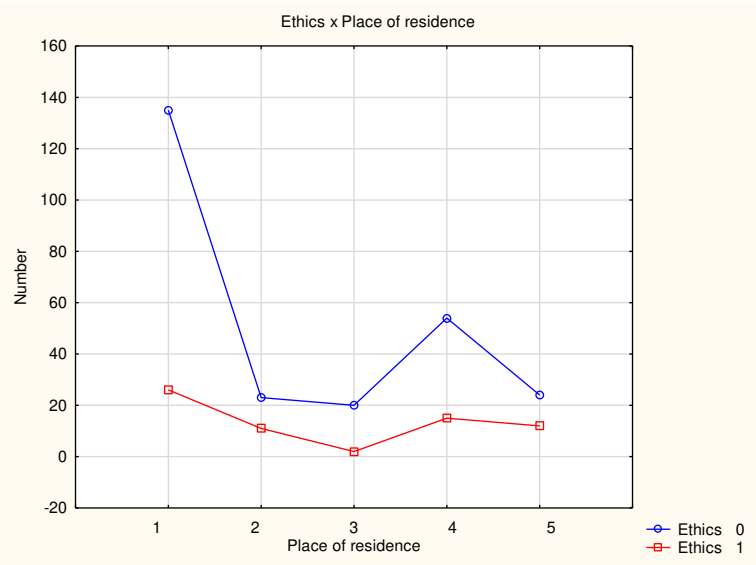
Source: own study.

In case of the study carried out in Poland in relation to two features/competencies:

1. ethics,
2. self-discipline

the results of Pearson's Chi-square test, at the assumed significance level ($\alpha = 0.05$), indicate the rejection of the verified null hypothesis. This means that there is a statistically significant correlation between the choice of the above-mentioned two features/competencies and the respondent's place of residence. The above-mentioned features/competencies were chosen mainly by respondents-inhabitants of rural areas in Poland, which is illustrated in Figures 5 and 6. However, this result should be treated with caution due to the small number of responses.

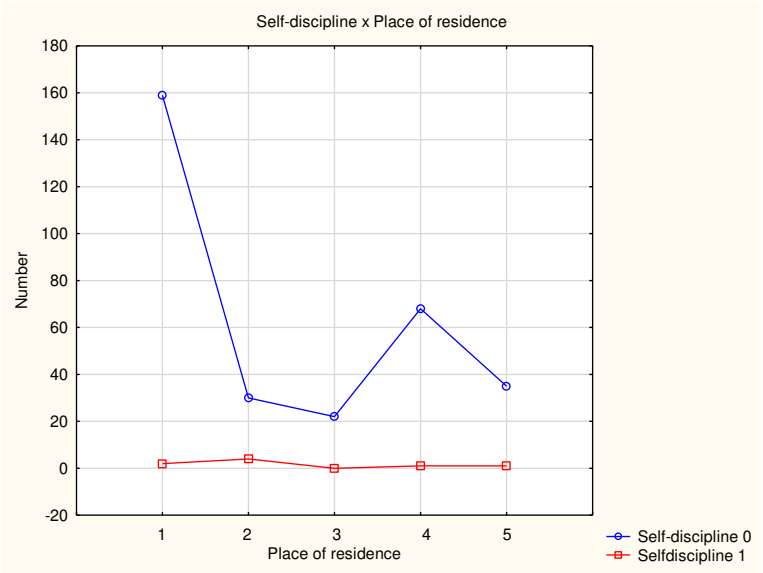
In case of the other examined features/competencies, the results of the Pearson Chi-square test, at the adopted significance level ($\alpha = 0.05$), indicate no grounds for rejecting the verified null hypothesis, and thus no connection between the choice of a specific feature/competencies and the respondent's place of residence in Poland.



where: 1. Village; 2. City up to 50 000 residents; 3. City up to 100 000 residents; 4. City up to 250 000 residents; 5. City over 250 000 residents.

Figure 5. Number of answers regarding the selection of features/competencies: Ethics and the respondent's place of residence in Poland in 2023.

Source: own study.



where: 1. Village; 2. City up to 50 000 residents; 3. City up to 100 000 residents; 4. City up to 250 000 residents; 5. City over 250 000 residents.

Figure 6. Number of answers regarding the selection of features/competencies: Self-discipline and the respondent's place of residence in Poland in 2023.

Source: own study.

Table 4.

Selection of the desirable features and competencies of the direct supervisor (manager) by the respondent's place of residence in Great Britain in 2023 and the results of the Pearson Chi-square test and the level of its significance

Characteristics and Competencies	Place of residence (% against number of responses = 322)						Pearson's Chi^2	p
	Village	City up to 100 000 residents	City up to 100 000 residents	City up to 250 000 residents	City over 250 000 residents	Row in total		
Ability to establish contacts easily (vitality)	3.77%	4.72%	5.66%	1.89%	7.55%	14.15%	4.1255	0.3893
Ability to feel what another person feels (empathy)	0.94%	0.94%	2.52%	0.31%	3.14%	7.86%	7.1984	0.1258
Ability to impact/affect others	0.63%	0	0.63%	0	0.63%	1.89%	3.1570	0.5319
Ability to manage conflicts	0.94%	0.63%	0.31%	0.31%	0.94%	3.14%	0.6555	0.9567
Ability to manage emotions	0	0	1.26%	0	1.26%	2.52%	**10.3348**	**0.0352**
Ability to motivate	2.52%	2.20%	0.63%	1.26%	3.77%	10.38%	3.1232	0.5374
Ability to predict the consequences of own and other people's actions	2.83%	3.14%	2.83%	1.89%	5.35%	16.04%	0.5907	0.9641
Ability to set goals (for oneself and others)	0.63%	0	0.31%	0.63%	0.31%	1.89%	4.7250	0.3167
Assertiveness	0.63%	0	0.31%	0.63%	0.31%	1.89%	4.7250	0.3167
Attractive appearance	0	0.94%	0.63%	0.31%	0	1.89%	7.6697	0.1045
Broad general knowledge	3.77%	4.72%	5.66%	1.89%	7.55%	23.58%	5.2345	0.2641
Charisma – inspiring leadership, optimism, passion	1.26%	0	1.57%	0.63%	3.46%	6.92%	7.5337	0.1102
Communication skills (including the ability to listen)	6.60%	5.66%	5.03%	3.77%	10.38%	31.45%	0.3409	0.9870
Consistency	10.38%	8.81%	7.55%	4.09%	1101%	41.82%	4.3931	0.3554

Cont. table 4.

Cooperation on clearly defined, transparent terms	1.26%	0.31%	0.63%	0.94%	0.94%	4.09%	3.5122	0.4760
Courageous risk-taking	1.26%	0.94%	1.57%	0.94%	2.52%	7.23%	1.1129	0.8922
Creativity	5.97%	9.12%	5.35%	4.72%	14.47%	39.62%	**9.5828**	**0.0481**
Enforcing obedience (authoritarian attitude to employees)	0	0.31%	0.63%	0.31%	0.31%	1.57%	3.2876	0.5109
Enterprise	0.63%	1.57%	0.31%	0.31%	1.26%	4.09%	3.9725	0.4097
Ethics	5.35%	2.52%	3.46%	3.77%	9.12%	24.21%	7.1401	0.1287
Fairness	1.57%	2.83%	0.94%	0.31%	7.55%	13.21%	**18.1995**	**0.0011**
Firmness	5.03%	3.14%	2.20%	1.57%	5.97%	17.92%	2.6104	0.6250
Flexibility	5.35%	3.14%	3.46%	2.52%	4.09%	18.55%	4.4958	0.3431
Focus on competition and rivalry	0	0.63%	0.31%	0	0.31%	1.26%	3.6957	0.4488
Focus on team work	1.26%	0.94%	1.26%	0.94%	1.26%	5.66%	1.4497	0.8355
Friendliness	5.66%	5.03%	3.46%	3.46%	8.18%	25.79%	1.4680	0.8323
High self-esteem	0.94%	0	0.63%	0	1.57%	3.14%	4.5167	0.3406
Honesty	9.75%	7.86%	8.49%	5.03%	14.78%	45.91%	0.7042	0.9508
Intuition	0.94%	0.94%	1.26%	0.94%	3.14%	7.23%	2.4293	0.6574
Loyalty towards employees	2.20%	1.26%	1.57%	0.63%	3.46%	9.12%	1.3507	0.8527
Optimism	1.26%	0.63%	0.31%	0.31%	2.20%	4.72%	2.7672	0.5975
Resistance to stress	1.89%	1.57%	0.31%	0.31%	1.89%	5.97%	3.8052	0.4330
Responsibility	4.09%	3.14%	3.14%	2.20%	6.29%	18.87%	0.2331	0.9937
Self-discipline	0	0	0	0.94%	1.26%	2.20%	**12.1456**	**0.0163**
Treating employees as partners	4.72%	5.66%	5.35%	2.83%	9.12%	27.67%	1.9638	0.7424

Source: own study.

In case of a study carried out in Great Britain in relation to four features/competencies:

1. creativity,
2. self-discipline,
3. ability to manage emotions,
4. fairness

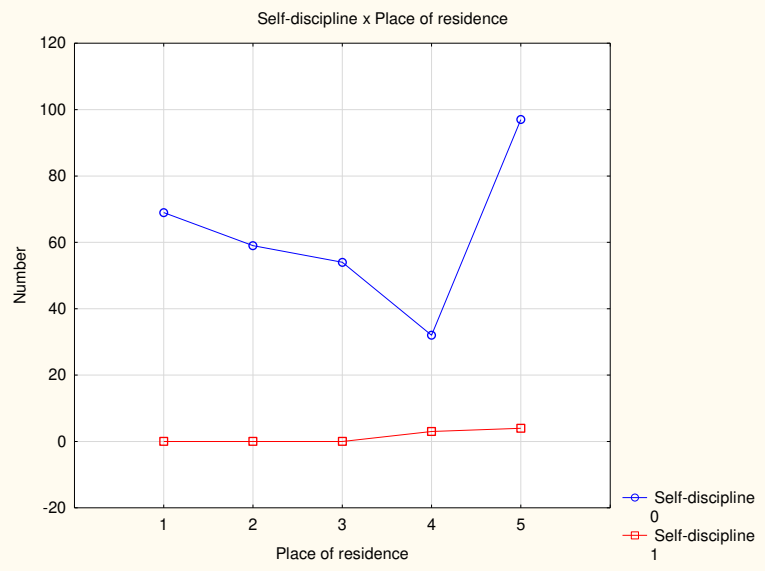
the results of Pearson's Chi-square test, at the assumed significance level ($\alpha = 0.05$), indicate the rejection of the verified null hypothesis. This means that there is a statistically significant correlation between the choice of the above-mentioned four features/competencies and the respondent's place of residence. The above-mentioned features/competencies were chosen mainly by respondents-inhabitants of cities in Great Britain, which is illustrated in Figures 7, 8, 9, and 10.

In case of the other examined features/competencies, the results of the Pearson Chi-square test, at the adopted significance level ($\alpha = 0.05$), indicate no grounds for rejecting the verified null hypothesis, and thus no connection between the choice of a specific feature/competencies and the respondent's place of residence in Great Britain.

where: 1. Village; 2. City up to 50 000 residents; 3. City up to 100 000 residents; 4. City up to 250 000 residents; 5. City over 250 000 residents.

Figure 7. Number of answers regarding the selection of features/competencies: Creativity and the respondent's place of residence in Great Britain in 2023.

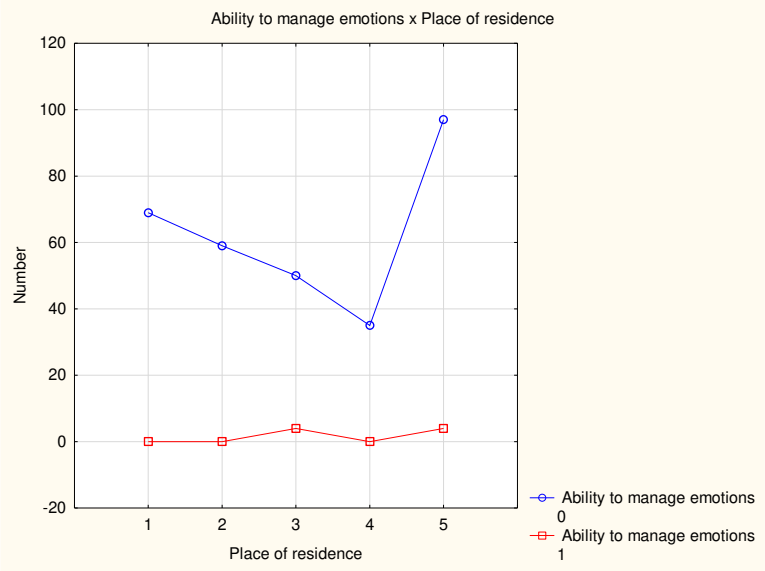
Source: own study.



where: 1. Village; 2. City up to 50 000 residents; 3. City up to 100 000 residents; 4. City up to 250 000 residents; 5. City over 250 000 residents.

Figure 8. Number of answers regarding the selection of feature: Self-discipline and the respondent's place of residence in Great Britain in 2023.

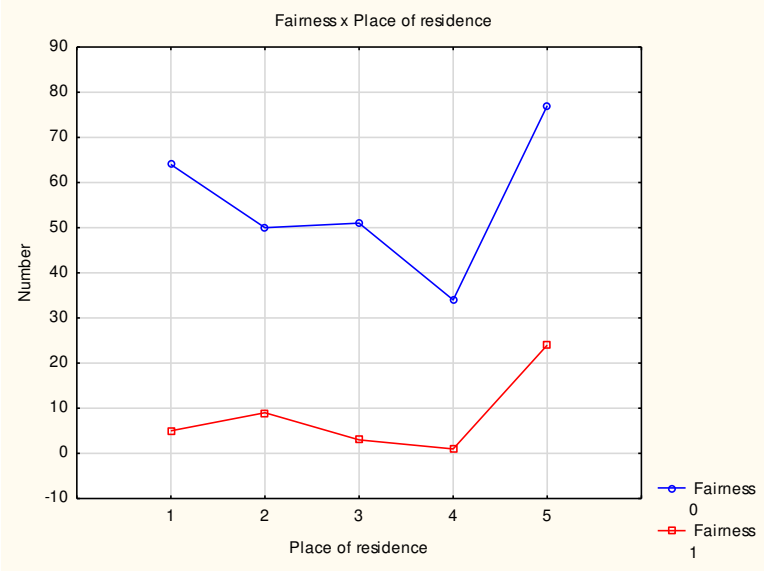
Source: own study.



where: 1. Village; 2. City up to 50 000 residents; 3. City up to 100 000 residents; 4. City up to 250 000 residents; 5. City over 250 000 residents.

Figure 9. Number of answers regarding the selection of features/competencies: Ability to manage emotions and the respondent's place of residence in Great Britain in 2023.

Source: own study.



where: 1. Village; 2. City up to 50 000 residents; 3. City up to 100 000 residents; 4. City up to 250 000 residents; 5. City over 250 000 residents.

Figure 10. Number of answers regarding the selection of features/competencies: Fairness and the respondent's place of residence in Great Britain in 2023.

Source: own study.

In conclusion, the calculated Pearson Chi-square indicators in Poland (Table 3) and the Great Britain (Table 4) differ significantly. However, this result should be treated with caution due to the small number of responses.

Discussion & conclusion

The analysis of the literature allowed to confirm that the research topic undertaken by the authors is important, and the number of studies focusing on it is systematically growing. It can also be noticed that more and more in-depth research topics are being undertaken, exploring various areas of the functioning of Generation Z representatives on the labor market. Some of the research focuses on identifying the expectations of Generation Z towards the conditions of their work. What is lacking, however, are studies dealing with the correlation between the respondent's gender or place of residence and his/ her expectations regarding the features and competencies that a direct supervisor should have. Generation Z representatives have a very precise idea what are the rules their work should be based on, as well as what qualities and competencies their direct supervisor should have. If their expectations are not met, they do not hesitate to change their workplace. Acquiring talents on the labor market and keeping them in the organization for a long time requires direct supervisors to know about the features and competencies that Generation Z expects from them. The conducted study made it possible to identify the features and competencies of direct supervisors desirable for the Generation Z. Main conclusions resulting from the analysis of the collected empirical data in relation to the research questions posed are presented in Table 5.

Table 5.
Summary of the study results obtained, by research questions

Research question	Answer – Poland	Answer – Great Britain
Q1. In the opinion of Generation Z representatives -what features and competencies should a direct supervisor have?	Desirable features and competencies: – creativity, – honesty, – broad general knowledge, – communication skills, – responsibility. Least desirable features: – high self-esteem, – enforcing obedience, – focus on rivalry and competition, – attractive appearance, – self-discipline.	Desirable features and competencies: – honesty, – consistency, – creativity, – communication skills, – treating employees as partners. Least desirable features: – focus on rivalry and competition, – enforcing obedience, – ability to set goals, – attractive appearance, – assertiveness, – ability to impact/affect others.

Cont. table 5.

Q2. Does the gender of the Generation Z representative affect the choice of desired features/competencies of the direct supervisor? If yes, how?	In four cases, gender significantly differentiated the analyzed variables. Women significantly more often than men chose: treating employees as partners. Men significantly more often than women chose: – charisma, – focus on rivalry and competition, – entrepreneurship.	In fiver cases gender significantly differentiated the analyzed variables. Women significantly more often than men chose: – communication skills, – empathy, – high self-esteem. Men significantly more often than women chose: – ability to predict the consequences of their own and other people's actions, – firmness.
Q3. Does the place of residence of the Generation Z representative affect the choice of desired features/competencies of the direct supervisor? If yes, how?	In two cases place of residence significantly differentiated the analyzed variables. Rural residents significantly more often chose: – ethics, – self-discipline.	In four cases place of residence significantly differentiated the analyzed variables. City residents significantly more often chose: – creativity, – self-discipline, – ability to manage emotions, – honesty.

Source: own study.

The presented study results broaden the knowledge about the expectations of Generation Z representatives towards the features and competencies of their direct supervisors. Despite the differences in the answers of respondents representing Poland and Great Britain, similarities can also be noticed. Respondents in both surveyed countries considered *honesty*, *creativity*, and *communication skills (including the ability to listen)* to be the most desirable features and competencies of direct supervisors. As the least desirable they indicated *enforcing obedience*, *focus on rivalry and competition*, and *attractive appearance*. Men's assessment differed from women's assessment.

These results are consistent with the analyzed results of research by other authors when it comes to indicating the features and competencies of direct supervisors, desirable for Generation Z (Sladek, Grabinger, 2014; Gabrielova, Buchko, 2021; Rybowska, 2016; Gajda, 2017; Jensen, 2021; Humanitas, 2023). On the other hand, the research results presented in the paper complement the research conducted so far by identifying the correlation between the desirable features and competencies of direct supervisors, and the gender and place of residence of Generation Z representatives, as well as in Great Britain. The choice of desirable features/competencies of the direct supervisor was influenced by the gender of the Generation Z representative residing both in Poland and in the Great Britain. In Poland, women significantly more often than men chose *treating employees as partners*, however men significantly more often than women indicated *charisma*, *focus on rivalry and competition*, and *entrepreneurship*. In Great Britain women in this research group significantly more often than men chose *communication skills (including the ability to listen)*, *ability to feel what another person feels (empathy)* and *high self-esteem*, in turn, men more often than women

indicated *ability to predict the consequences of own and other people's actions*, as well as *firmness*. The place of residence of the Generation Z representative also affects the choice of desirable features/competencies of the direct supervisor. In Poland, rural residents significantly more often chose *ethics* and *self-discipline*; however in Great Britain city residents significantly more often chose *creativity*, *self-discipline*, *ability to manage emotions*, and *honesty*. The results of the study on the correlation between the respondents' answers and their gender, conducted by the authors, are inconsistent with the results of A. Rybowska's study (Rybowska, 2016), but they complement this study by indicating the correlation between the respondent's place of residence and his/her assessment of the features and competencies of his direct supervisor.

Presented results also indicate the differences in the features and competencies of direct superiors, desirable for Generation Z representatives in Poland and in Great Britain. It can therefore be concluded that the nationality of respondents is an important factor differentiating preferences and values in the workplace of Generation Z. These results underline the importance of managing diversity in enterprises and even the need to understand differences in the value of a multinational workforce. This may be a valuable clue for entrepreneurs, that a uniform approach to managing nationally diverse human resources, e.g. in international corporations where Generation Z often works, is ineffective.

Generation Z representatives have different expectations related to their work than representatives of previous generations. Without knowing and understanding the needs and style of their work, organizations will have difficulty not only in acquiring the talents of this group, but also in retaining them. The relationship between the direct supervisor (manager) and the generation Z representatives will largely determine the success of cooperation.

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EFFECTIVENESS OF SOCIAL MEDIA PROFILES OF PUBLIC INSTITUTIONS AS A FACTOR IN BUILDING AN EFFICIENT FUTURE COMMUNICATION STRATEGY

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Purpose: Current digital transformation processes dynamically influence the development of new business models. The future public service processes means the need to redefine the traditional concepts of communication and e-service models. The article is an attempt to answer the research question: is the use of future communication channels by main city halls in Poland effective? Which content/information guarantee the effective construction of communication management?
Design/methodology/approach: The research is based on quantitative and qualitative methods. The effectiveness of communication of public institutions' activity on social networking sites were examined by statistical methods such as the DEA (Data Envelopment Analysis) methods, while the triangulation method was used to analyse the published content.
Findings: The scope of the research covers the effectiveness of public institutions' promotional and information activities that use modern and digital technologies as a tool for communication. The results of the analysis indicate which cities use social media tools to build effective communication with the citizens considering the type of published content.
Research limitations/implications: The added value for the continuation of the research is the assessment of the effectiveness of the achievement of goals by applying a dynamic analysis of the effectiveness of time series in the form of the input-oriented Malmquist Productivity Index (MPI).
Practical implications: The results of the analysis can be used to build more effective communication channels for the interactive exchange of knowledge, information and e-services between public institutions and citizens, as well as to effectively create knowledge and build a new model of customer relationships management.
Originality/value: The results of the analysis of the effectiveness of communication on social platforms are the first considering a content group. The effectiveness of posts was analyzed due to the type of content. The detail of the analysis because of the content is precisely the original value of the article.

Keywords: digital communication; information strategy, public e-service; social media.

Category of the paper: Research paper.

1. Introduction

The business challenges of today's market are mainly oriented towards offering value (product, service), which is characterized by complexity and flexibility. Flexibility is seen as the willingness to change according to the dynamically changing needs and expectations of the customer. Currently, such value is offered by digital services, for which operational business models are being created focused on building the optimal value of personalized service. That's why today the current digital transformation processes have a dynamic impact on the development of new business models. Future public service processes necessitate the revision of traditional communication and e-service models (Jabłoński, Jabłoński, 2020; Dohrmann, Raith, 2015).

The public sector is an integral part of the national economy of any country. Regardless of the concept of the state adopted, the fulfilment of public tasks by the state requires special organizational structures. The main and fundamental elements of the public sector are the state, local governments and entities of mixed ownership, which in their activities provide services related to ensuring universal access to educational, social, health and other services for citizens to meet public needs. This fact compels us to Tools need to be developed, by which the effectiveness and efficiency of communication of public institutions in carrying out their tasks can be assessed.

New public management (NPM) models and models based on participatory management concepts, such as good governance (European Commission, 2007), new public governance or new public services (NPS), consider the role of citizens as clients and partners of public institutions. Viewed in this light, public institutions contribute to the effective and successful delivery of their missions and ultimate goals jointly developed with their stakeholders when they act in an innovative, participatory, compliant and ethical manner and ac-countable for their mandates. Citizens provide added value (Strąk, 2021).

To date, no generally accepted method for assessing the profitability of operating utilities has been developed. It is widely recognized in the literature (Kleer, 2005) that there is a need to measure the success of public institutions using the categories of efficiency and effectiveness in order to achieve their statutory objectives and meet the needs of their stakeholders at the lowest possible cost (Kaplan, Norton, 2006). However, the performance evaluation of public institutions and the research findings to date have sparked numerous controversies and controversies.

Due to the specificity of public entities and the potential to use innovative technological solutions, the performance evaluation of these entities in the field of digital models of public services is mainly considered in the context of information management. Social media communications models refer to the intended use of information technology for such activities as searching for customers, building relations, communication, in-forming and providing, and

exchanging offers. The feature used by social media as electronic communication technology is to provide interactive opportunities to post comments or other content and rate the content (Chaffey et al., 2009). Boyd and Ellison (2007) describe social networking sites as "Web-based services that allow individuals to create public profiles in a comprehensive system, create lists of other users with whom they share connections, and list their views and search connections".

The statistical data show more than 4.26 billion people worldwide use social media in 2021, and this number is expected to increase to nearly 6 billion by 2027. Social networking is one of the most popular digital activities in the world, and it's no surprise that social networking adoption is growing steadily across all regions. In January 2020, the global social media usage rate was 49%. This number is expected to increase as less developed digital markets catch up with other regions in terms of infrastructure development and the availability of cheap mobile devices. Social media has become an integral part of everyday internet use. On average, Internet users spend 144 minutes per day on social media and messaging apps, an increase of more than half an hour since 2015. Market leader Facebook was the first social network to cross the 1 billion registered accounts mark and currently has around 2,7 billion monthly active users, making it the most popular social network in the world (https://www.statista.com, 2022).

This paper presents the findings of a study on the effectiveness of information and promotional campaigns for 18 Voivodeship Town Halls in Polish social media. The use of social media tools to promote public services and build a successful communication is consistent with the premise of participatory management concepts. The accountability of the tasks performed is based on a model of the effectiveness of the social media sites used by the municipality, using the data envelopment analysis (DEA) method to measure the ratios of the results obtained and their impact to the inputs received (Pollitt, Bouckaert, 1999) For public institutions, success is measured by delivering value to the widest possible range of citizens, as measured by the number of respondents.

2. Materials and Methods

The professional literature justifies the implementation of electronic public administration services using the NPM concept. Advertising and information campaigns should reach as many recipients as possible. Reasons for using IT tools and social media: saving time, diversifying choices and diversifying service offerings, convenience, overcoming geographical and time barriers, saving money (Kotnis, 2020, pp. 85-98). There is no doubt that society's needs and ways of life determine the nature, form and extent of communication online public services. Due to globalization and consumerism, young societies are looking for new social models and attitudes. Mobility, active leisure behavior and the use of information and communication technologies are the main features of the lifestyle of modern society, which make social

activities carried out more consciously and responsibly. Therefore, meeting the needs of today's citizens requires a similar style of communication. Today's communication is based on media convergence, which can reach target groups through multiple channels, so that various contents can complement and promote each other, and broadcasters can engage in dialogue with decision makers.

The methodology used in the study is related to the analysis of website management on social media platforms operated by municipal offices in the provinces of Poland. The aim is to study the phenomenon of information campaign effectiveness, as well as its dynamics and relevance in the Facebook community of the units studied. For research design, the question to be answered is how to "translate" the research question of analysis into the language of actionable concepts and research questions, and which methods and tools should be used to achieve the goal.

The most commonly used method belongs to non-parametric methods and is data envelopment analysis (DEA). It allows analysis of the efficiency of a limited number of decision-making units (DMUs). For example, decision makers are companies, public institutions, schools, libraries, hospitals and bank branches. The DEA method is suitable for companies pursuing the same goals and operating under the same market conditions. Furthermore, the factors characterizing their activities are the same except for the range and intensity of consumption (Ćwiąkała-Małys, Nowak, 2009). In the case study, the decision makers were the 18 selected town halls. In general, the DEA method is used most of the time for efficiency analysis, but works that use the DEA method to measure the effectiveness of a specific group of decision-making units can also be found (Moravcikova, Krizanova, 2019).

In the DEA model, the efficiency (in our case – effectiveness) of a given object is defined as follows (Cooper, Seiford et al., 2007):

$$U_q = \frac{Weighted \sum of\ outputs}{Weighted \sum of\ inputs} = \frac{\sum_{i=1}^{r} \mu_i y_{iq}}{\sum_{j=1}^{m} v_i x_{jq}} = \frac{\mu_1 y_{1q} + \mu_2 y_{2q} + \cdots + \mu_r y_{r}}{v_1 x_{1q} + v_2 x_{2q} + \cdots + v_m x_m} \quad (1)$$

where:
r – the number of outputs,
m – the number of inputs,
y_r – output values,
x_m – input values,
μ_r – the weights of outputs,
v_m – the weights of inputs

During the analyse it was possible to identify a source of determining inefficiency while determining how a production unit can become effective by reducing/increasing inputs or outputs. It also states that the number of decision units should be three times greater than the sum of their inputs and outputs (Bartošová, Kral, 2007, pp. 151-163).

3. Data Collection, Inputs and Outputs

The study was based on multi-criteria data analysis to present quantitative relationships among interactions. Institutions included in the study were selected considering the e-service priorities of the public administration, within which a single market for digital information services is currently being created. Other factors that determine the choice of a public institution for research are the range of services offered and the field of activity of a particular institution. As part of the research, statistical data from the town hall's social network profiles were analysed, as well as a qualitative analysis of published posts. Based on observations and interviews, it has been suggested that public institutions that keep personal data share their activities in a similar way. In addition, social network trends and technological possibilities are taken into account, which form the basis for determining the most posted topics. To achieve the research objectives, the authors identified six feature article groups for four main areas of published information:

1. Public e-services: posts informing about public projects and competition, participatory budget – messages directly aimed at citizens, e.g., informing of a participatory budgets, competition, inviting to an local event, weather alerts; posts informing about a municipal or citizens' initiative and ecology issues or changes in public transport – these posts inform citizens about social, municipal and environmental events;
2. Ex-ante Information: posts informing about upcoming cultural and entertainment events and anniversary celebrations;
3. Ex post Coverage: coverage of events attended by public authorities and politicians; coverage of events attended by local community members – the presence of residents is highlighted in the post;
4. Photo/Panorama: photos/city panorama/film promoting local attractions – promotion of the city or landmark;

A quantitative analysis was performed for the six identified thematic groups, and the effectiveness of the maintained profiles was evaluated. Quantitative data were analyzed as part of the research to describe the activity on the website: frequency of posts, activity, and intensity of interaction. The research findings depict office activity on social networking sites in September 2021. The month was chosen because September is the most active business month in Poland, with no international, national, or religious holidays interfering with the working rhythm. It is a time of active and intense business activity. Because of this, business and marketing activities in both the public and private sectors are the most goal-oriented.

The DEA study's inputs and outputs had to be carefully chosen because they could affect the distribution of effectiveness. Measuring the effectiveness of city halls' use of Facebook to promote their brands may be difficult. City halls rarely collect data on the impact of social media outcomes on brand promotion. As a result, the output is measured using the intermediate

results of a city hall's Facebook page. As a result, the inputs are the types of information published by city halls on their Facebook pages, and the output is the Likes, Comments, and Shares made by fans on the comments posted. The inputs and outputs model is following described:

- The input total number of post “E-services” deliver the output Likes = ∑(number of Likes posted/number of followers), Comments = ∑(number of comments posted/number of followers) and Sharing ∑(number of shares posted/number of followers);
- The input total number of post “Ex-ante information” deliver the output Likes = ∑(number of Likes posted/ number of followers), Comments = ∑(number of comments posted/number of followers) and Sharing ∑(number of shares posted/number of followers);
- The input total number of post “Ex-post coverage” deliver the output Likes = ∑(number of Likes posted/ number of followers), Comments = ∑(number of comments posted/number of followers) and Sharing ∑(number of shares posted/number of followers);
- The input total number of post “Photo/panorama” deliver the output Likes = ∑(number of Likes posted/number of followers), Comments = ∑(number of comments posted/number of followers) and Sharing ∑(number of shares posted/ number of followers);

The variables output Likes, Comments, and Shares represent the number of Likes, Comments, and Shares considering the number of fans for each specific post. Because the number of fans on Facebook varies by city, these variables are used in the study rather than the number of Likes, Comments, and Shares. The research was divided into three stages:

1. First stage – examining of a general model (Model 1). Model 1 used three input variables (the total number of posts titled "E-services," the total number of posts titled "Ex-ante information" + "Ex-post coverage", and the total number of posts titled "Photo/panorama") and three output variables (Likes, Comments, and Shares);
2. Second stage - examining of an effectiveness of Models 2, 3, 4, and 5. These models show the effectiveness of each category of promotional activity in the cities studied. Except for Model 2, which used two input variables and three output variables, almost all of the models in this group examined one input variable and three output variables (Likes, Comments, and Shares);
3. Third stage - the effective/efficient analysis, which is performed for models with one summary input variable (the number of posts) and three output variables (Likes, Comments, and Shares) for Model 6.

Table below shows the input and output variable selection scheme for each model.

Table 1.
Determinants of effectiveness in each model

Inputs	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Total number of post "E-services"	√					
Total number of posts about the project		√				
Total number of posts about municipal initiatives		√				
Total number of post "Ex-ante information"	√		√			
Total number of post "Ex-post coverage"	√			√		
Total number of post "Photo/panorama"	√				√	
Total number of posts in all categories						√
Inputs						
Likes= ∑ (number of Likes posted/number of followers)	√	√	√	√	√	√
Comments=∑ (number of comments posted/number of followers)	√	√	√	√	√	√
Sharing ∑ (number of shares posted/number of followers)	√	√	√	√	√	√

4. Results

EMS Software (Scheel, 2000) was applied to conduct the effectiveness analysis. For the first stage of analysis (Model 1) a general DEA model has been chosen. This model includes four inputs (total number of post "E-services," total number of post "Ex-ante information" + "Ex-post coverage", and total number of post "Photo/panorama") and three outputs was chosen (Likes, Comments, and Shares). This model provides an overall value of average effectiveness as well as a clear way to differentiate between the units (city halls). Table 2 shows the results for the year 2021 in terms of the effectiveness of various city halls, with a descriptive analysis of the effectiveness coefficients, where 100% means effectiveness.

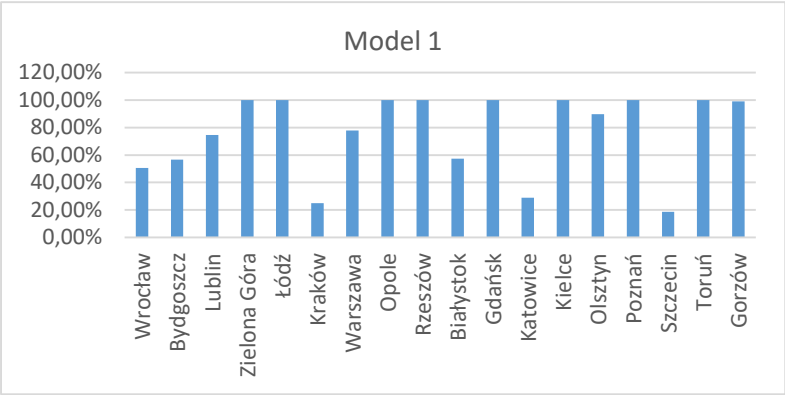

Figure 1. DEA effectiveness scores of posts about public e-services (Model 1).

Source: Autor's own work.

In the first stage of the research, Model 1 was examined, and the research results indicate a list of 8 out of 18 voivodship cities in Poland that managed to achieve full effectiveness of published posts. This means that all posts from each group received a relatively large number of responses. These are the cities that have reached the 100% indicator, i.e Zielona Góra, Łódź, Opole, Gdańsk, Kielce, Poznań, Toruń, Rzeszów.

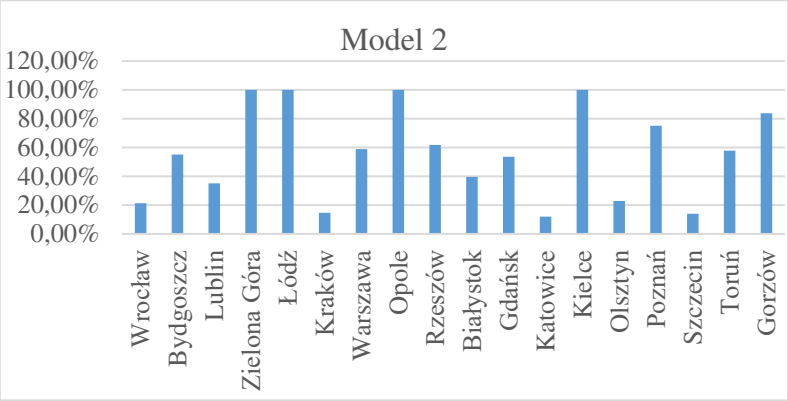

Figure 2. DEA effectiveness scores of promotional activities about the public projects and municipal initiatives (Model 2).

Source: Autor's own work.

In the second stage of the analysis, the effectiveness of promotional activities was examined by dividing them into particular groups of inputs (Models 2-5). In the group of "e-services" posts (Model 2), where two categories of inputs defining the promotion of e-services were taken into account, the most effective were Opole, Łódź, Zielona Góra and Kielce. These two categories of posts inform about public services and e-services offered by municipal offices. From the point of view of the purpose of government and government institutions, these are the most important categories of posts in the area of building effective communication between public institutions and citizens.

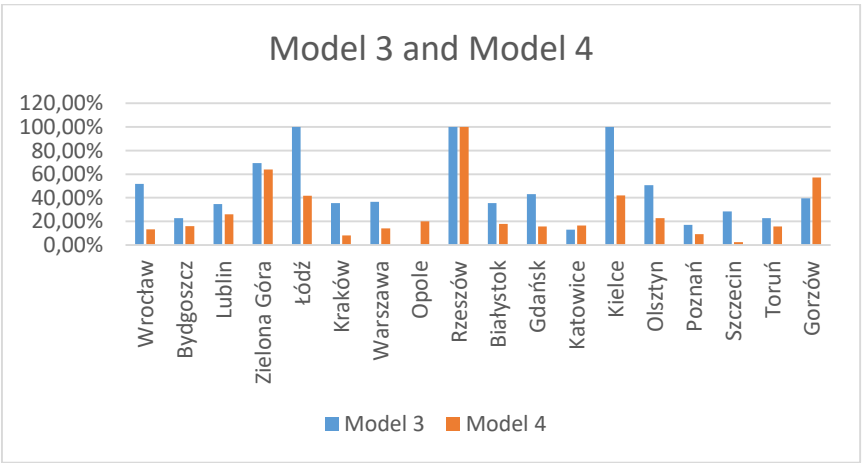

Figure 3. DEA effectiveness scores of promotional activities about the ex-ante information (Model 3) and ex-post coverage (Model 4).

Source: Autor's own work.

In the group of posts from the "Ex-ante information" category (Model 3), the cities of Łódź, Rzeszów and Kielce are effective in their online activities. The results of the analysis indicate that these cities effectively implement marketing activities by promoting cultural and educational events. The greatest activity of residents on the social profile of these cities indicates a high level of interest. The city Opole didn't published some post in the analyzed period. In Model 4, where the effectiveness of "Ex-post coverage" posts was examined. This group of posts was included because of the fact, the social media can be an upcoming tool for political marketing effectiveness (Safiullah, Pramod et al., 2017). In this Model only Rzeszów achieved 100% effectiveness. In Model 5 – the category of posts "Photo/panorama". In this model, the city of Łódź and Toruń proved to be the leader. Due to a lack of data, Opole were not analyzed.

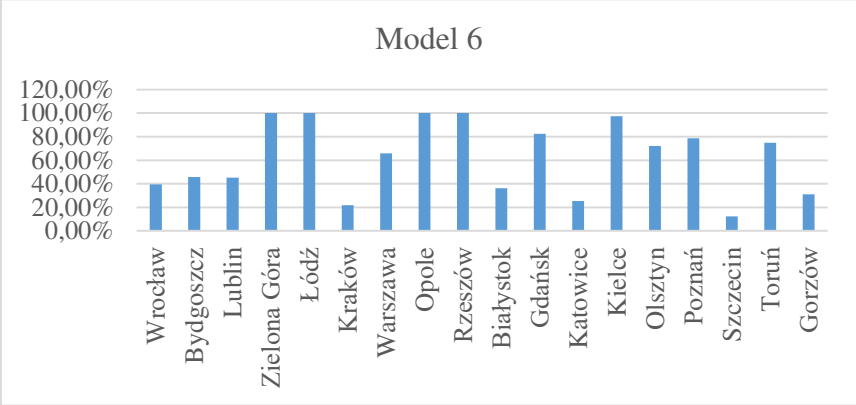

Figure 5. DEA effectiveness scores of the analyze with one summary input variable and three output variables (Model 6).

Source: Autor's own work.

In the third stage of the analysis, calculations were performed on the accumulated monthly data, thus creating a model with one input (total number of posts) and three results for Facebook (Model 6). In this Model the city of Opole and Rzeszów proved to be the leader. The results of Model 6 indicate a city that is able to effectively and to the greatest extent engage the local community in the information and communication activities of the city hall.

4. Discussion

The scope of the research covers the effectiveness of public institutions' promotional and information activities that use modern and digital technologies as a tool for communication. The results of the analysis indicate which cities use social media tools to build effective communication with the citizens. In addition, during the research, attention was paid to the possibility of increasing the effectiveness of these activities when the names of social profiles of city offices will clearly indicate these institutions. An example may be the profile of the

Szczecin City Hall, which is run under the name: Szczecin Floating Garden. For the purposes of the research, an additional analysis was carried out among respondents aged 19-25, asking the question: Why is the name of the profile of the city of Szczecin named Szczecin Floating Garden? Over 96% did not know the correct answer. Thus, the transparency and information efficiency of the institution may significantly decrease.

In order to obtain a full picture of the changes taking place in the level and effectiveness of the use of digital technologies of public institutions in promotional and information activities, research should be continued over a longer period of time in order to examine the dependencies and dynamics of changes. The added value for the continuation of the research is the assessment of the effectiveness of the achievement of goals by applying a dynamic analysis of the effectiveness of time series in the form of the input-oriented Malmquist Productivity Index (MPI) (Lee, 2011). Additional it seems important to extend the research with the analysis of published content. Text Mining analysis using, for example, the R language seems to be helpful. Thanks to the extended research procedure, it will be possible to identify posts containing specific content, grouping, clustering, identifying links and visualization (Lula, 2005). Research is an important contribution to science. The research results justify the use of digital technologies and modern communication platforms for the effective operation of public institutions.

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JOB CRAFTING AMONG EMPLOYEES OF ENTERPRISES IN THE UPPER SILESIAN-ZAGŁĘBIE METROPOLIS (GZM) AREA

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Purpose: The aim of this article is to find out whether job crafting occurs among employees of small and medium-sized enterprises (SME) in the Upper Silesian-Zagłębie Metropolis (GZM).
Design/methodology/approach: The study used the Job Crafting Questionnaire, based on the Job Crafting Scale (JCS), designed to measure the transformation of work conceptualised within the model: job demands-resources. The questionnaire covers three forms of job crafting: crafting tasks, relationships, and cognitions about work. Descriptive statistics (M, Me, SD, S, r), the Mann-Whitney test, and Student's t-test were used in the analysis of the results. A significance level of $\alpha = 0.05$ was adopted in applying the statistical tests.
Findings: The results obtained confirm that SME employees in the GZM do craft their jobs, most strongly in the task and cognitive crafting dimensions, and to a lesser extent in the relational dimension. Statistically significant SME differences were found for three statements (two on task crafting, one on cognitive crafting) – the average score for medium-sized enterprises was higher compared to small enterprises.
Research limitations/implications: The study was conducted only among SMEs in the GZM area. Omission of other types of organisations may affect the completeness of the analysis. In future, it would be worthwhile to include a more diverse sample that includes different sizes of enterprises. Additional research methods, e.g., in-depth interviews, could be considered.
Practical implications: The results of the survey constitute an important contribution to understanding the current situation and identifying the needs that characterise small and medium-sized enterprises operating in the GZM area.
Social implications: Job crafting practices can be an important tool in improving employee-work relations and can serve to strengthen work engagement.
Originality/value: Although the issue of job crafting has featured in academic publications for some time, little empirical research has been conducted on the subject. The results obtained in this study add to the body of knowledge about actual job crafting practices in the context of small and medium-sized enterprises operating in the GZM area. The results may be relevant for managers – discovering that employees are active in shaping their work may encourage employers to create conditions that foster such activities.

Keywords: job crafting, small and medium-sized enterprises, Upper Silesian-Zagłębie Metropolis.

Category of the paper: research paper.

1. Introduction

Job crafting, as an expression of positive interactions at work, has been a subject of growing interest among both researchers and practitioners for several years (Rogala, Cieślak, 2019). In the Polish literature, job crafting is sometimes referred to as 'kształtowanie pracy' (Kasprzak, Michalak, Minda, 2017; Minda, Kasprzak, 2018) or 'przekształcanie pracy' (Rogala, Cieślak, 2019). Job crafting is based on the assumption that greater employee effectiveness, but also greater job satisfaction and employee well-being, depends to a large extent on the creative potential and self-initiative of employees at each level of an organisation. In job crafting, the employee takes the initiative to adapt the work they perform to their own needs, requirements and resources (skills, competencies, talents), which involves physical and cognitive modification of work activities and tasks, resulting in work gaining a personal dimension (Berg et al., 2010) and adapting to the individual preferences of employees. The actions taken by the employee are conscious and purposeful, and have the character of proactively-introduced changes (Bruning, Campion, 2018), which help employees to maintain, but also increase, their motivation and energy for work. The key aspect of job crafting is that it is the employee who takes the initiative in shaping the work, not the supervisor, as for example in the job enrichment method (Slemp, Vella-Brodrick, 2014). By undertaking the shaping of their own work, employees expand their resources, grow, and take on new challenges (Hakanen, Peeters, Schaufeli, 2018). In the simplest terms, job crafting can be defined as an employee making physical and cognitive changes to the tasks or relationships within the work they perform (Wrześniewski, Dutton, 2001).

2. Literature review

Job crafting generates a number of benefits, not only for the employee but also for the employer. It influences the experience of positive emotions and the development of positive attitudes towards work (Ko, 2011; Van de Riet, 2015), increased job satisfaction and enjoyment (Berg et al., 2010), employee engagement (Bakker et al., 2012; Leana et al., 2009; Tims et al., 2012), more effective functioning under time pressure and stress, the development of social relationships (Slemp, Vella-Brodnik, 2014), reduced levels of burnout, reduced levels of absenteeism from work, better coping with change, increased efficiency (Ghitulescu, 2006; Tims, Bakker, Derks, 2014), increased creativity (Hu, Wang, Long, 2020), reduced boredom (Oprea, Barzin, Virga, Iliescu, Rusu, 2019), professional development in a positive direction (Bakker, Demerouti, 2014), enhanced well-being (Boehnlein, Baum, 2020), and the sense of meaning in one's work. Taking responsibility for one's well-being at work and giving meaning

to one's duties are some of the key needs of an employee (Wrześniewski, Dutton, 2001), also influencing increased involvement in shaping work. Employees know what duties they perform and how they perform them, so they themselves can create their optimal working environment and intervene, when necessary, to prevent negative outcomes such as reduced motivation or productivity (Berings, De Fruyt, Bouwen, 2004).

Based on the model of job crafting outlined by A. Wrzesniewski and J. Dutton (2001), three forms of job crafting can be identified: task crafting, which involves changing the number, type or nature of tasks; relational crafting, which involves changing the number, type and intensity of relationships and the style of interaction; and cognitive crafting, which involves changing the perception of tasks and their meaning.

A number of factors, both those related to the individual (Bandura, Lyons, 2014) and to the nature of the job (Lyons, 2008) and its demands (Petrou et al., 2012), influence employees' engagement in job crafting activities.

Therefore, the right circumstances must be present for work-shaping activities to be undertaken (Wrześniewski, Dutton, 2001). First and foremost, the employee must feel the motivation necessary to take action. This motivation can be driven by the needs for: control, meaningful work, positive self-esteem, cooperation with others, and a sense of fulfilment and self-development. Another important element is the employee's belief that change can be made, so the employee must have some autonomy to act. In addition, the less control from superiors and the more freedom of action the employee experiences, the more likely they are to be open to introducing work-improving changes themselves from the bottom up. It is also emphasised that personality traits such as, for example, a belief in one's self-efficacy (Roczniewska, Rogala, Puchalska-Kaminska, Cieślak, Retowski, 2020) and a proactive personality (Rudolph, Katz, Lavigne, Zacher, 2017; Xu, Jiang, Wang, 2019) are very important for taking action towards job crafting.

Feedback and support from superiors for the employee are also not insignificant (Ghitulescu, 2013). Enabling employees to modify and personalise the work they perform also fosters a positive atmosphere at work and mutual relationships based on partnership, mutual respect, and trust. On the other hand, engaged employees may be more proactive and willing to do more than others to shape their own work (Hakanen, Perhoniemi, Toppinen-Tanner, 2008).

It is significant that job crafting is not a one-off or incidental activity, but a continuous and systematic process (Wrześniewski, Dutton, 2001; Kasprzak, Michalak, Minda, 2017).

Undoubtedly, job crafting encourages employees to connect their work to their individual predispositions, interests, values, or talents. In addition to the previously mentioned range of positive effects of job crafting, the employee's joy and pride in the tasks they perform cannot be ignored.

3. Methods and Materials

Taking into account the impact of job crafting on, among other things, organisational effectiveness, work atmosphere, risk-taking ability, employees' level of commitment, and loyalty to the organisation, a study was conducted among employees of small and medium-sized enterprises in the Upper Silesian-Zagłębie Metropolis to find an answer to the question of whether job crafting occurs among employees of small and medium-sized enterprises in the GZM. The survey also sought to answer the question of what job crafting behaviours are used by employees of these organisations. The research tool used was the Polish version of a scale — the Job Crafting Questionnaire ('kwestionariusz kształtowania pracy', KKPracy) – based on the *Job Crafting Scale (JCS)* (Tims, Bakker, Derks, 2012), a scale that measures job crafting conceptualised within the 'job demands-resources' model and was designed based on the results of an exploratory factor analysis and validated by the results of a confirmatory factor analysis. The questionnaire covers three forms of job crafting: crafting tasks, crafting relationships, and crafting cognitions about work. The research process was guided by some of the tenets of grounded theory.

The analysis of the survey results was carried out, firstly, using basic descriptive statistics (arithmetic mean [M], median [Me], standard deviation [SD], skewness coefficient [S], and Pearson's linear correlation coefficient [r]). Secondly, the comparison between small and medium-sized enterprises was made using the Mann-Whitney test, a test which is used to compare two populations from the point of view of a variable measured on an ordinal scale, but also when the studied phenomenon is quantitative but shows significant deviations from a normal distribution (Wiktorowicz, Grzelak, Grzeszkiewicz-Radulska, 2020); in this case, it was used to compare responses to individual questions on job shaping. Additionally, the Student's t-test for independent samples was used to compare variables measuring job crafting in aggregate – overall and within three subscales. The significance of the relationship was assessed using the Student's t-test. A significance level of $\alpha = 0.05$ was adopted in applying the statistical tests.

The metric properties of the tool for measuring job crafting were confirmed using exploratory factor analysis (validity) and Cronbach's alpha coefficient (reliability). Exploratory factor analysis (EFA) assesses whether and which subscales of variables should be distinguished within a given scale (Tabachnick, Fidell, 2007). The sample size is appropriate for this type of analysis (n = 500) (Comrey, Lee, 1992). After checking the initial conditions, i.e., the correlation between the scale items, using, among other tools, the KMO measure (Kaiser-Meyer-Olkin Measure of Sampling Adequacy, which should be above 0.5) and Bartlett's Test of Sphericity, in which $p < \alpha$ is expected (Wiktorowicz, 2016), the model parameters were estimated using the principal components method (an adaptation of Hotelling's method for the purpose of factor analysis) (Walesiak, Bak, 1997). The number of factors was

confirmed using the Kaiser-Cattell criterion (scree plot), while in order to find a solution (indicate items related to a given factor), a factor rotation (varimax) was performed (Wiktorowicz, 2016). The Cronbach's alpha coefficient (Cronbach's alpha) used to assess reliability can take values in the range [0; 1], and 0.7 is usually taken as the threshold value (Rószkiewicz, 2011). Calculations were performed using IBM SPSS Statistics 28.0.

4. Sample composition

The study included 500 enterprises, of which 50.0% were small enterprises (10 to 49 people) and the other half were medium-sized enterprises (50 to 249 people). Approximately 70.0% of the respondents were women, while the remaining percentage were men. There is a similar distribution in enterprise size, with a slightly higher proportion of women in medium-sized enterprises compared to small enterprises (72.4% versus 68.8%). The majority of respondents were aged 35-44 (33.8%) and 45-54 (31.0%). The least numerous groups were those at the extremes of the age range, i.e., under 25 (2.0%) and 65 and over (2.2%). A similar distribution was observed in enterprise size. When analysing the job position, the vast majority (64.2% of the total, 62.8% of small enterprises, 65.5% of medium-sized enterprises) were employed as a specialist or independent worker. About 20.0% of the respondents were mid-level managers, while about 12.0% were executives. Those employed in other positions accounted for approximately 3.5% of the sample. More than 70.0% of the respondents were university graduates, regardless of the size of the enterprise. A high percentage was also represented by those with secondary education (24.4% of the total). Elementary education was held by 1.2% of the total respondents, while postgraduate education was held by 4.0% (with more than twice as many in medium-sized enterprises compared to small enterprises). Analysing the period of employment in the enterprise, more than 48.0% were those with a length of employment in the current company between 6 and 15 years. The smallest percentage were those working at the current enterprise for less than a year (5.8% of the total, 6.4% in small enterprises, 5.2% in medium-sized enterprises). It is worth noting the not insignificant percentage of those who worked at a surveyed enterprise for more than 20 years – 16.0% of the total. A similar distribution was observed when analysing overall length of employment. More than 43.0% of respondents had work experience of 6 to 15 years, with the most numerous group being those with work experience of more than 20 years (31.8% of the total, 30.0% in small enterprises, 33.6% in medium-sized enterprises).

Table 1.
Sample composition by enterprise size

Specification		Total		Small (from 10 to 49 people)		Medium-sized (from 50 to 249 people)	
		n	%	n	%	n	%
Total		500	100.0	250	50.0	250	50.0
Gender	Woman	353	70.6	172	68.8	181	72.4
	Man	147	29.4	78	31.2	69	27.6
Age	Up to 25 years old	10	2.0	7	2.8	3	1.2
	26-34 years old	83	16.6	40	16.0	43	17.2
	35-44 years old	169	33.8	86	34.4	83	33.2
	45-54 years old	155	31.0	73	29.2	82	32.8
	55-64 years old	72	14.4	39	15.6	33	13.2
	65 and older	11	2.2	5	2.0	6	2.4
Position	Specialist or independent worker	321	64.2	157	62.8	164	65.6
	Mid-level manager (e.g., coordinator, supervisor)	101	20.2	48	19.2	53	21.2
	Executive (e.g., director, president)	60	12.0	35	14.0	25	10.0
	Other	18	3.6	10	4.0	8	3.2
Education	Elementary	6	1.2	4	1.6	2	0.8
	Secondary	122	24.4	67	26.8	55	22.0
	Higher	352	70.4	173	69.2	179	71.6
	Postgraduate	20	4.0	6	2.4	14	5.6
	Tertiary	–	–	–	–	–	–
	Other	–	–	–	–	–	–
Length of employment in current company	Less than a year	29	5.8	16	6.4	13	5.2
	1-5 years	132	26.4	60	24.0	72	28.8
	6-10 years	109	21.8	59	23.6	50	20.0
	11-15 years	90	18.0	43	17.2	47	18.8
	16-20 years	60	12.0	31	12.4	29	11.6
	More than 20 years	80	16.0	41	16.4	39	15.6
Overall length of work experience	Less than a year	2	0.4	2	0.8	–	–
	1-5 years	33	6.6	17	6.8	16	6.4
	6-10 years	96	19.2	41	16.4	55	22.0
	11-15 years	120	24.0	63	25.2	57	22.8
	16-20 years	90	18.0	52	20.8	38	15.2
	More than 20 years	159	31.8	75	30.0	84	33.6

Source: own survey.

1. Job crafting in enterprises in the GZM area

Employees of small and medium-sized enterprises filled out the job crafting questionnaire. They assessed each statement on a scale of 1 to 6, where a higher score indicated a higher rating. Table 2 summarises the distributions of responses to each question and presents basic descriptive statistics, in total, for the entire sample.

Table 2.
Job crafting according to employees of small and medium-sized enterprises in the Upper Silesian-Zagłębie Metropolis

Statement	Percentage of responses per score						Descriptive statistics			
	1	2	3	4	5	6	M	Me	SD	S
I introduce new solutions to improve my work.	2.6	2.6	8.2	15.2	28.6	42.8	4.93	5	1.25	–1.25
I change the scope or type of tasks I perform at work.	10.6	8.0	12.2	19.6	23.6	26.0	4.16	4	1.63	–0.59
I take on new tasks that I think are better suited to my skills and interests.	7.0	4.8	13.0	20.8	25.0	29.4	4.40	5	1.49	–0.77
I decide to take on additional tasks at work.	4.4	5.6	8.0	17.2	29.8	35.0	4.67	5	1.40	–1.06
I prioritise tasks that match my skills and interests.	5.6	3.6	9.8	17.2	31.4	32.4	4.62	5	1.40	–1.06
I reflect on the meaning work gives to my life.	8.8	5.8	11.8	17.0	25.4	31.2	4.38	5	1.58	–0.79
I think about the importance my work has for the success of my company.	4.0	4.8	10.4	21.6	24.4	34.8	4.62	5	1.38	–0.89
I remind myself of the importance of my work to the broader community.	9.6	8.8	15.6	23.6	20.2	22.2	4.03	4	1.57	–0.43
I think about how work positively impacts my life.	4.8	4.8	11.0	18.4	28.8	32.2	4.58	5	1.41	–0.93
I reflect on the importance of work for my overall well-being.	3.8	3.8	11.8	16.8	27.2	36.6	4.70	5	1.37	–0.98
I make an effort to get to know the people at work better.	2.6	3.6	8.0	19.0	24.0	42.8	4.87	5	1.29	–1.11
I organise or participate in meetings with work colleagues outside of work as well.	11.0	8.2	14.2	15.0	22.4	29.2	4.17	5	1.68	–0.57
I organise special gatherings at the workplace (e.g., celebrating a colleague's birthday).	13.6	10.6	11.8	12.6	20.8	30.6	4.08	5	1.79	–0.49
I choose to mentor and help new employees (officially or unofficially).	4.2	4.2	10.4	15.2	31.2	34.8	4.69	5	1.37	–1.06
I form friendships with those colleagues at work who have similar skills or interests to mine.	9.0	8.2	12.2	18.2	25.8	26.6	4.23	5	1.59	–0.65

M – mean, Me – median, SD – standard deviation, S – skewness coefficient.

Source: own survey

Analysing the frequency distribution of ratings for each statement, it was observed that the predominant rating for each statement was '6' – the most for the statement 'I introduce new solutions to improve my work' – 42.8%, while the least for the statement 'I remind myself of the importance of my work to the broader community' – 22.2%. A slightly lower percentage of respondents rated statements at the '5' level. The lowest point ratings were given to the statement 'I organise special gatherings at the workplace (e.g., celebrating a colleague's birthday)' – 36.0% of respondents rated it at most '3'. Commenting on the results for descriptive statistics, similar conclusions were drawn. All statements were rated at a level higher than '4', with the highest-rated statement being 'I introduce new solutions to improve my work',

with an average score of 4.93, and the lowest-rated being ‘I remind myself of the importance of my work to the broader community’, with an average score of 4.03. For more than 86.0% of the statements, the median rating was ‘5’, meaning that half of the respondents assigned at most this rating. The remaining two statements have a median score of 4: ‘I change the scope or type of tasks I perform at work’ and ‘I remind myself of the importance of my work to the broader community’. Assessing the variation in the ratings, it is similar, with a range of 1.25 to 1.79 (highest for the statement ‘I organise special gatherings at the workplace (e.g., celebrating a colleague’s birthday’ and lowest for the statement ‘I introduce new solutions to improve my work’). Confirmation of the high ratings for the statements analysed is also provided by an analysis of the skewness of the ratings’ distribution. For all statements, the skewness coefficient is negative, which means that respondents were more likely to give ratings above the average level. The most symmetrical distribution of ratings was observed for the statement ‘I remind myself of the importance of my work to the broader community’, while the most asymmetrical distribution was observed for the statement ‘I introduce new solutions to improve my work’. Such a high asymmetry in the distribution of ratings for the statement ‘I introduce new solutions to improve my work’ is confirmed by the fact that more than 42.0% of the respondents assigned a rating of ‘6’ to this statement.

When comparing the distributions of the ratings assigned by the respondents in detail according to the size of the enterprise, it was observed that there were statistically significant differences in the ratings only in the case of the following three statements:

- I introduce new solutions to improve my work (p-value 0.002),
- I decide to take on additional tasks at work (p-value < 0.001), and
- I think about the importance my work has for the success of my company (p-value 0.027).

The first two statements are about task crafting. In both cases, the average score for medium-sized enterprises was statistically significantly higher compared to small enterprises (for new developments 5.08 vs 4.78, while for additional tasks 4.86 vs 4.49). In turn, the third statement concerns crafting cognitions about work. In this case, the average score for medium-sized enterprises was 4.77 vs 4.48 for small enterprises. For the rest, the distributions of ratings did not differ significantly by enterprise size.

In the case of the statement ‘I introduce new solutions to improve my work’, the average rating given by employees of medium-sized enterprises was 5.08 while that given by employees of small enterprises was 4.78. Employees of small enterprises gave a higher percentage of low ratings to this statement, while those of medium-sized enterprises gave correspondingly higher ratings (the percentage of ratings of at most ‘3’ for small enterprises is 16.0% and for medium-sized enterprises 10.8%; the percentage of ratings above ‘3’ for small enterprises is 84.0% and for medium-sized enterprises – 89.2%). The biggest difference in ratings was observed for the statement ‘I decide to take on additional tasks at work.’ The average rating among employees of medium-sized enterprises was 4.86 compared to 4.49 for small enterprises. In the case of

medium-sized enterprises, respondents gave a higher percentage of ratings of at least '5' for this statement (57.2% – small enterprises, 72.4% – medium-sized enterprises). The last statement for which a statistically significant difference in ratings was noted was 'I think about the importance my work has for the success of my company.' The average rating in small enterprises was 4.48, while in medium-sized enterprises it was 4.76. Employees of small enterprises were more likely to give ratings of at most '3', while employees of medium-sized enterprises were more likely to give ratings above '3'– (see Table 3).

Table 3.
Job crafting according to employees of small and medium-sized enterprises in the Upper Silesian-Zagłębie Metropolis

Statement	Small (10-49 people)				Medium-sized (50-249 people)				p-value
	M	Me	SD	S	M	Me	SD	S	
I introduce new solutions to improve my work.	4.78	5	1.27	-0.95	5.08	5	1.21	-1.64	0.002*
I change the scope or type of tasks I perform at work.	4.08	4	1.60	-0.48	4.23	5	1.66	-0.72	0.201
I take on new tasks that I think are better-suited to my skills and interests.	4.41	5	1.48	-0.80	4.40	5	1.51	-0.75	0.978
I decide to take on additional tasks at work.	4.49	5	1.41	-0.87	4.86	5	1.36	-1.30	<0,001*
I prioritise tasks that match my skills and interests.	4.54	5	1.42	-0.97	4.70	5	1.38	-1.17	0.178
I reflect on the meaning work gives to my life.	4.30	5	1.57	-0.68	4.46	5	1.59	-0.91	0.191
I think about the importance my work has for the success of my company.	4.48	5	1.42	-0.80	4.76	5	1.33	-0.98	0,027*
I remind myself of the importance of my work to the broader community.	4.02	4	1.57	-0.40	4.03	4	1.58	-0.47	0.956
I think about how work positively impacts my life.	4.56	5	1.41	-0.85	4.60	5	1.40	-1.01	0.737
I reflect on the importance of work for my overall well-being.	4.65	5	1.39	-0.85	4.74	5	1.35	-1.12	0.466
I make an effort to get to know the people at work better.	4.76	5	1.32	-0.95	4.97	5	1.26	-1.30	0.057
I organise or participate in meetings with work colleagues outside of work as well.	4.02	4	1.72	-0.42	4.32	5	1.63	-0.73	0.052
I organise special gatherings at the workplace (e.g., celebrating a colleague's birthday).	4.05	4	1.79	-0.43	4.12	5	1.79	-0.55	0.714
I choose to mentor and help new employees (officially or unofficially).	4.60	5	1.37	-0.97	4.78	5	1.36	-1.17	0.075
I form friendships with those colleagues at work who have similar skills or interests to mine.	4.16	4	1.57	-0.55	4.31	5	1.62	-0.76	0.191

M – mean, Me – median, SD – standard deviation, p – Mann-Whitney test probability, * statistically significant differences ($\alpha = 0.05$).

Source: own survey.

2. Evaluation of the properties of the job crafting measurement tool

Exploratory factor analysis and reliability analysis were used to assess the properties of the measurement tool. The KMO test and Bartlett's sphericity test were used to assess the validity of the factor analysis. The value of the KMO test was 0.889, which indicates a high degree of adequacy of the research sample. In the case of the Bartlett's sphericity test, on the other hand, the test statistic of 3699.93 (p-value < 0.001) indicates the need to reject the hypothesis of the singularity of the correlation matrix between the ratings of individual statements. The result is satisfactory and provides a rationale for the use of factor analysis. Based on the results of the factor analysis, it was observed that the analysed statements form three unobservable factors that explain a total of 62.26% of the variability of the input set of 15 statements. The first factor consisting of statements V11-V15 explains 42.68% of the variability, the second factor (statements V6-V10) explains 11.37% of the variability, while the last factor (statements V1-V5) explains 8.21% of the variability of the input set of statements. All of the items forming the individual factors are characterised by high factor loadings. For factor one – 'Crafting relationships at work' – the highest factor-loading value was observed for the statement V13: 'I organise special gatherings at the workplace (e.g., celebrating a colleague's birthday).' The second factor – 'Crafting cognitions about work' – mainly describes item V6: 'I reflect on the meaning work gives to my life.' On the other hand, for the third factor, 'crafting tasks', the highest factor load is found in the statement V3: 'I take on new tasks that I think are better-suited to my skills and interests' (see Table 4).

Tabela 4.
Evaluating job crafting – results of exploratory factor analysis and reliability analysis

Statement	Factor			Characteristic value	Cronbach's alpha
	F1	F2	F3		
V13: I organise special gatherings at the workplace (e.g., celebrating a colleague's birthday).	**0.82**	0.18	0.16	6.40	0.86
V12: I organise or participate in meetings with work colleagues outside of work as well.	**0.81**	0.21	0.16		
V15: I form friendships with those colleagues at work who have similar skills or interests to mine.	**0.74**	0.37	0.12		
V14: I choose to mentor and help new employees (officially or unofficially).	**0.69**	0.22	0.14		
V11: I make an effort to get to know the people at work better.	**0.63**	0.24	0.24		
V6: I reflect on the meaning work gives to my life.	0.10	**0.84**	0.18	1.71	0.88
V9: I think about how work positively impacts my life.	0.38	**0.75**	0.15		
V7: I think about the importance my work has for the success of my company.	0.27	**0.72**	0.18		
V10: I reflect on the importance of work for my overall well-being.	0.44	**0.71**	0.15		
V8: I remind myself of the importance of my work to the broader community.	0.24	**0.71**	0.21		

Cont. Table 4.

V3: I take on new tasks that I think are better-suited to my skills and interests.	0.15	0.14	**0.79**	1.23	0.78
V2: I change the scope or type of tasks I perform at work.	0.08	0.10	**0.77**		
V4: I decide to take on additional tasks at work	0.19	0.16	**0.71**		
V1: I introduce new solutions to improve my work.	0.10	0.11	**0.64**		
V5: I prioritise tasks that match my skills and interests.	0.25	0.32	**0.53**		

Source: own survey.

The study also confirmed the high reliability of the measurement tool. Cronbach's alpha for the entire set of 15 statements was at 0.90, which indicates a high level of reliability of the questionnaire. Similarly, for each of the subscales, the Cronbach's coefficient value is satisfactory (above 0.70).

3. Overall assessment of job crafting and assessment of relationships between subscales

When analysing the overall indicators of the evaluation of job crafting, it was observed that, regardless of the subscale, the average ratings were high. Additionally, a statistically significant difference was observed in the average ratings between small and medium-sized enterprises for the subscale 'task crafting'. The average value of the subscale for respondents representing medium-sized enterprises was statistically significantly higher compared to small enterprises (23.27 versus 22.30). The distributions of the overall values of the subscales are left-asymmetric, which means that respondents were more likely to give higher ratings to the items constituting the components of the studied subscales (see Table 5).

Table 5.
Job crafting (overall and subscales) – overall and comparison by enterprise size

Statistics	Task crafting			Cognitive crafting			Relational crafting			Overall scale		
	Total	Small	Medium -sized	Total	Small	Medium -sized	Total	Small	Medium -sized	Total	Small	Medium -sized
Min.	5	5	5	5	5	5	5	5	8	15	15	27
Max.	30	30	30	30	30	30	30	30	30	90	90	90
M	22.79	22.30	23.27	22.30	22.02	22.59	22.05	21.60	22.50	67.14	65.92	68.36
Me	23	23	24	23	22.5	24	23	22.5	24	67.5	66	69
SD	5.24	5.46	4.97	5.98	6.35	5.58	6.19	6.39	5.96	14.41	15.51	13.12
S	-0.78	-0.64	-0.92	-0.69	-0.66	-0.69	-0.46	-0.44	-0.47	-0.43	-0.45	-0.29
P-value	–	0.038*		–	0.289		–	0.103		–	0.058	

Min. – minimum, Max. –maximum, M – mean, Me – median, SD – standard deviation, S – coefficient of skewness, p – probability in Student's t-test for independent samples, *statistically significant differences (α = 0.05).

Source: own survey.

Correlation analysis between the subscales indicated that statistically significant relationships were observed regardless of enterprise size (see Table 6). Both when analysing the entire research sample together and when breaking it down by enterprise size, the relationships between the subscales are statistically significant, positive, and strong or moderately strong.

Table 6.
Correlations between the individual dimensions of job design – total and by enterprise size

		Total			Small			Medium-sized		
		KZ	**KM**	**KR**	**KZ**	**KM**	**KR**	**KZ**	**KM**	**KR**
KZ	r	1	0.478	0.449	1	0.584	0.521	1	0.341	0.356
	P-value	–	<0,001*	<0,001*	–	<0,001*	<0,001*	–	<0,001*	<0,001*
KM	r	0.478	1	0.634	0.584	1	0.650	0.341	1	0.612
	P-value	<0,001*	–	<0,001*	<0,001*	–	<0,001*	<0,001*	–	<0,001*
KR	r	0.449	0.634	1	0.521	0.650	1	0.356	0.612	1
	P-value	<0,001*	<0,001*	–	<0,001*	<0,001*	–	<0,001*	<0,001*	–

r – Pearson's linear correlation coefficient, p – probability in the significance test of the correlation coefficient, * – statistically significant relationship ($\alpha = 0.05$), KZ – Crafting tasks, KM – Crafting cognitions about work, KR – Crafting relationships at work.

Source: own survey

When analysing the relationships between the subscales without disaggregating by enterprise size, it was observed that the strongest relationship was between the subscale 'Crafting relationships at work' and 'Crafting cognitions about work' ($r = 0.643$). Similar results were obtained for small and medium-sized enterprises (0.650 and 0.612 respectively). The weakest relationship was observed for relational crafting and task crafting (overall: 0.449). In turn, by enterprise size: for small enterprises for the relationship between task crafting and relational crafting at work: 0.521, while for medium-sized enterprises for the relationship between task crafting and cognitions about work: 0.341. All relationships are statistically significant, positive.

4. Summary

Summarising the results obtained in the survey conducted among employees of small and medium-sized enterprises in the Upper Silesian-Zagłębie Metropolis area, it can be concluded that the phenomenon of job crafting is present among the employees of these organisations, and it applies to varying degrees to all areas of job crafting: crafting tasks, crafting cognitions about work, crafting relationships at work. Respondents acknowledged that they introduce new solutions at work in order to improve it. In this case, more than 42.0% of the respondents assigned a score of '6' to this statement. Respondents also make an effort to get to know the people at work better. They also reflect on the importance of work for their own overall well-being, decide to take on additional tasks at work, and to mentor and help new employees

(officially or unofficially). Respondents gave the lowest ratings to the statements: 'I remind myself of the importance of my work to the broader community' and 'I organise special gatherings in the workplace (e.g., celebrating a colleague's birthday)'. Taking into account the size of the enterprise, it should be noted that only three statements showed statistically significant differences in ratings. These related to introducing new solutions to improve work, deciding to take on additional tasks at work, and thinking about the importance of the respondents' work for the success of their organisation. For these three statements, the average rating for medium-sized enterprises was statistically significantly higher compared to small enterprises.

The overall job crafting evaluation indicators show high ratings, regardless of the specific aspects of work. Moreover, a statistically significant difference in ratings was noted between small and medium-sized enterprises in the context of task crafting. Respondents representing medium-sized enterprises gave higher ratings on average in this subscale than those from small enterprises.

Although there are differences in favour of medium-sized enterprises between the different types of enterprises in certain areas, it is important to emphasise the fact that the results in terms of job design obtained for the surveyed collective are generally high. The results obtained in the survey may indicate some recommendations for management practice. Undoubtedly, job crafting – the shaping of work by employees at every level – is an innovative activity that makes employees more responsive and flexible in the work context, thus facilitating the implementation of organisational and work improvement changes (Chmiel, Fraccaroli, Sverke, 2017). Of course, by definition, job crafting is a bottom-up activity, but it is nevertheless worth introducing circumstances in the organisation that will foster the development of this phenomenon. Introducing conditions that promote job crafting can bring many benefits. Organisations should aim to make the organisational structure more flexible, giving employees the opportunity to adapt their roles. For example, instead of imposing a rigid framework of tasks, a certain amount of freedom in performing them can be provided, which would stimulate creativity and engagement. Managers play a key role here. They should inspire autonomy and initiative in employees, encouraging adapting to change. This approach can enable employees to gain a sense of control over their tasks, which can ultimately increase their motivation and satisfaction. It is also worth creating an environment where mistakes are treated as a learning opportunity rather than a reason for penalties. This encourages employees to experiment with different ways of performing tasks and contributes to their development and, in turn, the development of the organisation.

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COMMUNICATION ISSUES IN THE CHANGE MANAGEMENT PROCESS IN PUBLIC ORGANISATIONS

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Purpose: The objective of this paper is to identify and evaluate the issues related to communicating in the process of change management in public organisations.
Design/methodology/approach: There were 576 properly filled out survey questionnaires, in which the respondents assessed individual statements, which are – in their opinion – important in the implementation of change in their organisation. The Likert scale was applied to assess these factors. In order to assess the relationship between the opinions and the features describing a study group, a stochastic independence analysis was performed. Two non-parametric tests for independent samples – the Mann-Whitney U test and the Kruskal-Wallis test – were applied. The minimum level of significance of $\alpha = 0.05$ was adopted. SPSS IBM was applied for statistical calculations.
Findings: The study findings show, in most cases, that there are issues in the public organisations under study associated with communication with change implementation. The study findings show that the individual scores depend mainly on the respondents' education, on the fact that the employees are involved in the change implementation, which is a key element of their function in the organisation and on the position occupied. There is no significant differentiation of the responses for the other features.
Research limitations/implications: There are certain limitations of the study, which is a consequence of the choice of articles for the literature review and the findings of studies published on change management in public organisations. The limitation in the case of empirical studies lies in the sample not being representative.
Practical implications: The findings should help public institution managers to identify the areas which could become a point of interest in change management.
Originality/value: Research in a practical dimension has the potential to raise public managers' awareness of the impact of communication on change management in public organizations.

Keywords: public organization, organisational changes, communication.

Category of the paper: research paper.

1. Introduction

Traditionally, public organisations are perceived as bureaucratic institutions which efficiently handle routine issues but are incapable of coping with change (Lam, 2004). However, according to modern public management theories, one of their main actions is a change adapted to the needs of the service recipient (Hood, 1991) and relationship building (Olinski, Szamrowski, 2017). A literature analysis shows that specific features of the public sector organisations have an impact on changes and their management (Isett et al., 2012). These may include ambiguity of goals, their immaterial nature or difficulty in measuring their effectiveness and formalisation of activities as a consequence of the bureaucratic nature of a public organisation. The importance of the surroundings in implementing changes (Lutrin, Shani, 1998; Oliński, Szamrowski, 2017) and the centralisation of decision-making (van der Voet, 2014) has also been emphasised. Therefore, change management in the public sector indicates a higher complexity and ambiguity of the process than in business organisations. An organisational change is any change or modification of organisational structures or processes (Zorn et al., 1999, p. 10; Krukowski, Raczyńska, 2019). It can also be defined as planned or unplanned changes in the organisational structure, technology or human resources related to the organisation (Greenberg, Baron, 2018). Such a change is also defined as a movement in an organisation from a known to an unknown state (Campbell, 2014). Activities in each organisation comprise changes of great importance and minor modifications of its functioning spheres. This arises from the organisation's life cycle, where purposeful implementation of changes is required (Lewis, 2011, p. 26; Kirrane et al., 2017). Therefore, change management involves the implementation of minor, emerging modifications and significant, strategic ones, which are associated with strategic decisions that affect the development and survival of the organisation. Despite the fact that the organisational changes are certain, change implementation projects have high failure rates (Ashkenas, 2014). Lack of success in achieving the desired results of a change may have many reasons. These may include, for example, its improper implementation, such as the lack of coherence with the existing organisational structures, lack of resources, lack of consent on the management level, internal communication or ambiguous goals of the change. Moreover, there are cases when a change is simply not necessary (Armenakis, Harris, 2009; Kotter, 1995; Schulz-Knappe et al., 2019). If there are problems with change implementation, the importance of communication is emphasised, which allows the personnel to understand the contents of (and reasons for) a change (Yue et al., 2019). Communicating is passing on information, thoughts or feelings in a manner that enables its reception and understanding by a recipient (Koschmann, 2016). The relationship between communication, management and organisational change has been attracting increasing attention from practitioners and scientists since the mid-1990s (Larkin, Larkin, 1994). A study by Lewis and Seibold (2012) concerning the scope of organisational

change emphasises the communication issues in change implementation. The research concerning change management in the public sector focuses – among other things – on the identification of the personnel approach to communication and their acceptance of the proposed change (Hameed et al., 2017; Graff et al., 2019). It has been stressed in the literature that communication and change should be developed (Johansson, Heide, 2004; Taylor et al., 2001). The objective of this paper is to identify and evaluate the issues related to communicating in the process of change management in public organisations.

2. Literature review

Basically, organisational changes imply a transition from the known to the unknown and from the secure to the uncertain. During this process, communication initiated by the management plays an important role in the change success because open and active communication between various internal and external organisation members is a key to handling uncertainty (Hameed et al., 2019; Isabella, 1990; Jablin, Kramer, 1998). It has also been emphasised that communication in an organisation is an essential and the most important factor for maintaining and developing an organisation (Suhertian, Satrya, 2022). Communication and passing on information is regarded as a key element of a successful implementation of change (Lewis, Seibold, 1998). According to Yue et al. (2019), employees can better understand the content and causes of change through effective internal communication. Effective and transparent internal communication allows for a better understanding of the personnel in connection with the organisational change. By placing emphasis on transparent communication, organisations support the leaders of change in maintaining better relations with the personnel, which should lead to the employees' openness to the change (Yue et al., 2019). Transparent communication is regarded as one of the tools for implementing change (Schulz-Knappe et al., 2019). Communication can be regarded as a type of a catalyst for managing change. Communication itself is insufficient to manage change effectively, but no change can be initiated or implemented without it (Lauer, 2020, p. 120). Communicating the need for and benefits from organisational changes appeared in studies concerning the implementation of changes in the late 20th century, regardless of the theoretical perspective lying at its base (Beer, Eisenstat, Spector, 1990; Dawson, 1994; French, Bell, 1995; Kottera, 1995). It has also been emphasised that a plan of change should be communicated to the personnel, and they should be persuaded to justify the change and to provide support (Stouten et al., 2018). Communication also facilitates understanding the change and helps the personnel to prepare for it (Augustsson et al., 2017). The personnel readiness for change is a significant area of the study presented in the literature (Wardani et al., 2020, p. 591). Assessment of change by the personnel is affected by cognitive factors and emotions

(Purwaningrum et al., 2020). How the employees respond to changes in an organisation and how they assess them reflects their readiness to accept the changes and to adapt to them. Readiness for a change is a multi-dimensional construct, which is affected - among other things - by managerial support and personal values (Armenakis, 1993). The problems arising from the personnel's lack of readiness for change are regarded as the factors affecting the change initiative's success (Rafferty et al., 2013). It has been pointed out regarding public organisations that the lack of readiness for change (understood as resistance) is one of the causes of failure in their implementation (Kuipers et al., 2014). Lack of readiness for a change may manifest as resistance and negative behaviour, including sabotaging changes and absence from work. According to studies, the failure rates for initiatives of change range from 70% to 75% (Lauer, 2021, pp. 45-56; Kroeh, 2014; Eaton, 2010). Most problems in change implementation result from misunderstandings, tight hierarchy, centralised bureaucracy and the need for a change initiated at the top management level, associated with the lack of communication with the personnel. These are features of a public organisation, often emphasised as those that limit the freedom for change implementation (Van der Voet, 2014). The study findings show that communication and anchoring the change effects in the organisational culture depends on the organisation type, while other factors can be regarded as "universal" in application in various types of public organisations (Krukowski et al., 2021). Stewart and Kringas (2003) studied various Australian public organisations and found care about communication within the organisation to be a key factor for success in change implementation. Some researchers point out that implementation of many changes without understanding the structure and nature of links between the subsystems, i.e. without understanding of communication, may entail additional costs and a longer period of implementation (Hannan et al., 2003). Denhardt and Denhardt (1999) describe in their studies how effective local government managers verify the need for a change by listening and learning and then communicate the need in a way that creates support for a change. Kjaerbeck also pointed out the importance of communication in her study of changes in hospitals (Kjaerbeck, 2017).

3. Study methodology

The survey was conducted in Q1 2020. The questionnaire was addressed to public organisation employees. The direct questionnaire technique was applied. It contained ten statements identified in the literature, describing issues in the process of introducing changes in public organisations (Doyle et al., 2000; Suhertian, Satrya, 2022; Hameed et al., 2019; Lauer, 2021):

P1 - A change often denotes a conflict between the goals of employees and the organisation.
P2- We need better relations between the management and personnel with respect to change implementation.
P3 - Perceiving changes is often in conflict with the supervisors' expectations.
P4 - Management in the organisation use informal communication effectively to stay in contact with the personnel.
P5 - Employees understand the need to communicate, but practical skills to implement it are lacking.
P6 - Issues related to communication between employees have been resolved in the organisation.
P7 - A change has encouraged the development of more innovative approaches to communication with personnel.
P8 – The organisation focuses more on the amount than on the quality of communication with the personnel.
P9 – The personnel are shown the long-term goals of the change.
P10 – The communication is so effective that the employees suffer from information overload.

There were 576 properly filled out survey questionnaires, in which the respondents assessed individual statements, which are – in their opinion – important in the implementation of change in their organisation. The Likert scale was applied to assess these factors, in which the following statements were assigned to individual values - 1 – I definitely disagree, 2 – I rather disagree, 3 – I don't have an opinion, 4 – I rather agree, 5 – I definitely agree. The dominant group among the personnel under study were people for whom change implementation is not a key element of their work (73.61%) (Table 1). Perceiving factors significant for change implementation can be affected by being qualified in change management. The personnel of the organisations under study were dominated by individuals without such qualifications (75.17%). However, the findings show that all the respondents participated in the implementation of change in their organisation.

Table 1.
Characterisation of the study sample (%)

Education			
secondary	**higher technical**	**higher education in humanities**	**higher social education**
9,55	41,67	28,82	19,97
Job position			
managerial		non-managerial	
14,41		85,59	
length of service (in years)			
<5	**from 6 to 10**	**from 11 to 20**	**<20**
29,17	9,55	24,27	17,01

Cont. table 1.

Gender	
man	**woman**
36,81	63,19
I am qualified in the change management area	
yes	**no**
24,83	75,17
Implementing changes is a key element in my role in the organization	
yes	**no**
26,39	73,61
Type of institution	
Governmental administration	3,65
Self-governmental administration	40,97
Governmental agency	7,47
Education	4,86
Healthcare	7,99
Higher education	35,07

Source: Own work based on research results.

The group of respondents was dominated by people with a university degree, with the largest group having a technical education (41.67%) (Table 1). Only 14.41% of the respondents occupied management positions. The employees working for up to five years accounted for the largest group (29.17%). Considering the systematic error of the methods (CMB), Brewer's sample split method was used in developing the questionnaire (Brewer, 2006). The aim of this approach was to eliminate CMB by using one respondent sample to assess the independent variable and the other – to assess the dependent variable. Administrative data were the independent variable, i.e. public organisation type, in the study presented here. (Podsakoff et al., 2012; Jakobsen, Jensen, 2015). The survey was addressed to many individuals who participated in the change management process in an organisation, which also reduces the risk of error (MacKenzie, Podsakoff, 2012). In order to reduce the error, respondents with sufficient specialist knowledge were selected for the study so that the responses to the questions did not concern unclear terms. The responses to the questions also concerned the current situation, which should also reduce the risk of error. The Cronbach alpha test, the Kaiser-Meyer-Olkin test and the Bartlett test were then applied (Table 2).

Table 2.
Measurement properties

Kaiser-Mayer-Olkin test	0,726	
Bartlett's test	Approximate chi-square	2679,202
	df	465
	Istotność	0,01

Source: Own work based on research results.

In order to examine the internal consistency of the variables describing the identified issues in change implementation, the reliability index on the Alpha-Cronbach scale was calculated and was $\alpha = 0.5986$ for the identified variables under assessment. This shows that the factors taken for assessment are consistent. The Cronbach alpha and the Kaiser-Meyer-Olkin test confirmed the reliability of this research tool. The author is aware that the factors selected for

the study are correlated with each other. However, the aim of the study was not to identify their correlation but to identify their presence and their assessment in the context of a unit type. However, this stems from the fact that they concern one phenomenon. In order to assess the relationship between the opinions and the features describing a study group, a stochastic independence analysis was performed. Two non-parametric tests for independent samples – the Mann-Whitney U test and the Kruskal-Wallis test – were applied. The minimum level of significance of α=0.05 was adopted. *SPSS IBM* was applied for statistical calculations.

4. Research Results

The assessment for individual statements concerning the issues in change implementation in organisations shows that, given the descriptive statistics, the highest assessment was given to the statement that a change often denotes a conflict between the goals of employees and the organisation (Me = 4; Mo = 4). This also stems from a high assessment of the statements: "we need better relations between the management and the personnel with respect to handling change" (Me = 4; Mo = 4) (Table 3). A high assessment was also given to the statement that "the organisation management use effectively informal communication to stay in contact with the personnel", which indicates that the formal communication channels do not play their role in change management. The problems in communication in the change implementation process are revealed by pointing to conflicts arising from the diversity of goals between management and employees. The lowest assessment was given to the statements that "employees are shown long-term goals of change" (Me = 3; Mo = 2) and that "communication is so effective that employees suffer from information overload" (Me = 3 Mo = 2). The responses dominating in these two cases indicate that the respondents disagree with the statements, i.e. they pointed out that there was no effective communication in their institutions. This may also show that the respondents disagreed with the statement that employees were informed about the long-term goals of the changes.

Table 3.
The descriptive statistics for the statements describing the issues in the process of change implementation in public organisations (n = 576)

Factor	Mean (*M*)	Median (*Me*)	Mode *(Mo)*
A change often denotes a conflict between the goals of employees and the organisation.	3,61	4,00	4,00
We need better relations between the management and personnel with respect to change implementation.	4,09	4,00	4,00
Management in the organisation use informal communication effectively to stay in contact with the personnel	3,45	4,00	4,00
Perceiving changes is often in conflict with the supervisors' expectations.	3,32	3,00	4,00

Cont. table 3.

Employees understand the need to communicate, but practical skills to implement it are lacking.	3,24	3,00	4,00
Issues related to communication between employees have been resolved in the organisation.	2,87	3,00	3,00
A change has encouraged the development of more innovative approaches to communication with personnel.	3,07	3,00	3,00
The organisation focuses more on the amount than on the quality of communication with the personnel.	3,06	3,00	3,00
The personnel are shown the long-term goals of the change	2,77	3,00	2,00
The communication is so effective that the employees suffer from information overload.	2,68	3,00	2,00

Source: Own work based on research results.

In order to assess the importance of each statement, individual responses were summarised (Table 4). The respondents usually agreed with the statements pointing to the fact that there was a need for better relations between the management and the personnel in the organisation with respect to handling change (79.51% responded with the assessment of 4 and 5). The public organisation employees under study also agree with the statements indicating that a change often denotes a conflict between the employees' and the organisations' goals (59.72% responses with the assessment of 4 and 5) and that managers in the organisation use communication effectively to stay in contact with the employees (53.34% responses with the assessment of 4 and 5). There were more than 40.0% responses for the statements that the change reception is often in conflict with the supervisors' expectations (46.53% of the responses with the assessment of 4 and 5) and that employees understand the need for communication, but they lack practical skills to implement it (44.79% responses with the assessment of 4 and 5). Public organisation employees also disagreed with the statement that communication is so effective that the employees suffer from information overload (49.83% responses with the assessment of 1 and 2) and that the employees are shown long-term goals of the change (47.40% responses with the assessment of 1 and 2). Nearly 40.0% of the respondents disagree with the statement that the issues related to communication between employees in their organisations have been resolved (39.58% responded with the assessment of 1 and 2).

Table 4.
The assessment for the statements describing the issues in the process of change implementation in public organisations (%)

Factor	% of indications		
	Sum of points 1 and 2	3	Sum of points 4 and 5
We need better relations between the management and personnel with respect to change implementation.	7,81	12,67	79,51
A change often denotes a conflict between the goals of employees and the organisation.	15,97	24,31	59,72
Management in the organisation use informal communication effectively to stay in contact with the personnel	20,14	25,52	54,34
Perceiving changes is often in conflict with the supervisors' expectations.	22,05	31,42	46,53
Employees understand the need to communicate, but practical skills to implement it are lacking.	24,48	30,73	44,79

Cont. table 4.

The organisation focuses more on the amount than on the quality of communication with the personnel.	32,12	31,94	35,94
A change has encouraged the development of more innovative approaches to communication with personnel.	24,83	42,88	32,29
The personnel are shown the long-term goals of the change	47,40	22,40	30,21
Issues related to communication between employees have been resolved in the organisation.	39,58	30,90	29,51
The communication is so effective that the employees suffer from information overload.	49,83	26,22	23,96

Source: Own work based on research results.

In order to examine the stochastic independence between the individual statements concerning the issues in the process of change implementation in public organisations and the study group characteristics (Table 5), a question was also asked whether the features that differentiate the study group make the respondents assess the statements concerning the issues in the process of change implementation in public organisations differently. Since the features differentiating the sample were assessed on various scales, two non-parametric tests were applied for independent samples, i.e. the Mann-Whitney U test (for differentiating features - change implementation is a key element in my function at the organisation (C1); I am qualified at the level of a course in change management (C2), position (C4), sex (C6) and Kruskal-Wallis test (for the differentiating features: education (C3), job seniority (C5); institution type (C7) (Table 6). The following hypotheses were adopted:

H_0: the distribution of the attitude towards change is the same as the sample differentiating feature - C1-C7.

H_1: the distribution of the attitude towards change is not the same as the sample differentiating feature - C1-C7.

The calculations show that some features that differentiate the sample cause differentiation with respect to the assessment of statements concerning the change implementation issues in public organisations. In such cases, the test probability is $p < 0.05$, which determines the rejection of the zero hypothesis.

An analysis and assessment of the results (Table 6) leads one to the conclusion that for the C1 feature (change implementation is a key element in my function in the organisation), the H_0 should be rejected and H_1 - accepted with respect to the following statement describing the issues in the change implementation process in public organisations – "a change often denotes a conflict between the employees' and organisation's goals". In other words, C1 makes the respondents assess differently their attitudes towards changes regarding the above statement. The C1 feature did not cause any differentiation in the other cases. For education (C3), H_0 should be rejected, and H_1 should be accepted, including for the statement that a change often denotes a conflict between the employees' goals and the organisation's goals and that the change encouraged the development of more innovative approaches to communication with employees. C3 prompts respondents to reassess their attitudes towards changes and highlights

the need for communication skills in employees who may lack practical experience in implementing them. The C3 feature did not cause any differentiation in the other cases.

For the occupied post (C4), H_0 should be rejected, and H_1 should be accepted, including for the statement that a change often denotes a conflict between the employees' goals and the organisation's goals. The C4 feature did not cause any differentiation in the other cases.

No significant differentiation was observed between the features: being qualified at the course level in change management (C2), job seniority (C5), sex (C6) and type of institution (C7).

Table 5

The assessment independence test for the statements describing the issues in the process of change implementation in public organisations

Factor	c1	c2	c3	c4	c5	c6	c7
	Test of significance						
A change often denotes a conflict between the goals of employees and the organisation.	**0,041***	0,955	**0,013***	**0,039***	0,735	0,705	0,711
We need better relations between the management and personnel with respect to change implementation.	0,444	0,051	0,110	0,899	0,737	0,381	0,929
Perceiving changes is often in conflict with the supervisors' expectations.	0,506	0,467	0,181	0,865	0,170	0,854	0,952
Issues related to communication between employees have been resolved in the organisation.	0,303	0,742	0,851	0,724	0,480	0,363	0,459
Management in the organisation use informal communication effectively to stay in contact with the personnel	0,790	0,817	0,485	0,241	0,919	0,352	0,644
A change has encouraged the development of more innovative approaches to communication with personnel.	0,988	0,981	**0,024***	0,303	0,748	0,371	0,103
The organisation focuses more on the amount than on the quality of communication with the personnel.	0,816	0,082	0,262	0,189	0,108	0,062	0,555
The personnel are shown the long-term goals of the change	0,123	0,936	0,679	0,546	0,557	0,222	0,136
The communication is so effective that the employees suffer from information overload.	0,776	0,689	0,896	0,847	0,941	0,217	0,936
Employees understand the need to communicate, but practical skills to implement it are lacking.	0,596	0,918	**0,022***	0,745	0,433	0,402	0,755

Source: Own work based on research results.

The statistical test is applied to examine the stochastic independence, but it does not inform about the strength or the direction of the existing correlation.

5. Discussion

The study shows that most respondents agree that they need better relations with the management with respect to change implementation. This is consistent with the opinion on the role of managers in change implementation. According to the literature, communication is becoming one of the most important tools at the disposal of the management in understanding the importance of the strategic changes implemented by the personnel (Aggerholm et al., 2012). The findings of studies published in the literature suggest that in order to implement changes in an organisation, it is necessary for leaders to build trust among the organisation's personnel (Zainab et al., 2022). According to van der Voet (2014), the leading role of the immediate superiors should not be omitted in organisational changes in public organisations.

The public organisation representatives under study also pointed out that the management in the organisation use informal communication effectively to stay in contact with the personnel. According to Yue et al. (2019), employees can understand better the content and causes for change through effective internal communication. Literature reports have also mentioned a great contribution of employees' trust, mutual control, neglect and monitoring through transparent communication, which is characterised by essential information, responsibility and employee participation. This may be favoured by internal informal communication (Men, Stacks, 2014; Zainab et al., 2022).

The respondents also pointed to the fact that a change often denotes a conflict between the employees' goals and the organisation's goals. Organisations with improper communication face fierce opposition from employees, and they cannot succeed in implementing change, which results in a failure of the change initiative (Zainab et al., 2022). The respondents in the entities under study mostly disagreed with the statement that the communication is so effective that the employees suffer from information overload (49.73% of the responses). According to the findings of the study by M. Doyle et al. (2000), 61.0% of the respondents disagreed with the statement that "we communicate so effectively that our employees suffer from information overload". The importance of the quality and quantity of information was pointed out in his research by Hameeda et al. (2019). According to their findings, those employees who receive adequate and useful information about the organisational changes in due time will perceive the changes as positive, and they will support them more eagerly. A study conducted by Bouckenooghe et al. (2009) also noted the quality and quantity of information. Their findings show that the effectiveness of communicating the changes is determined by the transparency, frequency and openness of the information provided. This means that the quality of communication helps to boost the employees' certainty that the change is needed by providing sufficient justification and alleviating the uncertainty associated with the change, making the personnel ready for the change.

6. Summary

The study findings show, in most cases, that there are issues in the public organisations under study associated with communication with change implementation. Most of the respondents agreed with the statement that there is a need in the entities under study for better relations between the management and personnel in the implementation of the changes. As many as 47.40% of the respondents disagree with the statement that the employees are shown long-term goals of the changes.

One should be pessimistic about the fact that most of the respondents disagree or do not have an opinion about the statement that "the change encouraged the organisation to develop more innovative approaches to communication with employees". This may be a consequence of the bureaucratic and centralised system of managing public organisations. The respondents usually agreed with the statements pointing to communication issues resulting from:

- the relations between the management and the personnel (the statement that better relations are needed between the management and the personnel with respect to change implementation – 79.51% of the respondents agreed with it to a various extent);
- conflicts between the employees' goals and the organisation's goals (with the statements that a change often denotes a conflict between the employees' goals and the organisation's goals – 59.72% of the respondents agreed with it to various extents);
- using informal communication (54.34% of the respondents agreed, to a various extent, with the statement that the managers in the organisation use informal communication effectively to stay in contact with the personnel);
- lack of practical skills in implementation of change (44.79% of the respondents agreed, to a various extent, that the employees understand the need for communication, but they lack practical skills to implement it).

The study findings show that the individual scores depend mainly on the respondents' education (C3) (three responses), on the fact that the employees are involved in the change implementation, which is a key element of their function in the organisation (C1) (1 response) and on the position occupied (C4) (1 response). There is no significant differentiation of the responses for the other features.

It is also noteworthy that about 30% of the public organisation employees under study have no opinion on the issues associated with the implementation of the organisational changes in their institutions.

There are certain limitations of the study, which is a consequence of the choice of articles for the literature review and the findings of studies published on change management in public organisations. The limitation in the case of empirical studies lies in the sample not being representative. However, the findings should help public institution managers to identify the areas which could become a point of interest in change management. The study findings can also be used as the basis for further analyses of change management in public organisations.

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ACTIVITY OF GENERATION Z ON SOCIAL MEDIA AS THE BASIS OF MARKETING ORIENTATION OF ENTERPRISES – COMPARISON OF POLAND AND GREAT BRITAIN

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Purpose: The aim of this article is to identify and compare the social media activity of Generation Z representatives in Poland and Great Britain in the context of customer orientation.
Design/methodology/approach: The study was conducted among students in Poland and Great Britain in 2023. The study used a survey method, in particular using the CATI survey technique. Descriptive statistics measures were used to analyze the research data.
Findings: The conducted research allowed us to identify the social media portals most frequently visited by Generation Z representatives, as well as the most frequently performed activities towards enterprises. Moreover, the relationship between respondents' answers and their gender and place of residence was examined. In several cases, gender and place of residence significantly differentiated the analyzed variables. The results also allowed us to identify differences in the social media activity of Generation Z representatives in Poland and in Great Britain.
Research limitations/implications: The use of survey research is associated with limitations, including: the possibility of superficial knowledge of the studied phenomena, or respondents giving false answers. However, the relatively small number of respondents does not allow the obtained research results to be treated as representative. Future research should be conducted on a larger sample, and quantitative research should be supplemented with qualitative research. Undertaking research in other countries would make it possible to compare the social media activity undertaken by representatives of Generation Z different nationalities and determine whether and which of them occur regardless of geographical location.
Practical implications: Understanding the activity of Generation Z representatives in social media will allow organizational employees to adjust their marketing activities to the expectations of this cohort. These activities, the aim of which is to reach the customer, provide him with information about the product, and encourage him to purchase, will ultimately translate into increased sales and profit of the organization. The obtained knowledge indicates that the nationality of respondents is an important factor differentiating activity in social media, which confirms the importance of diversifying marketing activities undertaken by organizations.
Originality/value: The article is addressed to employees of organizations responsible for contact with representatives of Generation Z on social media. The presented results complement and deepen knowledge about the activity of Generation Z in social media, including differences

in gender and place of residence of the respondent. They also indicate the influence of the nationality of Generation Z respondents on their activity in social media.

Keywords: generation Z, social media, enterprise, customer-centric marketing.

Category of the paper: Research paper.

1. Introduction

Researchers agree (including Dwyer, Azevedo, 2016; Dreyer, Stojanová, 2023) that although each person has individual characteristics, it is possible to identify specific values and limitations characteristic of all representatives of a given cohort, also in relation to issues related to customer orientation. Twenge and Campbell (2008) note that people belonging to the same generation have similar values and that these differ significantly from the values of previous generations. Each generation is shaped by specific events that greatly influence that generation's perceptions, preferences and expectations. Generational cohorts give researchers a tool to analyze changes in characteristics and views over time. They allow us to understand how various formative experiences (such as world events and technological, economic and social changes) interact with the life cycle and the aging process to shape people's views of the world (Dimock, 2019). In the case of Generation Z, these events included: social justice movements, the 2008 financial crisis, the smart phone and social media revolution, and growing up in a safety culture that encouraged overprotective parents (Schroth, 2019).

At the same time, it is worth agreeing with the views of Scholtz (2019), who questions the so-called the global convergence hypothesis stating that because Generation Z is a digitally connected generation, they should behave similarly and move in the same direction. While this is partly true on a global scale, differences are seen from country to country. Therefore, it is important to analyze Generation Z of separate nationalities in order to identify differences and similarities, which the authors presented in this study.

There is no doubt that entrepreneurs should strive to get to know Generation Z and build long-term relationships with them. Since every company relies on customers and interacts directly with them, customer orientation is a core and integral competency of every modern organization. It is the customer and his needs that determine the basic directions of development, and it is the customer who ultimately decides about the purchase and acceptance of the offer (Sheth, Sisodia, Sharma, 2000). Understanding the behavior of Generation Z customers, especially in their "natural environment" such as social media, is important from the point of view of the profitability and competitiveness of modern enterprises. Generation Z is a very important market partner of modern enterprises – approximately 30% of Generation Z representatives aged 18 to 25 live with their families, which allows them to limit their expenses on rent, utilities, food and at the same time increase the value of the amount at their disposal

(Credit Karma, 2022). This generation had approximately $360 billion in disposable income in 2021 (Pollard, 2021).

Currently, there are many studies on Generation Z, e.g. in the field of distinguishing generational characteristics (Dimock, 2019), appropriate management styles (Rudolph, Rauvola, Zacher, 2018), generational differences and their impact on leadership styles (Singh, 2016), entrepreneurship issues (Dreyer, Stojanová, 2023) and the characteristics of Generation Z as customers (Wood, 2013). Taking into account the gap in existing research and the need to analyze the same generation in different countries, the aim of this article is to identify and compare the social media activity of Generation Z representatives in Poland and in Great Britain in the context of customer orientation.

2. Literature review

No generation has as many terms as Generation Z, which is often called: iGeneration, Gen Tech, Online Generation, Post Millennials, Facebook Generation, Switchers, "always clicking" (Dolot, 2018). The name "Generation Z" has taken over popular culture and journalism since around 2020. Sources from *Merriam-Webster* and *Oxford* to *Urban Dictionary* now include this name for the generation that follows Millennials, and *Google Trends* data shows that "generation Z" significantly outperforms other names in searches for information about this cohort (Dimock, 2019). Generation Z includes people born between 1995 and 2009. However, generational cut-off points should not be considered strict. They are perceived primarily as tools enabling analysis, but their limits are not arbitrary. It should also be emphasized that the next generation – known as Generation Alpha, i.e. people born since 2010 – follows Generation Z (Dolot, 2018; Csobanka, 2016; Stunża, 2017). Gaidhani, Arora, and Sharma (2019) note that Generation Z is more digitally oriented and technology is a large part of their identity. Some studies (e.g. Keller and Meaney, 2017) go as far as classifying Generation Z as digital natives. That's why Generation Z is also known as "Generation C". This expression comes from: "connected" (because its representatives are "connected to the Internet"), "computerized"; "communicative"; "content centric"; "social" (Hysa, 2016; Dolot, 2018). Generation Z therefore has an innate comfort in the virtual world. For these consumers, the Internet has always existed. Since their childhood, great advances have been made in technological devices (e.g., cell phone capabilities, video streaming, social networking sites). Consumers of this generation likely feel that constant innovation is obvious. Moreover, as consumers, Generation Z has always had more choices in the market (both in large stationary stores and e-commerce) than their predecessors (Wood, 2013).

Customer orientation is a very important independent competitive concept to maintain and establish long-term company-customer relationships (Harris, Mowen, Brown, 2005). This is due to the fact that companies stay on the market thanks to their customers, whose needs determine the choice and purchase of a given product, and ultimately the profitability of the company (Sheth, Sisodia, Sharma, 2000). Customer orientation, referring to the degree to which organizations meet and understand the needs of building long-term relationships (Rodriguez, Peterson, Ajjan, 2015), includes all activities related to obtaining information about buyers in the target market, understanding target buyers in order to create higher value for them in the form of the expected product/service on a continuous basis and dissemination of information throughout the enterprise (Narver, Slater, 1990). Building and strengthening relationships with customers leads to a profitable and sustainable increase in sales revenues (Soltani, Zareie, Milani, Navimipour, 2018).

In the 21st century, the basic function of marketing is still effective customer service. Sheth, Sisodia, and Sharma (2000) emphasize the growing role of customer-centric marketing. The basis of customer-centric marketing is the growing pressure on companies to improve marketing efficiency, increase market diversity and use modern technologies, including social media. Social media has gained enormous fame as a highly influential communication channel facilitating participatory interaction between businesses, organizations, groups, communities, consumers, etc. Researchers (e.g., Go, You, 2016; Cook, Hopkins, 2008; Kaplan, Haenlein, 2010; Dwivedi, Kapoor, Chen, 2015) have defined social media as comprising online communication tools that stimulate opinion-sharing and information exchange, as well as Internet-based applications that allow for the production and circulation of user-generated content and real-time peer-to-peer interaction. This topic has become widespread in literature and practice, and social media marketing is undertaken and analyzed in many studies (Dwivedi, Kapoor, Chen, 2015). Scientists agree that by using social media platforms, an enterprise can gain a competitive advantage, adapt to internal and external changes, and learn and meet customer requirements. In 2022, over 4.5 billion people used social media worldwide, and this number is expected to increase to almost 6 billion by 2027 (Statista, 2022). Modern managers should take advantage of the popularity of the use of social media platforms by providing useful and credible information about their products or services for greater customer engagement (Cardoso da Silva et al., 2023).

Due to the development of social media and the increase in digital interactions of enterprises with customers, the above-mentioned concept of "customer engagement" has gained importance in the marketing literature (Kulikovskaja et al., 2023). The goal of effective customer engagement is to deliver relevant content through social media marketing campaigns that encourage repeatable interactions (Korombel, Ławińska, 2022).

The impact of social media on customer purchasing behavior has been confirmed by many studies (e.g. Makudza, Mugarisanwa, Siziba, 2020; McClure, Seock, 2020; Tsai, Bui, 2021). Research also confirms that consumers using social media are 29% more likely to make

a purchase on the same day and are four times more likely to spend more on their purchases (Deloitte, 2015).

Social media is the main source of information on virtually every topic for Generation Z. Research confirms (including Ravula et al., 2023; García-Carrión et al., 2023) that the most effective way to provide information and motivate representatives of Generation Z to be active are visualizations, videos on YouTube and short videos posted online. This generation, overloaded with news, addicted to mobile phones and digital gadgets, feeling stress, fatigue, 'fear of missing out' and 'phubbing', is radically changing its behavior on social media (Sharma, Kaushal, Joshi, 2023). During the COVID-19 pandemic, the influx of negative information has increased the desire among users of this generation to disconnect from social media and stop using social networking sites (Liu, Liu, Yoganathan, Osburg, 2021). Since social media users are unable to filter credible information due to its huge amount, entrepreneurs, providers of social media services and platforms should develop ways of transmitting information that cause the least user fatigue (Sharma, Kaushal, Joshi, 2023). Managers responsible for contact with customers on social media, who want to communicate effectively with Generation Z, should have knowledge of, among others: about which social media sites Generation Z is most active on and what activities they are most likely to perform.

Based on the analysis of the literature on the subject, the authors built a catalog of portals and the types of activities undertaken by representatives of Generation Z in social media, which were used in the research. Also based on the literature analysis, the authors formulated the following research questions:

1. Which social networking sites are most frequently used by Generation Z representatives?
2. Is there a relationship between the choice of a social networking site and the gender of a Generation Z representative?
3. Is there a relationship between the choice of a social networking site and the place of residence of a representative of Generation Z?
4. What activities are most often performed by Generation Z representatives in social media towards companies?
5. Does the respondent's gender influence the frequency of activities he or she undertakes towards enterprises in social media?
6. Does the respondent's place of residence influence the frequency of activities he or she undertakes in social media towards enterprises?
7. Are there differences between the social media activity of Generation Z representatives in Poland and in Great Britain? If so, what are the differences?

3. Methods

The research on Gen Zers' attitudes towards brands on social media is a part of a broader study conducted by the authors among students in Poland and Great Britain in 2023. The research employed a combination of qualitative and quantitative approaches, utilizing survey research as an indirect measurement method. It employed survey as the research technique and survey questionnaire as the research tool. The selection of variables used in the study was based on a critical analysis of relevant literature (Gummerus et al., 2012; Gregor, Kubiak, 2014).

Regarding the birth year of Generation Z representatives, there is no consensus in the literature. The most frequently cited date is the year 1995, which the authors of the paper adopted as the cutoff year for their study.

The authors also assumed that the independent variable in their study is the specific group of respondents being tested, rather than the entire population of Generation Z. Due to the challenge of definitively determining the age range of Generation Z, it becomes problematic to treat this variable as independent. However, the authors found that utilizing Generation Z as a heuristic is valuable, as generational profiling is now prevalent in popular media and popular culture, providing a descriptive framework.

Prior to commencing the main research, the authors conducted a pilot study in 2018, enabling them to identify and rectify any errors in the survey questionnaire before proceeding with the main study. In Poland, a total of 322 students participated (166 females and 156 males), while in Great Britain, a total of 318 students participated (199 females and 119 males). The research employed the CAWI (Computer-Assisted Web Interviewing) technique. In Poland, an online survey questionnaire was administered through the Webankieta.pl platform, while data collection in Great Britain was outsourced to an external institution specializing in survey administration. It is important to note that the sampling method used in both studies was non-probabilistic. While utilizing non-probabilistic sampling, the authors employed statistical inference as an opportunity to identify relationships within the studied groups, as descriptive statistics alone would not allow for such analysis.

Based on the research results, the authors calculated the number and frequency of respondents' responses to each question in the survey. The authors are aware that the sampling technique employed does not allow for the estimation of errors that may arise when generalizing the observed patterns in the sample to the entire population. To identify potential relationships within the studied groups, the authors utilized statistical inference, for which they adopted a certain level of significance, as descriptive statistics alone cannot provide such analysis. Statistical inference was conducted with a predetermined significance level set at $\alpha = 0.05$, and a p-value was calculated for each test. The authors compared the p-value with the level of statistical significance to determine whether there was sufficient evidence to reject the null

hypothesis (H_0) in favor of the alternative hypothesis (H_1) ($p < \alpha$), or not ($p \geq \alpha$). All analyses were performed using Statistica software, version 13.3.

The authors acknowledge that survey research has certain limitations, such as providing only a surface-level understanding of the phenomena under study and the possibility of respondents providing inaccurate answers. One potential criticism of the presented research results is that the study was conducted on a small group of participants. While small sample sizes can raise methodological concerns, such as limitations in generalization, they can still provide valuable insights when proper statistical tests are applied for inference (Yates, 1934; Nachar, 2008).

4. Results

The presented results are a fragment of research conducted by the authors in Poland and Great Britain at the beginning of 2023. All surveyed representatives of Generation Z in Poland and Great Britain indicated that they used social networking sites. Figure 1 presents the number of answers (in %) to the multiple-choice question about which social networking sites the respondents used in 2023.

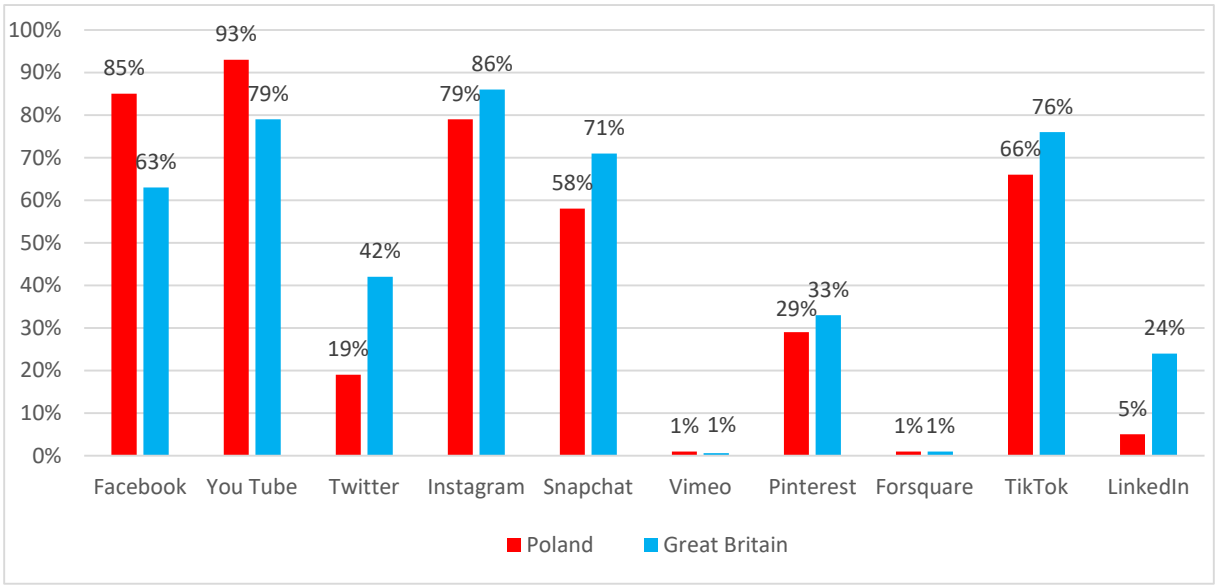


Figure 1. Use of social networking sites by Generation Z respondents in Poland and Great Britain in 2023.

Source: own study.

Based on the collected data, it is possible to indicate the most popular social networking sites in the surveyed groups of respondents in 2023. In Poland, YouTube, Facebook and Instagram were indicated, while in Great Britain, Generation Z respondents most often used Instagram, YouTube and TikTok. Moreover, there are very large differences in the use of

Twitter (42% in GB and 19% in PL), Facebook (85% in PL and 63% in GB) and LinkedIn (24% in GB and 5% in % in PL) by respondents in Poland and Great Britain.

In the category of other portals (apart from those mentioned in the question), respondents indicated:

- in Poland: Telegram (5 persons), Reddit (2 persons), Twitch (4 persons), BeReal (5 persons), Discord (3 persons), WhatsApp (1 person), Viber (1 person), Messenger (2 persons),
- in Great Britain: Tumblr (1 person), BeReal (1 person).

The next stage of data analysis was to verify whether there is a relationship between the variables: the choice of a social networking site (variable X) and the respondent's gender (variable Y). For this purpose, a significance test for structure indicators was used (comparison of two structure indicators). It was assumed that in the group of women the fraction index of this feature was p_1, and in the group of men – p_2. The null hypothesis was verified:

$$H_0: p_1 = p_2$$

towards the alternative hypothesis:

$$H_1: p_1 > p_2$$

Due to the adopted form of the alternative hypothesis, a one-sided critical area was considered. The analysis concerned answers to multiple-response questions, indicators were calculated for the general population and for women and men, and then it was verified using the structure index test whether gender significantly differentiates these indicators. Detailed data on the use of social networking sites by respondents in Poland and Great Britain in 2023 and the result of the significance test for structure indicators by respondent's gender are included in Tables 1 and 2.

Table 1.
The use of social networking sites by respondents in Poland in 2023 and the result of the significance test for structure indicators by gender

Responses	In Total		Females		Males		p
	Number	Percentage of Cases	Number	Percentage of Cases	Number	Percentage of Cases	
Facebook	274	85.09%	145	87.35%	129	82.69%	0.1203
YouTube	298	92.55%	147	88.55%	151	96.79%	**0.0025**
Twitter	61	18.94%	17	10.24%	44	28.21%	**0.0001**
Instagram	254	78.88%	142	85.54%	112	71.79%	**0.0013**
Snapchat	186	57.76%	110	66.27%	76	48.72%	**0.0007**
Vimeo	1	0.31%	0	0	1	0.64%	0.1510
Pinterest	94	29.19%	71	42.77%	23	14.74%	**0.0001**
Forsquare	1	0.31%	0	0	1	0.64%	0.1510
TikTok	212	65.84%	125	75.30%	87	55.77%	**0.0001**
LinkedIn	16	4.97%	7	4.22%	9	5.77%	0.2612

Source: own study.

Data collected in Poland in 2023 indicate large differences (% of cases) in women and men using a given social networking site. The difference between structure indicators according to the respondent's gender turned out to be statistically significant in six cases. Men used YouTube and Twitter more often than women. An inverse relationship can be observed in the case of the following websites: Instagram, Snapchat, Pinterest and TikTok – women used these social media more often.

Table 2.
The use of social networking sites by respondents in Great Britain in 2023 and the result of the significance test for structure indicators by gender

Responses	In Total		Females		Males		p
	Number	Percentage of Cases	Number	Percentage of Cases	Number	Percentage of Cases	
Facebook	201	63.21%	138	69.35%	63	52.94%	**0.0017**
YouTube	251	78.93%	154	77.39%	97	81.51%	0.1916
Twitter	134	42.14%	78	39.20%	56	47.06%	0.0848
Instagram	274	86.16%	179	89.95%	95	79.83%	**0.0057**
Snapchat	226	71.07%	145	72.86%	81	68.07%	0.1810
Vimeo	2	0.63%	1	0.50%	1	0.84%	0.3551
Pinterest	106	33.33%	89	44.72%	17	14.29%	**0.0001**
Forsquare	2	0.63%	1	0.50%	1	0.84%	0.3551
TikTok	242	76.10%	157	78.89%	85	71.43%	0.0656
LinkedIn	77	24.21%	58	29.15%	19	15.97%	**0.0040**

Source: own study.

The analysis of data collected in Great Britain indicates that the share (% of cases) of men and women using a given social networking site was similar in six cases. The difference between the structure indicators according to the respondent's gender turned out to be statistically significant in the case of using: Facebook, Instagram, Pinterest and LinkedIn - surveyed women used this portal more often than men.

The next step was an attempt to verify the hypothesis about the independence of two qualitative features: the choice of a social networking site and the respondent's place of residence. For this purpose, the Pearson's chi-square test was used, which enabled the analysis of the collected data (included in Tables 3 and 4) and providing evidence of the relationship between these two variables. The Pearson's chi-square test involved comparing the observed frequencies with the expected frequencies assuming the null hypothesis (of no relationship between these two variables). The null hypothesis was verified:

H_0: features X and Y are independent

towards the alternative hypothesis:

H_1: features X and Y are dependent

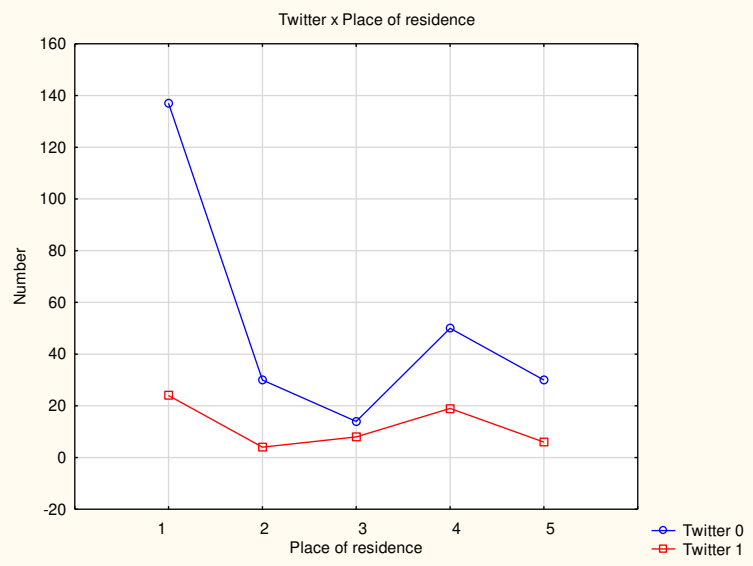
The collected data on the use of a social networking site by the respondent's place of residence in 2023 and the results of the Pearson's chi-square test and its significance level are presented in Tables 3 (data for Poland) and 4 (data for Great Britain).

Table 3.
Use of a social networking site by the respondent's place of residence in Poland in 2023 and the results of the Pearson's chi-square test and its significance level

Responses	Place of residence (% against number of responses = 322)						Pearson's Chi^2	p
	Village	City up to 50 000 residents	City up to 100 000 residents	City up to 250 000 residents	City over 250 000 residents	Row in total		
Facebook	44.72%	8.70%	5.59%	17.70%	8.39%	85.09%	6.0136	0.1981
YouTube	46.89%	9.01%	6.83%	19.88%	9.94%	92.55%	5.4271	0.2462
Twitter	7.45%	1.24%	2.48%	5.90%	1.86%	18.94%	**10.6367**	**0.0310**
Instagram	39.75%	8.07%	4.66%	17.39%	9.01%	78.88%	1.9434	0.7462
Snapchat	30.43%	5.28%	3.73%	12.42%	5.90%	57.76%	1.9380	0.7472
Vimeo	0.31%	0	0	0	0	0.31%	1.0031	0.9093
Pinterest	13.04%	2.48%	2.17%	6.52%	4.97%	29.19%	5.4550	0.2437
Forsquare	0.00%	0	0	0.31%	0	0.31%	3.6781	0.4513
TikTok	32.92%	6.83%	4.97%	13.04%	8.07%	65.84%	1.8933	0.7554
LinkedIn	2.80%	0	0.93%	0.93%	0.31%	4.97%	5.8318	0.2121

Source: own study.

In the case of Twitter, the results of the Pearson's chi-square test (p = 0.0310), with the adopted significance level ($\alpha = 0.05$), provide grounds for rejecting the verified null hypothesis. This means that there is a statistically significant relationship between the choice of Twitter and the respondent's place of residence - this website was chosen mainly by representatives of Generation Z in the countryside and residents of cities with a population of up to 250,000 in Poland, as illustrated in Figure 2. However, this result should be treated with great caution due to the small number of responses.



where: 1. village, 2. city up to 50 000 residents, 3. city up to 100 000 residents, 4. city up to 250 000 residents, 5. city over 250 000 residents.

Figure 2. Interaction chart – use of the Twitter social networking site by Generation Z respondents by place of residence in Poland in 2023.

Source: own study.

The results of the Pearson's chi-square test at the adopted level of significance ($\alpha = 0.05$) in the case of the remaining social networking sites listed in Table 3 indicate that there are no grounds to reject the verified null hypothesis and, therefore, that there is no relationship between the choice of the site and the respondent's place of residence in Poland. in 2023.

Table 4.
Use of a social networking site by the respondent's place of residence in Great Britain in 2023 and the results of the Pearson's chi square test and its significance level

Responses	Place of residence (% against number of responses = 318)						Pearson's Chi^2	p
	Village	City up to 50 000 residents	City up to 100 000 residents	City up to 250 000 residents	City over 250 000 residents	Row in total		
Facebook	15.41%	12.58%	10.06%	7.23%	17.92%	63.21%	4.7909	0.3094
You Tube	15.09%	15.09%	14.47%	7.55%	26.73%	78.93%	9.0365	0.0602
Twitter	7.55%	8.18%	7.86%	3.46%	15.09%	42.14%	4.8525	0.3028
Instagram	17.92%	15.41%	14.78%	10.06%	27.99%	86.16%	2.3831	0.6657
Snapchat	15.41%	13.52%	11.95%	7.55%	22.64%	71.07%	0.2157	0.9946
Vimeo	0.31%	0	0	0	0.31%	0.63%	1.8905	0.7559
Pinterest	5.66%	5.66%	6.29%	4.40%	11.32%	33.33%	3.1182	0.5382
Forsquare	0.31%	0	0	0	0.31%	0.63%	1.8905	0.7559
TikTok	14.78%	13.21%	14.15%	7.55%	26.42%	76.10%	8.6202	0.0713
LinkedIn	4.40%	4.40%	3.14%	3.46%	8.81%	24.21%	3.2115	0.5231

Source: own study.

The results of the Pearson's chi-square test – in the case of all social networking sites listed in Table 4 – at the adopted level of significance ($\alpha = 0.05$), indicate that there are no grounds to reject the verified null hypothesis and demonstrate the lack of relationship between the choice of the site and the respondent's place of residence in Great Britain in 2023. We can therefore conclude about similar research results in both communities (countries). The only difference occurred in the case of Twitter, where the place of residence turned out to be statistically significant when choosing this social networking site by Polish Generation Z respondents.

The use of the Pearson's chi-square test allowed for measuring the significance of the relationship between the studied variables, but did not allow for measuring its strength and causal nature of connections between variables (choice of a social networking site and the respondent's place of residence).

The next part of the survey questionnaire also included the question: *How often do you perform the following activities on social media?* The results obtained in Poland and Great Britain in 2023 are presented in Figures 3 and 4.

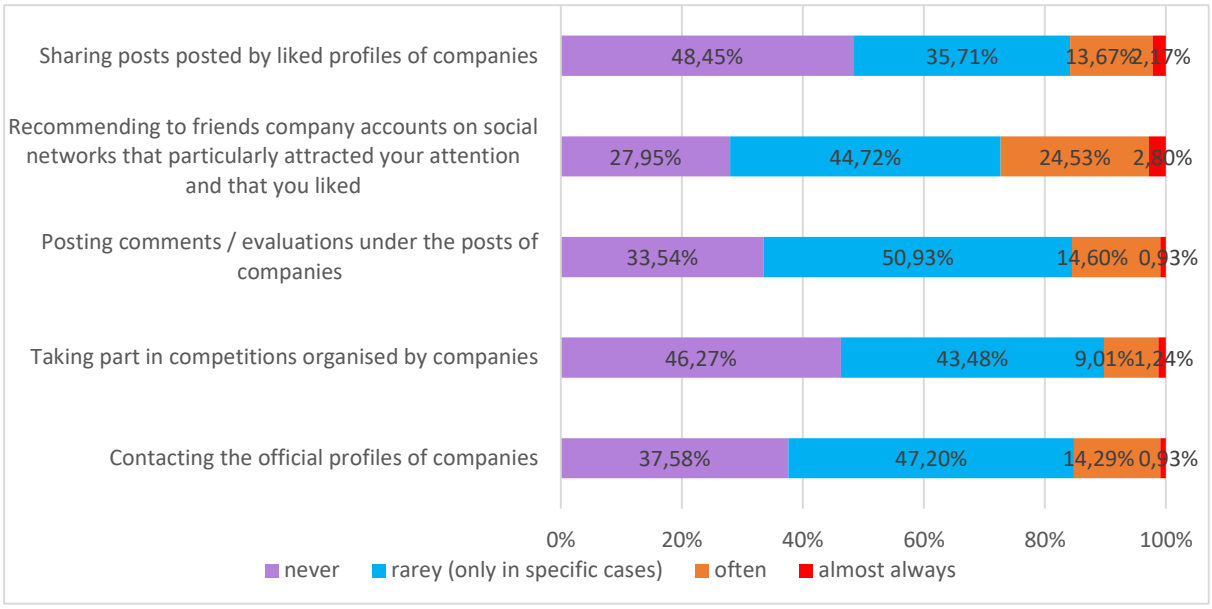


Figure 3. Activities performed in social media by respondents in Poland in 2023.

Source: own study.

The results of a study carried out in Poland in 2023 indicate that the surveyed representatives of Generation Z generally never performed or rarely performed the above-mentioned activities on social media. This may indicate the low interest of respondents in the content published by entrepreneurs on social media in Poland. The most common activity among those mentioned (Figure 3) was recommending to friends those business accounts on social networking sites that caught the attention and appeal of the respondents.

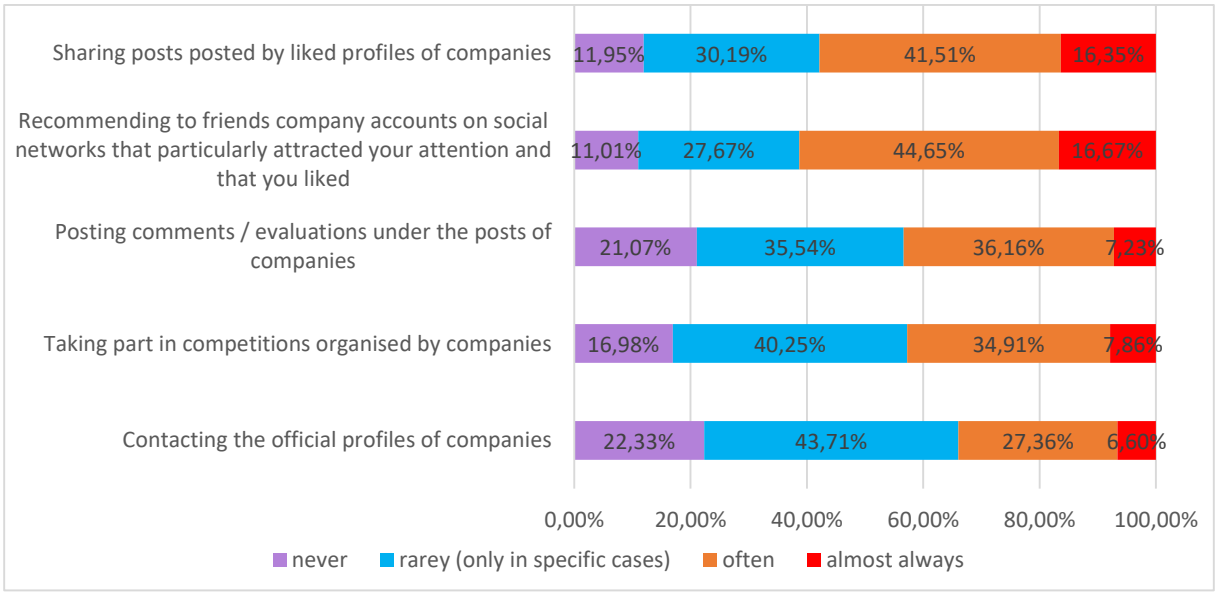


Figure 4. Activities performed in social media by respondents in Great Britain in 2023.

Source: own study.

In the case of the study carried out in Great Britain, in relation to all the mentioned activities, apart from contacting official company profiles, approximately 50%-60% of respondents answered that they do them often or always. The numbers of responses obtained among

Generation Z representatives in Great Britain were very different from those obtained from respondents in Poland. In both research groups, in 2023, the most frequently performed activity by Generation Z respondents was recommending to their friends those company accounts on social networking sites that particularly caught their attention and liked them.

In order to determine whether the respondent's gender affects the frequency of performing specific activities on social media, the authors used the Mann-Whitney U test (with continuity correction). This test was used to analyze answers to questions about differences between the study groups, because it has the great advantage that it can be used on small samples of respondents. It can also be used when the measured variables are ordinal, e.g. on a Likert scale (Nachar, 2008). In both studies (in Poland and in Great Britain), respondents were divided into two groups (women and men). The authors could not conclude that the two studied groups came from a normal distribution because they included a relatively small number of participants. In this case, the authors could not resort to the parametric mean test using the Student's t-distribution because it was not possible to check whether both samples were normally distributed (Fay, Proschan, 2010; Walters, 2021). The results obtained in 2023 regarding the impact of gender on activities performed in social media, which the authors subjected to statistical analysis, are presented in Tables 5 and 6.

Table 5.
Results of the Mann-Whitney U test (with continuity correction) regarding the relationship between the frequency of activities on social media and the respondent's gender in Poland in 2023

Variables	Sum of ranks Female	Sum of ranks Male	U	Z	p
contacting the official profiles of companies & gender	27750.5	24252,5	12006.5	-1.23	0.2185
taking part in competitions organised by companies & gender	27050.0	24953,0	12707.0	-0.32	0.7501
posting comments/evaluations under the posts of companies & gender	26936.0	25067,0	12821.0	-0.17	0.8677
recommending to friends company accounts on social networks that particularly attracted your attention and that you liked & gender	10272.5	29484,5	-3.2	**-3.43**	**0.0006**
sharing posts posted by liked profiles of companies & gender	28280.5	23722,5	11476.5	-1.92	0.0543

Source: own study.

Based on the adopted level of $\alpha = 0.05$, the Z statistics of the Mann Whitney U test with continuity correction, as well as on the basis of the exact U statistics, it can be assumed that there are statistically significant differences between female and male Generation Z respondents in Poland in 2023 in terms of the frequency of recommendations to friends of those company accounts on social networking sites that particularly caught attention and liked them. The differences lie in the fact that women were more likely to recommend business accounts on social networking sites to their friends. They can be described based on the median, quartiles and the largest and smallest values, which are also visible on the box-and-whisker chart (Figure 5).

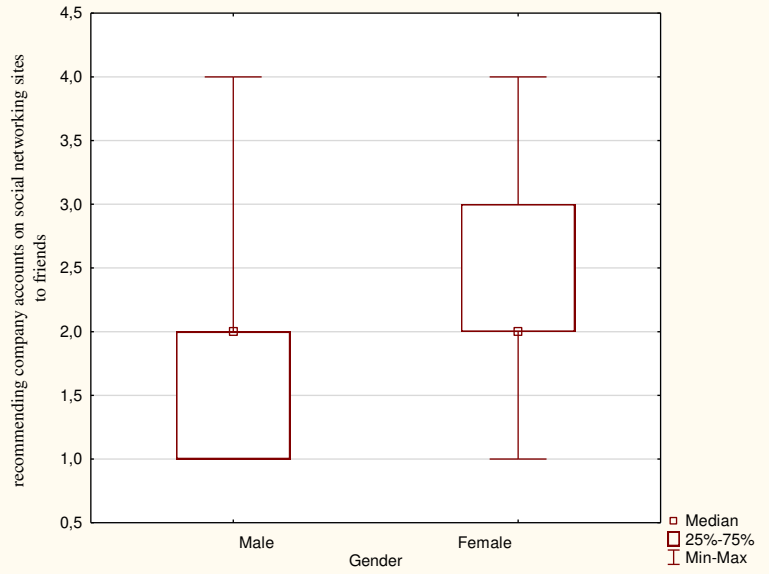


Figure 5. Frequency of recommending company accounts on social networking sites to friends by respondent's gender in Poland in 2023.

Source: own study.

In the scope of the study carried out in Poland, in the case of the remaining activities listed in Table 5, the analysis of the collected data did not allow the conclusion that gender significantly differentiated the analyzed variables ($p < 0.05$ was not obtained for any of the variables). This means that in the study group, both women and men performed the above-mentioned activities with a similar frequency.

Table 6.
Results of the Mann-Whitney U test on the relationship between the frequency of social media activities and the respondent's gender in Great Britain in 2023

Variables	Sum of ranks Female	Sum of ranks Male	U	Z	p
contacting the official profiles of companies & gender	30196.0	20525.0	10296.0	**-2.07**	**0.0385**
taking part in competitions organised by companies & gender	32080.5	18640.5	11500.5	0.45	0.6496
posting comments/evaluations under the posts of companies & gender	30274.0	20447.0	10374.0	-1.95	0.0512
recommending to friends company accounts on social networks that particularly attracted your attention and that you liked & gender	32706.5	18014.5	10874.5	1.29	0.1955
sharing posts posted by liked profiles of companies & gender	32349.5	18371.5	11231.5	0.81	0.4175

Source: own study.

Based on the adopted level of $\alpha = 0.05$, the Z statistics of the Mann Whitney U test with continuity correction, as well as on the basis of the exact U statistics, it can be assumed that there are statistically significant differences between female and male Generation Z respondents in Great Britain in 2023 in terms of frequency contacting official company profiles. These differences lie in the fact that women contacted companies on social media more often

than men. They can be described based on the median, quartiles and the largest and smallest values, which are also visible on the box-and-whisker chart (Figure 6).

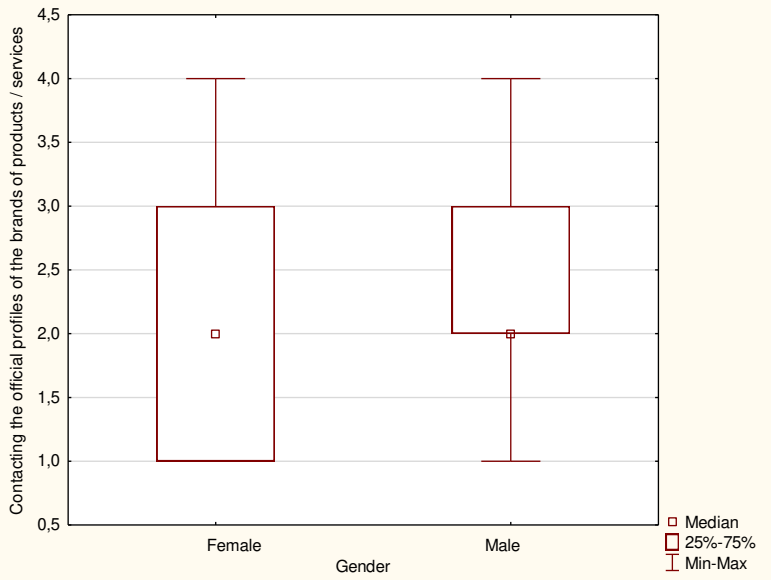


Figure 6. Frequency of contacts with official company profiles on social media by respondent's gender in Great Britain in 2023.

Source: own study.

In the case of the remaining social media activities listed in Table 6, the statistical analysis showed that the gender of the respondent in Great Britain did not differentiate the frequency of performing these activities. To sum up, the results of the research conducted in both countries (Tables 5 and 6) indicate differences in only two cases in terms of the examined correlations between the variables ($p > 0.05$).

The next stage of the analysis was to verify whether there is a relationship between the variables: frequency of activities on social media (variable X) and the respondent's place of residence (variable Y). To assess the correlation between two qualitative features (Akoglu, 2018), the authors used a non-parametric test – Spearman's rank correlation coefficient (Tables 7 and 8). Spearman's rank correlation coefficient is used to analyze the interdependence of objects in terms of a two-dimensional feature (X, Y). The Rxy coefficient calculated from the sample is an estimate of the correlation coefficient ρ in the general population, and its numerical value is a point assessment of the strength of the connection in the entire population (Akoglu, 2018; Wiśnienwski, 2014). Hence the need to test the significance of the correlation coefficient calculated based on a random sample. The following set of hypotheses was verified:

$$H_0: \rho = 0$$

towards the alternative hypothesis:

$$H_1: \rho \neq 0$$

Verification of the null hypothesis helped to assess whether the existing relationship between the studied variables (X and Y) in the sample is only accidental or may be a regularity in the studied communities (countries). The calculated Spearman's correlation coefficients and

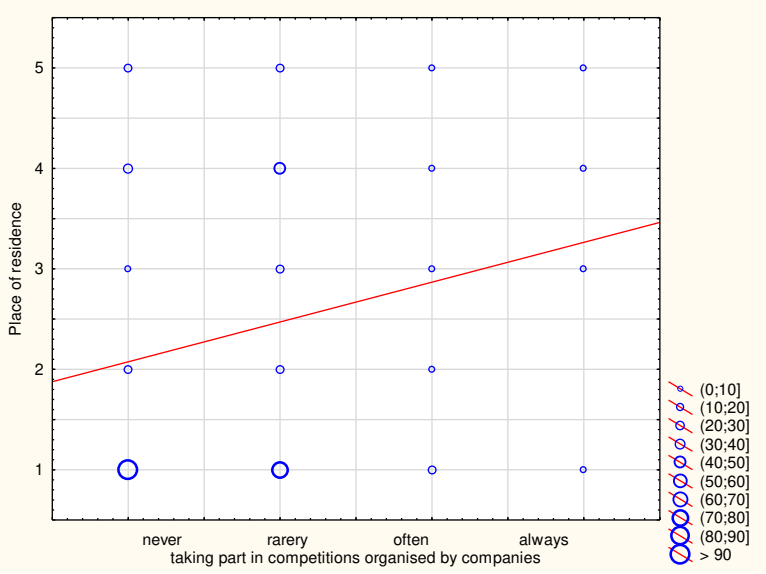
their significance levels regarding the relationship between the frequency of individual activities on social media and the place of residence of respondents in 2023 are presented in Tables 7 (data for Poland) and 8 (data for Great Britain).

Table 7.
Spearman's rank order correlation between the frequency of activities on social media and the respondent's place of residence in Poland in 2023

Variables	N of valid ones	Spearman's rank R	t(N-2)	p
contacting the official profiles of companies & place of residence	322	0,0597	1,0701	0,2854
taking part in competitions organised by companies & place of residence	322	**0,1729**	**3,1402**	**0,0018**
posting comments/evaluations under the posts of companies & place of residence	322	**0,2080**	**3,8048**	**0,0002**
recommending to friends company accounts on social networks that particularly attracted your attention and that you liked & place of residence	322	**0,1133**	**2,0392**	**0,0422**
sharing posts posted by liked profiles of companies & place of residence	322	**0,1675**	**3,0388**	**0,0026**

Source: own study.

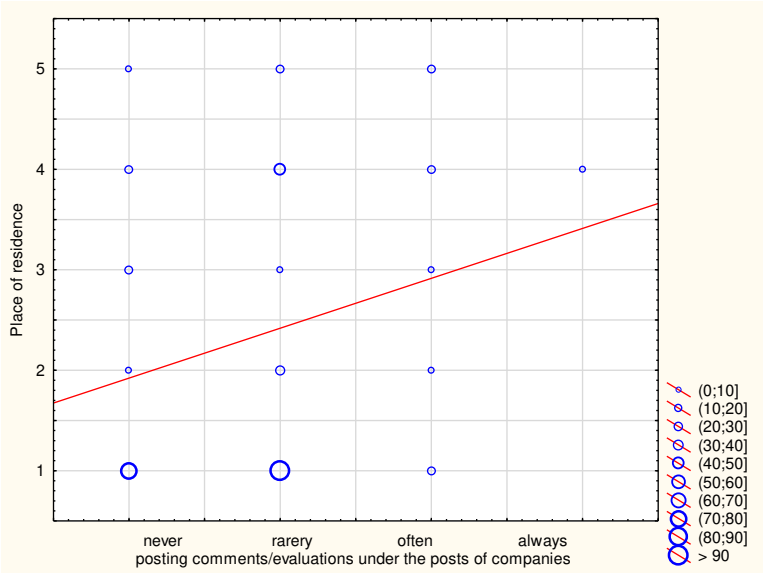
Data analysis (Table 7) indicates that in the case of the study conducted in Poland, there were statistically significant correlations between the analyzed variables, i.e. the frequency of performing as many as four of the mentioned activities on social media and the respondent's place of residence in 2023 ($p < 0.05$). A detailed interpretation of the correlations found is provided by scatterplots (Figures 7, 8, 9, and 10).



where: 1. village, 2. city up to 50 000 residents, 3. city up to 100 000 residents, 4. city up to 250 000 residents, 5. city over 250 000 residents.

Figure 7. Scatterplot of the correlation between the frequency of participating in competitions organized by enterprises and the respondent's place of residence in Poland in 2023.

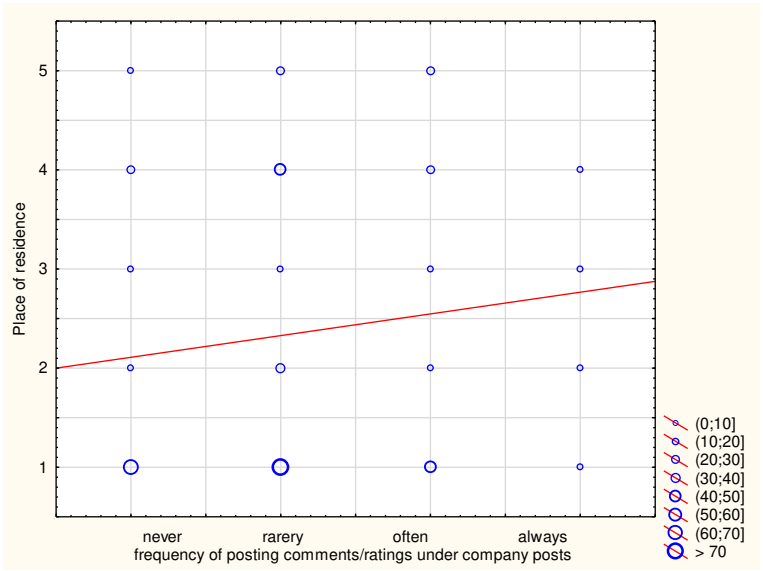
Source: own study.



where: 1. village, 2. city up to 50 000 residents, 3. city up to 100 000 residents, 4. city up to 250 000 residents, 5. city over 250 000 residents.

Figure 8. Scatterplot of the correlation between the frequency of posting comments/ratings under company posts and the respondent's place of residence in Poland in 2023.

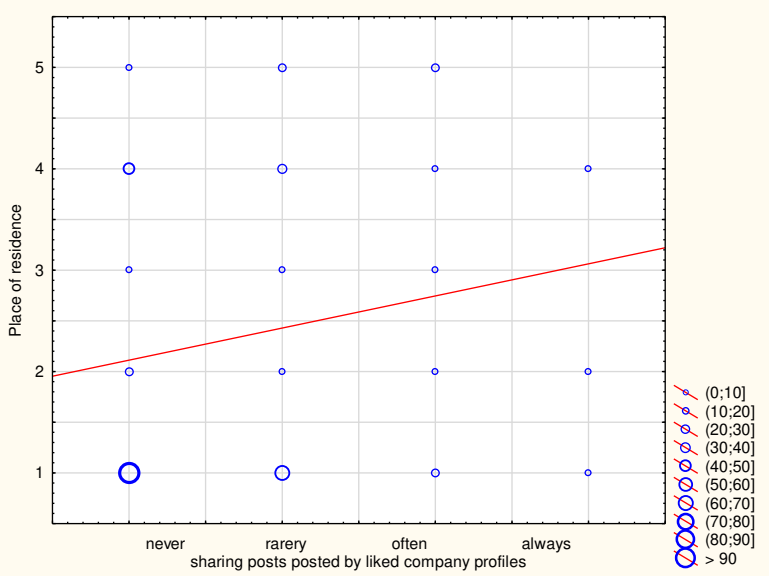
Source: own study.



where: 1. village, 2. city up to 50 000 residents, 3. city up to 100 000 residents, 4. city up to 250 000 residents, 5. city over 250 000 residents.

Figure 9. Scatterplot of the correlation between the frequency of recommending to friends those company profiles on social networking sites that particularly attracted attention and were liked, and the respondent's place of residence in Poland in 2023.

Source: own study.



where: 1. village, 2. city up to 50 000 residents, 3. city up to 100 000 residents, 4. city up to 250 000 residents, 5. city over 250 000 residents.

Figure 10. Scatterplot of the correlation between the frequency of sharing posts posted by liked company profiles and the respondent's place of residence in Poland in 2023.

Source: own study.

Data analysis (Figures 7, 8, 9, and 10) indicates that all the above-mentioned activities, apart from contacting official company profiles, were rarely or not performed at all by respondents living in rural areas in Poland.

Table 8.
Spearman's rank order correlation of the relationship between the frequency of activities on social media and the respondent's place of residence in Great Britain in 2023

Variables	N of valid ones	Spearman's rank R	t(N-2)	p
contacting the official profiles of companies & place of residence	318	0.0509	0.9059	0.3657
taking part in competitions organised by companies & place of residence	318	-0.0023	-0.0410	0.9673
posting comments/evaluations under the posts of companies & place of residence	318	0.0804	1.4336	0.1527
recommending to friends company accounts on social networks that particularly attracted your attention and that you liked & place of residence	318	0.0448	0.7971	0.4260
sharing posts posted by liked profiles of companies & place of residence	318	0.0884	1.5783	0.1155

Source: own study.

Statistical analysis of data collected in Great Britain in 2023 (Table 8) indicates the lack of statistically significant correlations between the analyzed variables ($p > 0.05$). In summary, respondents' place of residence in Great Britain was not related to the frequency of their activities on social media. Summarizing the results of the research conducted in both countries (Tables 7 and 8), it is necessary to confirm the fundamental differences in the scope of the examined correlations between the variables.

5. Discussion and conclusion

The current principles of digital-first marketing, which worked well for the Millennial generation, are less and less applicable to Generation Z. Both generations have many things in common and at the same time many differences. Generation Z has clearly defined values and does not buy products from companies that do not reflect these values (Alves, 2023). The impact of social media on the lives, including shopping, of Generation Z is enormous – over half of Generation Z representatives spend at least 4 hours a day on social media, and nearly 40% of this cohort even longer (Briggs, 2022; Morning Consult, 2022). Over 80% of Generation Z representatives search for information and solutions on the Internet every day, and almost 70% do it even several times a day (Rio SEO, 2022). Almost 80% of this generation bought a product they saw on social media (Statistics, 2022). The role that social media plays in the lives of Generation Z cannot be overestimated. It should encourage managers to learn about the relationship between the activities undertaken by enterprises and the activity and involvement of this generation in communication with the enterprise. Since Generation Z spends most of their time on the Internet following social networking sites, this is where companies should interact with their customers, develop their company websites and place product advertisements (Sadowa, 2019).

The results of the research conducted by the authors expand the existing knowledge about the activity of Generation Z in social media towards enterprises. The results indicate significant relationships between the activity undertaken and the respondent's gender and place of residence. The main conclusions resulting from the analysis of the collected empirical data in relation to the research questions are presented in Table 9.

Table 9.
Summary of the obtained research results divided into the research questions asked

Research question	Answer - Poland	Answer - Great Britain
Q1. What social networking sites are most frequently used by Generation Z members?	YouTube Facebook Instagram	Instagram YouTube TikTok
Q2. Is there a relationship between the choice of a social networking site and the gender of a Generation Z representative?	Yes, the difference between structure indicators according to the respondent's gender turned out to be statistically significant in the following cases: – men used YouTube and Twitter more often than women, – women, more often than men, used Instagram, Snapchat, Pinterest and TikTok.	Yes, the difference between structure indicators according to the respondent's gender turned out to be statistically significant in the following cases: women used Facebook, Instagram, Pinterest and LinkedIn more often than men.

Cont. table 9.

Q3. Is there a relationship between the choice of a social networking site and the place of residence of a representative of Generation Z?	Yes, but only when using Twitter. This portal was chosen mainly by rural residents and urban residents up to 250,000.	No (no statistically significant correlations between the analyzed variables)
Q4. What activities are most often performed by Generation Z representatives in social media towards companies?	Recommending to your friends those business profiles on social networking sites that particularly caught your attention and appealed to you.	1. Recommending to your friends those business profiles on social networking sites that particularly caught your attention and appealed to you. 2. Sharing posts posted by company profiles you like
Q5. Does the respondent's gender influence the frequency of actions he or she undertakes towards enterprises in social media?	Yes, women more often than men recommended to their friends those business profiles on social networking sites that particularly caught their attention and they liked	Yes, women contacted companies on social media more often than men
Q6. Does the respondent's place of residence influence the frequency of activities he or she undertakes in social media towards enterprises?	Yes, four activities were performed rarely or not at all by rural residents: – taking part in competitions organized by companies, – posting comments/ratings under company posts, – recommending to friends those company profiles on social networking sites that have particularly attracted attention and liked them, – sharing posts posted by liked company profiles.	No, there are no statistically significant correlations between the analyzed variables.

Source: own study.

The results of the conducted research are partially consistent with the results presented in the literature. The most frequently used platforms by Generation Z include YouTube, Instagram, TikTok and Snapchat (Briggs, 2022; Morning Consult, 2022; Dumford et al., 2023). The research conducted by the authors showed that representatives of Generation Z in Poland still frequently visit Facebook, contrary to the surveyed respondents from Great Britain and the research results of other authors. Generation Z uses social media for various reasons, the most important of which are entertainment and convenience (Alhabash et al., 2017). The research results allowed us to identify the most frequently performed activities by representatives of Generation Z in social media in relation to enterprises. The fact that Generation Z is faithful to its values and will only engage in what is consistent with them has been confirmed (Alves, 2023). Respondents in both surveyed countries are most likely to recommend to their friends those company profiles on social networking sites that particularly caught their attention and which they liked, i.e. which are consistent with the values they represent.

The results obtained by the authors identifying the relationships between the choice of a social networking site and the gender and place of residence of Generation Z representatives complement the research conducted so far. Both in Poland and in Great Britain, the respondent's

gender determines his choice of social networking site. In Poland, women used Instagram, Snapchat, Pinterest and TikTok more often than men. However, in Great Britain, women used Facebook, Instagram, Pinterest and LinkedIn more often than men. The respondent's place of residence influenced the choice of websites only for respondents living in Poland – the Twitter website was chosen mainly by rural residents and city residents with a population of up to 250,000. The respondent's gender also influences the type of activity he or she performs in social media towards enterprises. In Poland, women were more likely than men to recommend business profiles on social networking sites that they particularly liked to their friends, while in Great Britain, women were more likely than men to contact companies on social media. The influence of the respondent's place of residence on his/her activities was identified only among respondents living in Poland – rural residents did not take part in competitions organized by enterprises, did not post comments/ratings under enterprise posts, did not recommend company profiles on social networking sites to friends, did not share posts posted by liked company profiles or performed these activities rarely.

Enterprises should focus on formulating the content provided to customers and on taking actions that will engage customers in social media and be active towards them. Taking care of individual engagement in discussions, likes and shares, as well as the visibility of individual posts may be a better indicator of a company's success than the number of people following the profile (Alves, 2023). A holistic approach to customer contact and service (omnichannel marketing) is the best way to communicate with Generation Z on social media, still constituting an interesting puzzle for marketers (Alves, 2023). Customer orientation using knowledge about which of the activities undertaken by enterprises in social media will most stimulate the activity and interest of Generation Z customers, leading to their involvement in communication, will allow not only to optimize the company's costs incurred for communication, but above all to acquire and keep customers. Future research should be conducted on a larger sample, and quantitative research should be supplemented with qualitative research. Undertaking research in other countries would allow us to compare the features of Generation Z's activity in social media and determine whether and which of them occur regardless of geographical location.

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CREATING THE VALUE NETWORK AND CONVERTING THE BUSINESS MODEL OF TECHNOLOGY COMPANIES

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Purpose: The objective of this publication is to understand and explain the relationships between the creation of the value network and the conversion of the business model of technology enterprises that are built on digital platforms.
Design/methodology/approach: To accomplish the assumed objective, the following research methods were used: critical analysis of literature, case study and trend analysis. The research period is the years 2018-2022. The case study deals with the examples of companies that are listed on the Nasdaq Stock Exchange or NYSE: Amazon, Alibaba, and Facebook.
Findings: The results of the empirical research in terms of acquiring knowledge about the relationships between the creation of value networks and the conversion of the business model of the surveyed technology companies show that the surveyed enterprises convert their business models by creating the value network, competing for customers on the market of digital platforms. Understanding the processes of creating the value network in the business model enables long-term competition on the market, which at the same time shapes the development of the enterprise.
Originality/value: The publication deepens the understanding of the dynamic perspective of creating the value network extended to the catalog of stakeholders of the value created, from customers and owners to suppliers, and potentially by other stakeholders, creating the value network. The construct of the value network allows for searching for new areas of value creation, pointing to the network effect, which may, on the one hand, strengthen value generation, and on the other hand, may lead to its destruction.

Keywords: Creation of value networks, business model, technology companies, enterprise management.

Category of the paper: Case study.

1. Introduction

Value creation is one of the principles of the new management paradigm (Zakrzewska-Bielawska, 2011), which is a strategic category in the process of enterprise management

(Oliveira et al., 2012). This means that value creation processes are connected with the formulation of the company's objectives and translate into their effectiveness (Davidow, 2018). Therefore, modern enterprises should redefine their objectives so as to create common value, both for the enterprise and society (Kramer, Porter, 2011). However, changes in the market environment caused by the COVID-19 pandemic and the war in Ukraine have brought about that many enterprises are struggling with the uncertainty of conducting a business and difficulties in the process of value creation.

The situation is different in the case of technology companies that manufacture, develop, and sell products containing a significant element of modern science (Lepak, Smith, Taylor, 2007). A change in the approach to value creation processes in these enterprises contributes to the formation of links between social progress and the company's success (Cyfert, Krzakiewicz, 2016). A new objective can be accomplished by converting the existing business model, in which the value chain will be redefined through innovation, networks or through new markets. Technology companies, in order to satisfy the changing needs of customers, modify the existing business model. In this context, a business model emerges, which is an important component of the value creation process (Dyduch, 2019) and the structure of the innovative and competitive potential of the company, enabling the creation of value (Prahalad, Krishnan, 2010). Business models of digital platforms are of particular importance in the process of creating the value of technology enterprises. Due to the network effects, technology companies built on digital platforms achieve above-average efficiency (Skoczylas, Małe, 2004), which reflects the directions of the business conducted and explains the ways to achieve a competitive advantage.

The distribution of value created by technology companies will depend on the subjective assessment of the end user regarding the novelty, appropriateness, usefulness, and correctness of the exchange item (Amabile, et. al., 1996). Therefore, the study poses a research question: is it possible to identify the relationships between the creation of the value network and the conversion of the business model of technology companies that are built on digital platforms? The business model of technology companies built on digital platforms should consider such a configuration of revenues, costs, and potential profits so as to create value for itself, while strengthening its own market position. Hence, the objective of this publication is to understand and explain the relationships between the creation of value networks and the conversion of the business model of technology enterprises that are built on digital platforms. Referring to the research question, the empirical findings deal with the examples of companies that are listed on the Nasdaq Stock Exchange: Amazon, Alibaba, and Facebook. The research period is the years 2018-2022. To accomplish the assumed objective, the following research methods were used: critical analysis of literature, case study and trend analysis. This study develops the issue of identifying the determinants for creating the value network in the business model of digital platforms, which is important and up-to-date due to the lack of the in-depth theoretical research on the conversion of their business models, which

constitutes a cognitive gap. The above arguments brought about that an attempt of a theoretical analysis was made and a case study was conducted to fill the identified gap by deepening the understanding of the value creation process due to network effects by technology companies built on digital platforms.

2. The significance of creating value networks by enterprises

In the strategic approach to enterprise management, an important area of value generation is the creation of the value network. The idea of the value network assumes that the company together with general partners creates a value network (Brandenburger, Nalebuff, 1996). The theoretical framework for the value network is based on game theory and supplements the analysis of M.E. Porter's (Porter, 1985) five forces with the sixth force of coopetition.

The primary competitive force for enterprises competing within a given sector is created by customers, who are identified with the bargaining power of buyers. Another force is competitors, in the case of whom the risk of substitutes appearing on the market, and suppliers with their bargaining power is important. The next force is constituted by new competitors, providing customers with additional, complementary goods and services, generating increased added value (Brandenburger, Nalebuff, 1995).

It is worth noting that the creation of the value network is an element of the transformation of the chain of traditional values of the enterprise, supplemented with the force of coopetition. In traditional enterprises, customers purchasing products generate revenues, and suppliers provide the enterprise with resources constituting the cost parameter of value flow. Competitors, on the other hand, focus on creating substitutes for products offered by the traditional company. When creating the value network based on the force of coopetition, enterprises compete and cooperate at the same time, and the competition applies to both customers, resources, and suppliers (Hamel, Doz, Prahalad, 1989).

To sum up, it is worth emphasizing that in the case of enterprises creating value networks, the scope of activities of other network participants that may strive to capture a greater proportion of the added value generated should be analyzed (Otola, Grabowska, 2020). The company operating in the value network is strongly connected with other participants in the network. A change in the scope of activities of one of its participants may result in positive or negative changes in the scope of activities of other members, causing a change in the configuration of added value distribution. The scope of activities can be changed by creating or eliminating links between the participants of the value network, therefore, when preparing to change the scope of activities, it is necessary to go beyond tactics and analyze the market in a broader, strategic perspective.

3. Research methodology and research procedure

The objective of the conducted research is to understand and explain the relationships between the creation of the value network and the conversion of the business model of technology enterprises operating on the basis of digital platforms. The study of the above-mentioned relationships requires a deliberate and selective choice of research methods. The research methods used to achieve the objective are critical analysis of literature, case study, trend analysis. The use of triangulation of research methods is intended to enable the accomplishment of the assumed objective by presenting the description of the studied phenomena and limiting the possibility of errors in the research procedure (Mangan, 2004).

Critical analysis of literature is a method that serves both cognitive and utilitarian purposes. The method of critical analysis of literature can be the basis for the implementation of appropriate research in relation to the set cognitive objectives (Jesson, Lacey, 2006). In addition, this method allows the use of scientific achievements in specific activities through the synthesis and evaluation of the existing achievements in the case of the implementation of utilitarian objectives by the researcher (Andrews, Harlen, 2006).

The premise for conducting the research using the triple case study method is the fact that the issue of the role played by technologies in the processes of creating value networks through network effects is presented in the literature in a fragmentary and dispersed way (Kraus et al., 2022). The current state of knowledge in this field is characterized by methodological multiplicity, and the lack of in-depth theoretical research results in few attempts to identify the impact of technology on the processes of creating the value network in the business model. It is worth noting that the scientific nature of the case study method is evidenced by objective, systematic, organized, rational and structured activities, and their purpose is to ensure the credibility of conclusions (Eisenhardt, Graebner, 2007), therefore developing a theory based on a case study is considered reliable in the literature (Yin, 2009).

The relationship between the creation of the value network and the conversion of the business model of technology enterprises was verified based on trend analysis. Trend analysis studies are widely used to explain the studied phenomena (Popper et al., 2007) and are easy to implement. Trend analysis is designed to reflect the long-term tendency to regular, one-way systematic changes caused by an increase or decrease in the value of the variables under study. The selection of the variables for the empirical research was carried out based on logical premises and was also conditioned by the objective of the research. The variables examined in the first and second stages are: Total Revenue, Cost of Revenue and Gross Profit of the surveyed entities. In order to explain the relationships between the creation of the value network and the conversion of the business model of technology companies, the research procedure aimed at achieving the assumed objective was carried out in two stages. In the first stage, the analysis of the above-mentioned variables will allow the measurement of

value created from the customer's perspective, revealing the processes of creating value networks in the surveyed enterprises (Ranjith, 2016). In the second stage, the same variables will be examined from the perspective of the surveyed enterprises (Kaplan, Norton, 2006), which will enable the assessment of the conversion of the business model, which is of strategic importance for the activities conducted by the surveyed technology enterprises, and the identification of the relationship between the creation of the value network and the conversion of the business model.

4. Description of the sample selection and outline of the activities of the surveyed enterprises

The surveyed technology companies are digital platforms that were selected on the basis of purposeful sampling, in accordance with the following criteria:

- the companies subject to the study were listed on the NASDAQ or NYSE stock exchanges throughout the research period,
- the empirical data of the surveyed enterprises were available on the NASDAQ or NYSE Stock Exchange websites for the entire research period,
- in all cases, individual financial statements are available on an annual basis, in accordance with the assumption that enterprises separated based on the organizational and legal criterion are economically independent and remain in competitive relations.
- the list of enterprises covered by the study is constant throughout the research period,
- the surveyed enterprises can be classified as digital platforms.

Such assumptions ultimately led to the empirical research being carried out on a sample of three companies listed on the NASDAQ Stock Exchange: Amazon, Alibaba, and Facebook – currently Meta Platforms. The research period was the years of 2018-2022.

- Amazon is a global e-commerce platform. Amazon (AMAZ) is an online electronic retailer. The company creates the value network by offering computer services, consumer electronics, digital content, and other local services such as daily deals and groceries (statista.com/topics/846/amazon, 2023). Amazon was founded in 1994 in Seattle (USA) and is famous for its strategy of discounting products (Ritala, Golnam, Wegmann, (2014), with a low base price. Initially, Amazon's activity focused on the online sale of books (Peprah et al., 2022). Currently, the company is a leader in the Business to Consumer (B2C) e-commerce industry. Amazon's corporate value network includes, among others, Alexa Internet, SoundUnwound, Joyo.com and IMDb. Amazon’s portfolio includes Twitch, Zappos, The Washington Post, Kindle e-book reader, Amazon Fire Phone, Amazon Prime, FireTV. Amazon’s low-price strategy is based on economies of scale (Keen, Williams, 2013). Amazon, being one of the largest

players in the e-commerce market, can buy significant quantities of specific goods directly from the manufacturer or distributor, which allows it to negotiate significantly lower prices compared to the competitors (Daniel, Kahlun, 2021). In addition, Amazon offers assistance in sales service and provides customers with servers (Amazon Web Services), due to which they can use the virtual cloud without incurring high costs (Wadhwa et al., 2020). When growing, Amazon introduced the virtual voice assistant, Amazon Alex. Moreover, Amazon uses an extensive network of distributors to deliver parcels via courier companies (external - DHL, DPD and FedEx and internal - Amazon Logistics).

- Facebook Inc. changed its name to Meta Platforms (META) in October 2021. Facebook was founded in 2004 and is an international technology company headquartered in California (Menlo Park, USA). The flagship product of the company is a social platform. Currently, the group of Meta Platforms applications that create the value network also includes Messenger, WhatsApp, Instagram, Oculus, Mapillary and Giphy. Changes in the company initiated in 2021 are directed towards the development of the Metaverse (statista.com/topics/9038/meta, 2023). In this regard, the company develops virtual reality (VR) and augmented reality (AR) products and services, among which Reality Labs attracts attention, around which the company concentrates its research and development activities. The introduced change signals the implementation of a new business model (Kraus et al., 2022), which was based on the configuration of the following three components: value creation, value proposition and value capture (Pucihar et al., 2017). The new business model remains in relation to the strategic resources of the company through the configuration of unique activities, resources, and competences (Chen, 2014), the task of which is to support the implementation of strategic goals (Hu, 2011). The main source of the Total Revenue of Meta Platforms is advertising revenue; hence it is important for the company's development to accept the value proposition generated by augmented and virtual reality through a different type of online experience.
- Alibaba (BABA) is a leading platform for global wholesale trade that creates the value network by bringing together many branches of the e-commerce market. Alibaba Group was founded in 1999 in Hangzhou (China). The primary objective of the group is to enable suppliers and customers to freely trade goods from anywhere (Yun et al., 2020). Alibaba is a leader in wholesale, used by sellers and customers around the world (Schmuck, Benke, 2020). Alibaba creates modern sales platforms such as Business to Business (B2B), Business to Consumer (B2C) and Consumer to Consumer (C2C), which are a form of presenting business and sales offers. Alibaba was first listed on the New York Stock Exchange (NYSE) on 19 September 2014. Alibaba Group's main corporate campus include, among others, Taobao Marketplace, Tmall, AliExpress, Alibaba.com, 1688.com, Alimama, Alibaba Cloud, Cainiao Network, Ant Financial.

The company has offices in many places around the world. They play an important role as intermediaries between the largest Chinese sales platform and suppliers and customers who would like to enter the Chinese online market (Zhang-Zhang et al., 2020). Alibaba Group focuses its activities on providing companies with various ways to market products and sell them (Kwak et al., 2019). Alibaba also offers modern technological solutions that enable customers to increase productivity and work efficiency.

5. Results of the conducted empirical research

The processes of creating the value network are the basic element of building the business model and competitive advantage of the company. The current state of knowledge in the field of management science indicates that the company should concentrate its activities on creating the value network for the client (MacDonald, Ryall, 2004). Therefore, enterprises operating on the basis of digital platforms, in order to satisfy the changing needs of customers, should modify the existing business model by identifying variables affecting the creation of value.

5.1. The first stage of the research procedure

Acquiring knowledge about the relationship between the creation of value and the conversion of the business model of the surveyed enterprises requires the observation of socio-economic phenomena. A special category of variables are the Total Revenue, Cost of Revenue and Gross Profit of the surveyed entities. These listed variables are of strategic importance for the continuation of the company's operations. In a situation of competition for a competitive advantage, these variables become the carrier of the value created for the customer. In the first stage of the research procedure, the Total Revenue, Cost of Revenue, and Gross Profit of the examined entities will be subject to comparative analysis.

The analysis of the trend lines of the examined variables becomes an important element of the decision-making process in the surveyed enterprises. This is due to the fact that trend analysis allows for assessing the level of value created in the network from the customer's perspective. When examining the level of Total Revenue in the surveyed enterprises, it is noted that in the base year, Amazon generates the highest Total Revenue in the analyzed period. In addition, the growth in Total Revenue in Amazon is highly dynamic, which suggests that the pandemic has become a factor positively affecting network relations for Amazon. Amazon has taken the opportunity to meet its customers' needs better by providing services through a digital platform, thus the mechanisms for exchanging value between the enterprise and the customer have enabled Amazon to create above average customer value through network effects.

Total Revenue in Meta Platforms (formerly Facebook) was much lower than in the case of Amazon. In 2018-2021, Meta Platforms was characterized by the growth in Total Revenue. However, the growth rate in 2022 was slower. This may indicate that there has been a shift in value towards new forms of doing business in Meta Platforms, which translates into a decrease in the growth rate of Total Revenue, and the pace of change suggests a lower potential for the growth of value created in the network.

Alibaba Group saw an increase in Total Revenue throughout the period under review. However, both the Total Revenue level and the growth rate are the slowest compared to the two previously discussed companies in the years 2018-2021. It should be noted that Alibaba Group is systematically and steadily increasing its share in the network service market. It is worth pinpointing that in 2022, the dynamics of the value chain creation processes in Alibaba Group may suggest that the surveyed company focuses its activities on increasing customer satisfaction. The development of the Total Revenue level in the surveyed enterprises is presented in Figure 1.

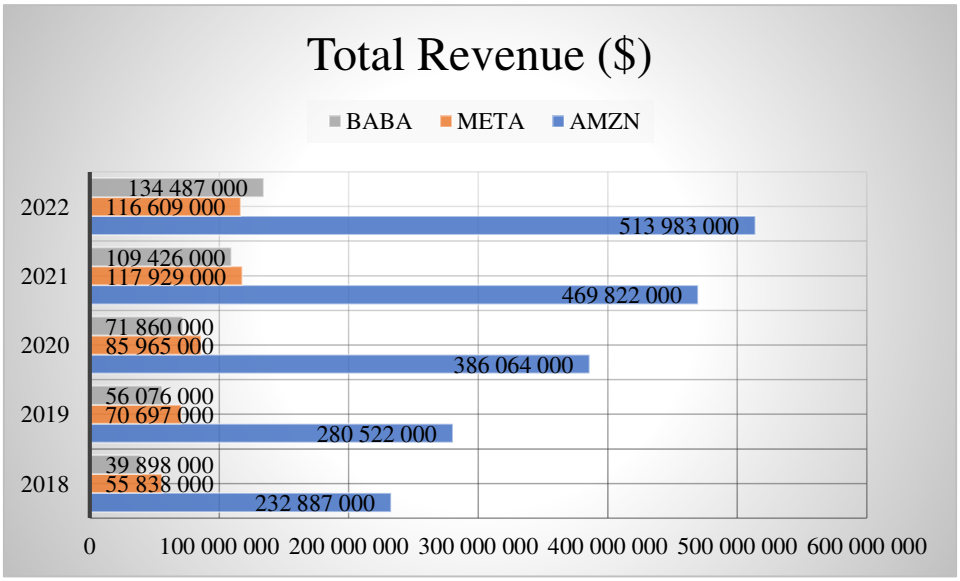

Figure 1. The Total Revenue level in the surveyed enterprises in the years 2018-2022.

Source: Own study: https://www.nasdaq.com/market-activity/stocks/.

When analyzing the development of Cost of Revenue in the surveyed enterprises, it is noted that the level of Cost of Revenue is the highest in Amazon. Moreover, the growth rate of Cost of Revenue is also the fastest in the case of Amazon. Alibaba Group keeps Cost of Revenue at a relatively low level. It is worth noting that Meta Platforms is characterized by a very low level of Cost of Revenue, and the growth rate of this variable is slower compared to the other two companies. The low level of Cost of Revenue in Meta Platforms may indicate cost discipline and the monitoring of tax-deductible costs. The development of the level of Cost of Revenue in the surveyed enterprises is presented in Figure 2.

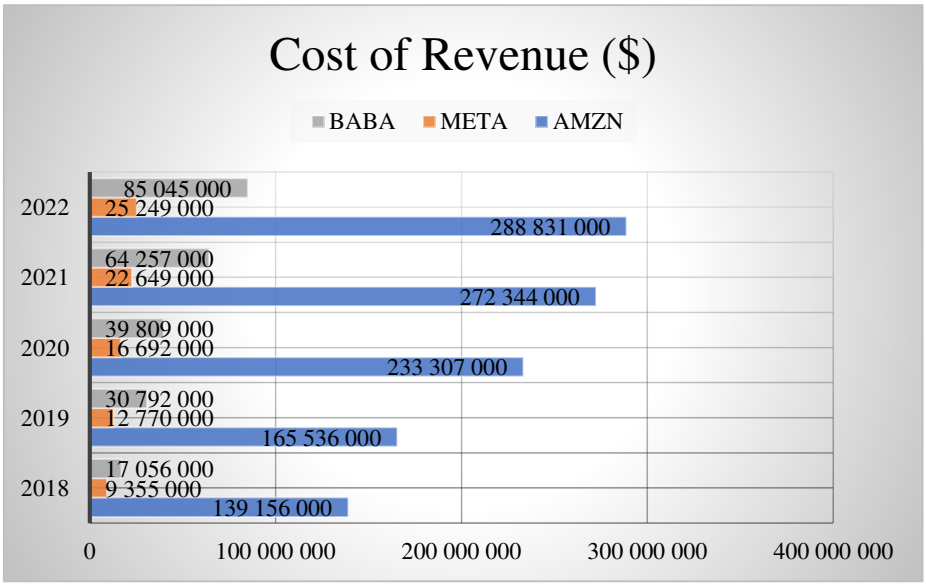

Figure 2. The Cost of Revenue level in the surveyed enterprises in the years 2018-2022.

Source: Own study: https://www.nasdaq.com/market-activity/stocks/.

When analyzing the growth in Gross Profit in the surveyed enterprises, it is noted that Amazon has the greatest ability to generate Gross Profit. Meta Platforms generates high Gross Profit by keeping Cost of Revenue low, which did not prevent the company from a decrease in the level of Gross Profit in 2022. On the other hand, the level of Gross Profit in Alibaba Group is the lowest compared to the other two companies. However, it is characterized by an upward trend throughout the research period. The development of the Gross Profit level in the surveyed enterprises is presented in Figure 3.

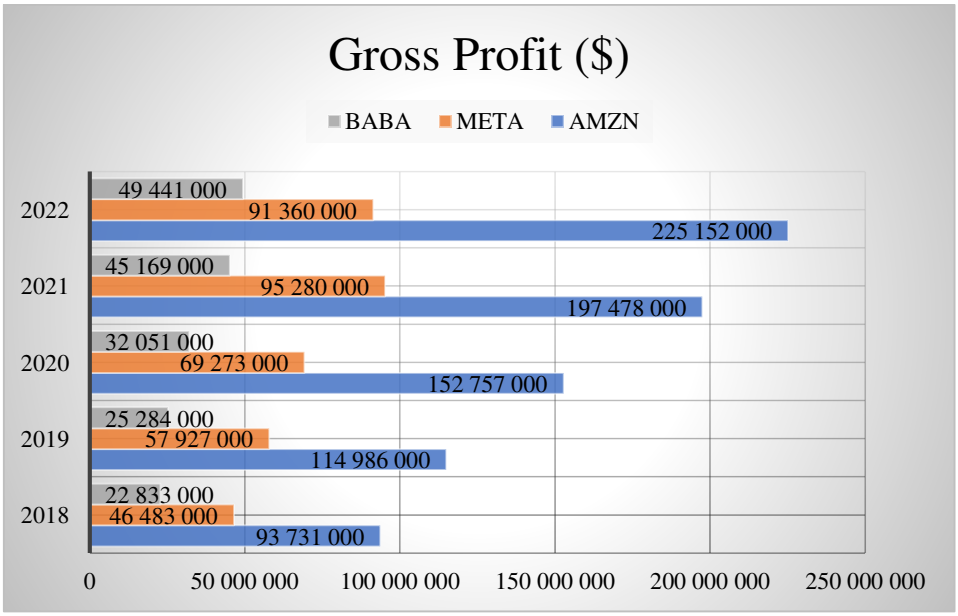

Figure 3. The Gross Profit level in the surveyed enterprises in the years 2018-2022.

Source: Own study: https://www.nasdaq.com/market-activity/stocks/.

When interpreting the obtained data, it can be concluded that Amazon and Meta Platforms have a significant ability to create value networks. The obtained data provide grounds for indicating that Alibaba Group has the ability to create the value network, however, the level and rate of change of the examined variables suggest that the methods of achieving revenue streams may be insufficient for the future development of the enterprise.

5.2. The second stage of the research procedure

In the second stage of the research procedure, the analysis of Total Revenue, Cost of Revenue and Gross Profit a will be carried out from the perspective of the surveyed enterprises. The research will enable the assessment of changes in the business model and show the relationship between the creation of the value network and the conversion of the business model of the surveyed enterprises.

When analyzing the Amazon business model, it is noted that the pandemic period was conducive to generating a high level of Total Revenue. Despite occupying the leading position on the market of the provided network services, it is noted that in the Amazon company, the growth in Cost of Revenue is controlled and its growth rate is slower than the growth rate of Total Revenue. Such an action translates into the level of Gross Profit in Amazon, which was systematic and even throughout the research period. The development of the level of the examined variables in the Amazon company is presented in Figure 4.

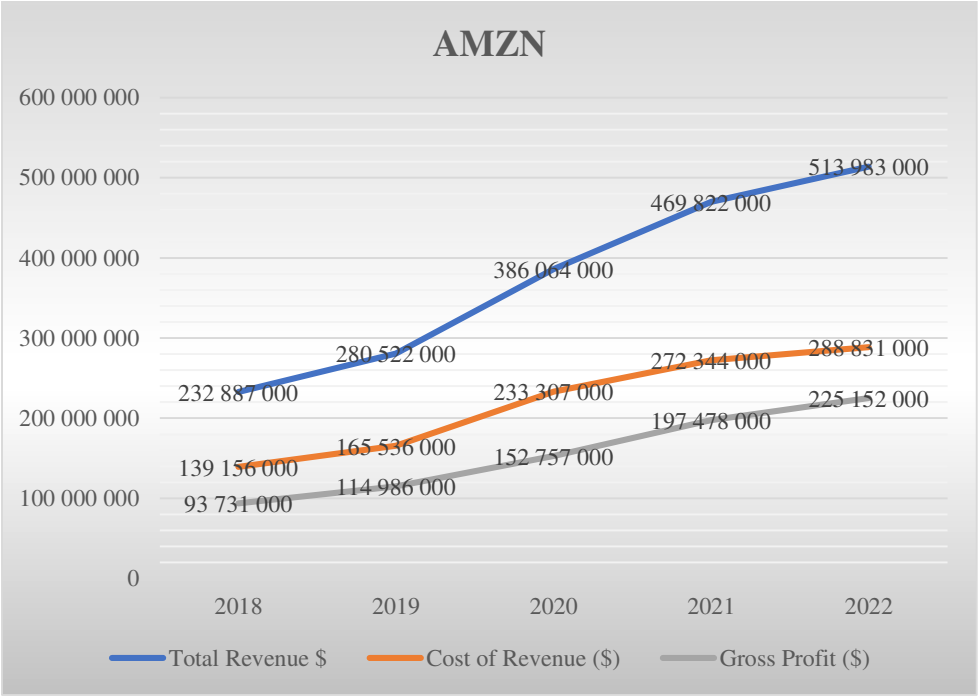

Figure 4. The level of the variables studied in the Amazon company in the years 2018-2022.
Source: Own study: https://www.nasdaq.com/market-activity/stocks/amzn/financials.

When considering the business model of Meta Platforms, it is noted that despite the dynamic upward trend of Total Revenue until 2021, the level of Cost of Revenue is not high and is characterized by slow growth. This means that Meta Platforms generates a high level of Gross Profit. The increase is proportional to Total Revenue, which means that during the pandemic, the company generates revenue streams that translate into high gross profit, which is not appropriated by decisions made in the field of operating costs. In 2022, a downward trend can be noticed in both Total Revenue and Gross Profit, while Cost of Revenue is increasing, which suggests that the company had problems in the area of tax-deductible cost management. The development of the level of the examined variables in the Meta Platforms enterprise is presented in Figure 5.

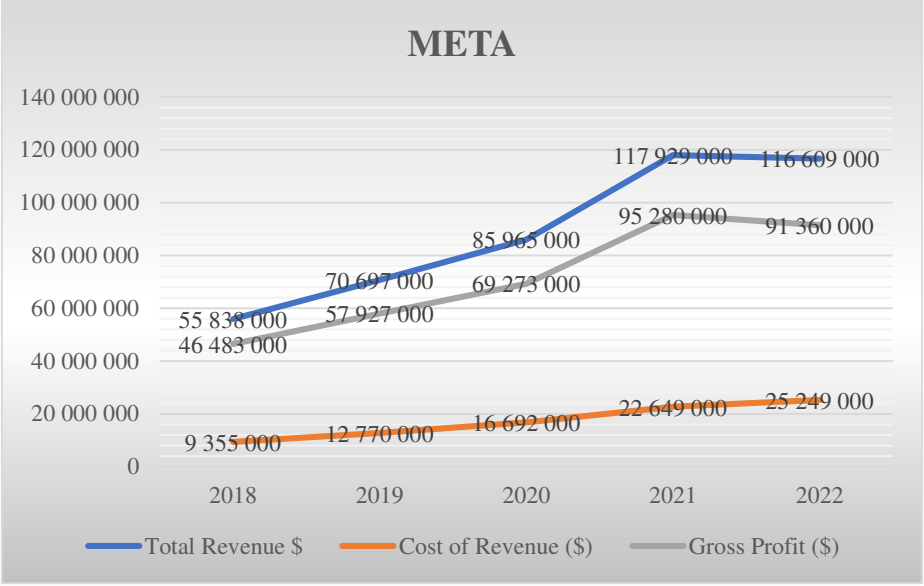

Figure 5. The level of the variables studied in the Meta Platforms company in the years 2018-2022.
Source: Own study: https://www.nasdaq.com/market-activity/stocks/meta/financials.

When examining Alibaba Group's business model, an interesting trend emerges. In 2018, the level of Cost of Revenue was lower than the level of Gross Profit. In the years 2019-2020, Cost of Revenue slightly exceeded the level of Gross Profit. The years 2021-2022 are characterized by a greater discrepancy between these two variables, although in the last of the analyzed periods it is characterized by a strong increase in Total Revenue, which proves that Alibaba Group met the expectations of its customers in a way that encourages further cooperation. The development of the level of the examined variables in the Alibaba Group enterprise is presented in Figure 6.

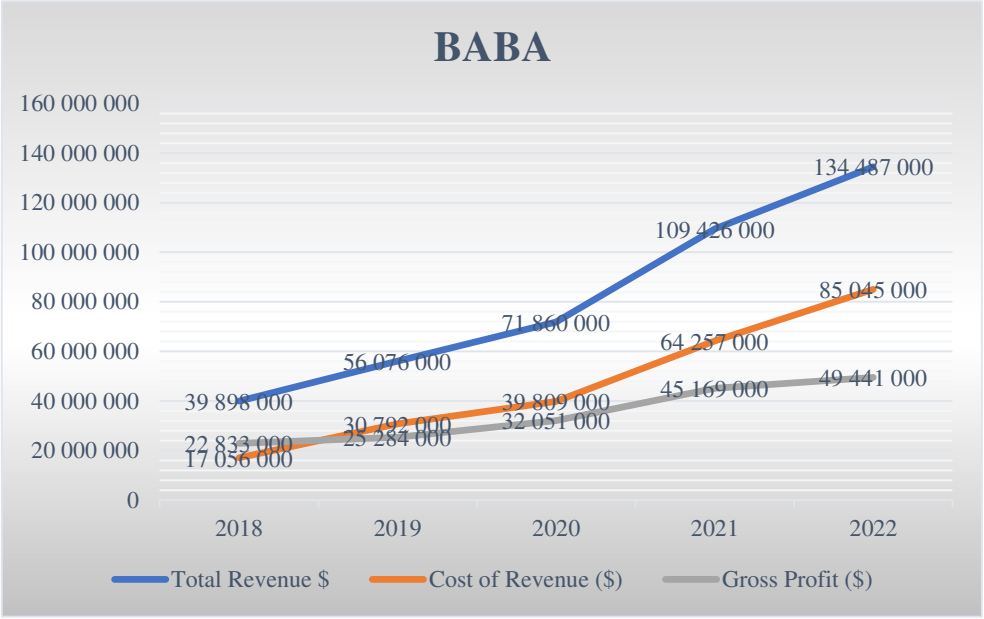

Figure 6. The level of the variables studied in the Alibaba Group company in the years 2018-2022. Source: Own study: https://www.nasdaq.com/market-activity/stocks/baba/financials.

Summarizing the results of the empirical research in the field of acquiring knowledge about the relationship between the creation of the value network and the conversion of the business model of the surveyed technology companies, it should be noted that the surveyed enterprises convert their business models since they compete for customers on the market of digital platforms. The trend analysis of the Total Revenue, Cost of Revenue and Gross Profit relationships leads to the conclusion that the surveyed companies used the pandemic as an opportunity to generate Total Revenue growth. However, the level of Cost of Revenue was not subject to managerial control in all cases, which translated into the development of the Gross Profit level in the surveyed enterprises.

6. Discussion

As a consequence of the considerations on the creation of value networks in technology companies competing for customers on the market of digital platforms, it follows that the surveyed enterprises gradate the value created by customers in their business models in a different way. This is reflected in the formation of the Total Revenue trend line. The market leader is the Amazon company, which suggests that it best satisfies the needs of its customers. The Meta Platforms company incurs low expenditure on the implementation of operating activities, which is reflected in the level of Cost of Revenue. In the case of Alibaba Group, it is noted that it is Gross Profit oriented, which brings about that the gross financial result, reflecting the effectiveness of the adopted growth strategy of the company, plays an important role here.

It is worth emphasizing that in the conditions of a pandemic, when the system of competitive and coopetitive forces changes on the market, technology companies operating on the basis of digital platforms should modify not only their sales processes by engaging external companies in network cooperation, but also reorient their operational activities in order to control costs. Thus, an important role in the process of creating the value network in the business model of enterprises operating on the basis of digital platforms should be played by the cooperation of all participants of the value network.

In the classic approach, the process of creating value is generated by the operational activity of the company. In the case of network cooperation, the process of creating value increases through coopetitive relationships, allowing access to many resources, thus becoming the source of relational advantage. In such a situation, enterprises operating on the basis of digital platforms may attempt to increase the created value network in two ways. First, they can increase their own value through activities such as branding or using resources more efficiently. Secondly, they can limit the part of the created value that they distribute to other participants in the network. It should be remembered that enterprises operating on the basis of digital platforms are structures composed of many entities. Therefore, the strategy of technology companies operating on the basis of digital platforms in terms of creating the value network should take into account such a configuration of its participants to create the greatest possible value for themselves, while strengthening their own market position.

The volatility of the competitive environment of technology enterprises built on digital platforms brings about that the processes of creating the value network result in the need to convert the current business model, the task of which is to permanently strengthen the development potential that distinguishes the company from the industry. The competitive environment of technologiy ecompanies operating on the basis of digital platforms affects the processes of creating the value network, which means that the current business model does not fulfill its functions. Hence, there is a need to convert the business model, taking into account changes in customer needs and preferences in terms of value proposition. Therefore, it is important that the processes of creating the value network in the business model are continuous.

7. Summary and conclusions

The usefulness of the conducted considerations results from the lack of the in-depth description of the relationships between the creation of the value network and the conversion of the business model of technology enterprises built on digital platforms. In conditions of turbulence in the environment, understanding the processes of creating the value network in the business model enables long-term competition on the market, which at the same time shapes

the development of the company. This work was based on the assumption of the existence of relationships between Total Revenue, Cost of Revenue and Gross Profit, which help determine the processes of value creation and provide information on the conversion of the business model of technology companies built on digital platforms. Based on the conducted analysis, a set of consistent information was obtained, enabling the multilateral assessment of relationships occurring in the process of creating the value network in the business model. The results of the conducted research suggest that the analysis of the processes of creating the value network from the company's and customer's perspective, based on the variables shaping the business model of the surveyed technology companies, allows for understanding and explaining the relationship between the creation of the value network and the conversion of the business model based on the diagnosis of revenue streams against costs.

Adopting a dynamic perspective of creating the value network expands the catalog of stakeholders of the value created, from customers and owners to suppliers and potentially, by other stakeholders, thus creating the value network. It follows that the construct of the value network allows for the search for new areas of value creation, pointing to the network effect, which may, on the one hand, strengthen the generation of value, and on the other hand, may lead to its destruction. Achieving the assumed objective of the work fills the perceived cognitive gap and contributes to the development of the theory of management science in the field of creating the value network and converting the business model of technology enterprises built on digital platforms. The basis for this achievement is empirical studies of enterprises, conducted using a variety of methodology, which indicate directions for converting the business model and creating the value network. The considerations highlighted in this study made it possible to accomplish the adopted objective and to state that the value creation processes are evolving, and the measurement of these processes allows for the protection of the created value network and enables its growth in changing conditions. The conducted considerations allowed the formulation of the following conclusions:

- the complexity of processes of creating the value network indicates the importance of searching for new solutions in enterprise management,
- the determinants of value creation are evolving towards network orientation,
- the process of value creation in the network provides unique value for both the customer and the company.

To sum up, it should be stated that the multifaceted nature of the problem of creating the value network in the business model and the interdisciplinary nature of the considerations brought about that the study presents selected aspects of the applicability of the proposed solutions. The issue of creating the value network in terms of business model conversion is important and up-to-date due to its impact on strategic decision-making in terms of the effectiveness of management of the surveyed enterprises.

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DEVELOPMENT OF RENEWABLE ENERGY USE IN POLISH INDUSTRY COMPARED TO EUROPEAN COUNTRIES

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Purpose: The article aims to look at the development of the use of renewable energy sources in industry, in Poland compared to European countries.
Design/methodology/approach: The research was conducted on data from 34 European countries between 2010 and 2021 using dynamic analysis and multivariate analysis in the form of cluster analysis.
Findings: Despite an overall upward trend, eleven countries saw a decline over the explored period. Countries where this development had just begun often increased the share of renewable energy in industry. On the other hand, some countries with slightly higher levels of this indicator initially did not show as much growth or even recorded a decrease.
Originality/value: The value of the article is to present the development of the share of renewable energy in industry in Poland and 34 European countries. A comparison of Poland with other countries showed the existence of uneven growth rates and even declines in the countries studied.

Keywords: renewable energy sources, energy in the industry, development of renewable energy sources.

Category of the paper: Research paper.

1. Introduction

The growing awareness of the need to protect the environment due to global warming is directing countries' efforts to increase the use of renewable energy sources. Traditional, coal-based energy sources have contributed to the increase of pollution through the emission of harmful substances. Renewable energy sources include solar, wind, geothermal, hydropower, tidal and biomass energy. They are considered inexhaustible, and their resources are not depleted in the very long term. Renewable energy sources have great potential as an alternative to traditional energy. An additional aspect, especially since Russia's aggression in Ukraine, is the pursuit of energy independence, which can be provided by renewable energy sources.

Therefore, today, it is increasingly important to ensure energy security toward greater diversification and independence.

The EU's Fit for 55 strategy ("Fit for 55", 2021) aims to reduce emissions by 55 per cent by the end of the decade and achieve climate neutrality by 2050. In Poland, as stated in (PEP2040, 2021) in the perspective of 2040, the aim will be to have about half of the electricity generation coming from renewable sources. It can be achieved - and there is much to be done here - by focusing efforts on many aspects, across national economies: from households to industry (Bogdanov et al., 2021; Dogaru, 2020; Jonek-Kowalska, 2022). This article focuses on aspects of the industry.

There have been many studies in the literature on the development of different renewable energy sources (Banasik, Czupryna-Nowak, 2022; Bórawski et al., 2019; Corrêa da Silva et al., 2016; Kubiak-Wójcicka, Szczęch, 2021; Kumar, Majid, 2020; Lo, 2014; Mularczyk, 2016; Mularczyk, Hysa, 2015; Mularczyk, Zdonek, 2022; Piwowar, Dzikuć, 2019; Tutak, Brodny, 2022; Wolniak, Skotnicka-Zasadzień, 2022).

The use of renewable energy sources also is of great importance in terms of industry, for environmental protection and sustainable development. It can contribute to both environmental protection and lower operating costs for companies thus increasing competitiveness (Amir et al., 2020; Diab et al., 2016; Espinosa et al., 2012; Figueiredo, 2010; Ge et al., 2022; Ghadimi et al., 2015; Giampieri et al., 2020; Hulshof, Mulder, 2020; Lombaerde, 2021; Philbert, 2017). For this reason, it is worth looking into the industry and the use of these energy sources in it.

The purpose of the article is to look at the development of the use of renewable energy sources in industry, in Poland compared to European countries. Accordingly, the following research questions were posed:

RQ1: What was the rate of growth of the share of renewable energy in the Polish industry between 2010 and 2021?

RQ2: What was the growth rate of renewable energy in Polish industry between 2010 and 2021 compared to European countries?

RQ3: What group of European countries does Poland belong to in terms of the development of the share of renewable energy in the industry?

2. Materials and Methods

For the study, data on the volume of renewable energy use in the industry was obtained from the Eurostat database (Database - Eurostat, 2023). The data was collected from 34 European countries. The selection of countries was determined by the availability of data in

the database. It was intended that countries outside the European Union would also participate in the study. The study covered the period from 2010 to 2021.

The collected data values were divided by total energy consumption levels in each country's industry. In this way, an indicator was obtained that denotes the percentage of renewable energy in the total energy consumed in the industry.

Calculations were performed in a spreadsheet and the R environment.

To answer the first and second research questions, methods were used to analyze the dynamics of the phenomena. The results were supplemented with data visualizations in the form of graphs. To answer the third research question, a cluster analysis was conducted. The results were accompanied by data visualizations in the form of box plots.

3. Results and discussion

To find the answer to the question of what the growth rate of renewable energy in the Polish industry in 2010-2021 was, a dynamics analysis was conducted, such as individual single-basis indexes, chain indexes and average rates of change.

Table 1 presents the results of the analysis of the growth rate of the share of renewable energy in total industrial energy for Poland over the 12 years studied.

Table 1.
Analysis of the dynamics of the share of renewable energy in the Polish industry

Year	Share of renewables in total	Year-to-year changes	Changes from 2010	Average annual growth from 2010
2010	6,8%	-	100%	-
2011	7,2%	105%	105%	5,2%
2012	7,6%	106%	112%	5,7%
2013	9,2%	121%	135%	10,6%
2014	9,5%	103%	140%	8,7%
2015	10,0%	105%	147%	8,0%
2016	10,6%	106%	156%	7,7%
2017	10,7%	101%	157%	6,7%
2018	10,5%	98%	154%	5,6%
2019	11,3%	108%	166%	5,8%
2020	12,6%	111%	185%	6,4%
2021	9,9%	78%	145%	3,4%

Source: Own calculations.

There was an almost constant year-on-year increase in the share of renewable energy in the total energy used by the industry. The first of the two exceptions was 2018, with a slight, 2%, decrease in this level compared to 2017. In contrast, the second was 2021. In that year, there was already a significant decrease in the surveyed measure, as much as 22% compared to the previous year. Therefore, considering only the years 2010 to 2020, the share of renewable energy in total energy increased by 85%. However, considering also 2021, the increase was 45%. The former has an average year-on-year increase of about 6.4% and the latter 3.4%.

Further calculations were then carried out to answer the question of how the growth rate of renewable energy in the Polish industry in 2010-2021 was shaped compared to the European economy. Firstly, to examine the dynamics of the share a chart is included in **Figure 1**. To ensure the transparency of the chart, only certain countries were selected for it. A common indicator for the 27 countries of the European Union has also been added.

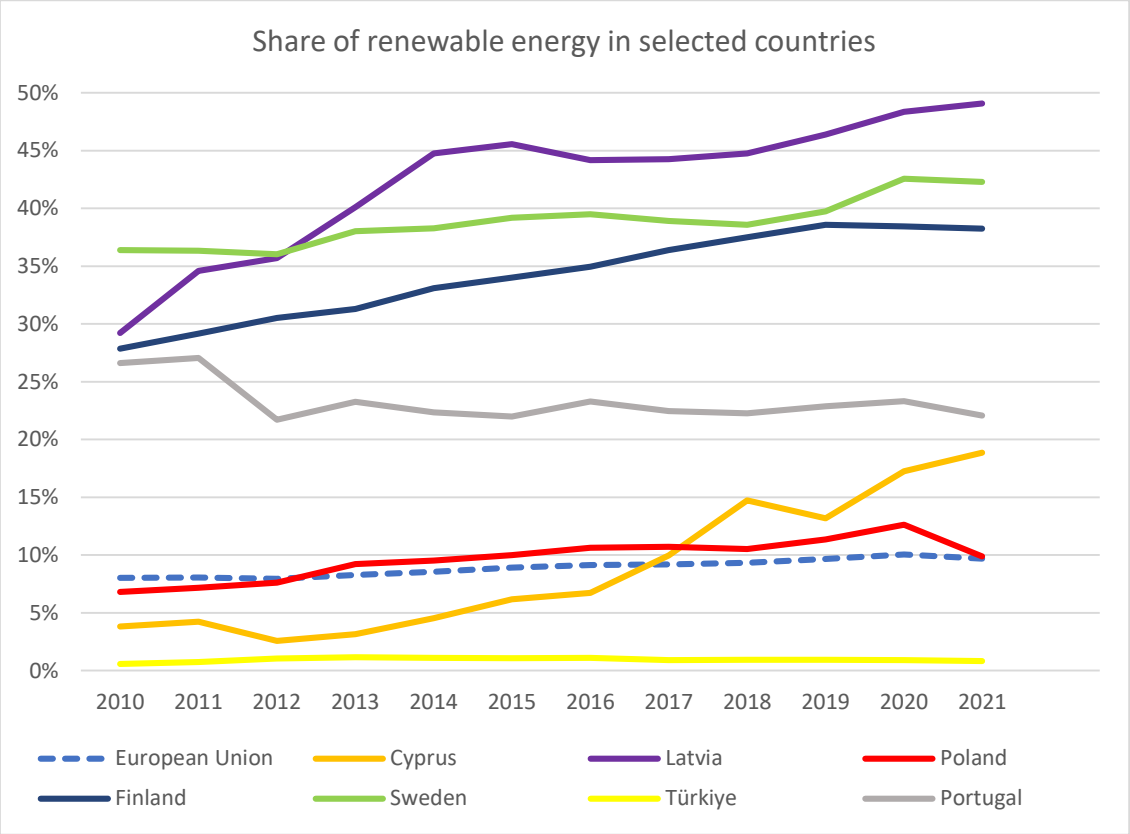

Figure 1. Dynamics of the share of renewable energy in total industry in European countries.
Source: Own calculations.

As the chart shows, the share of renewable energy in industry in Poland was roughly at the European Union average. A rather large decrease in this share in the Portuguese industry and a sharp increase in Cyprus also can be observed.

The graphs in **Figure 2** - **Figure 4** have been added for a better view, showing the states of the studied indicator in 2010, 2016 and 2021 (non-EU countries are yellow). It can be seen on the charts that Poland was initially ranked 13th (among the 34 European countries surveyed), and in 2016 it reached the highest place, 6th, to be ranked 9th in 2021.

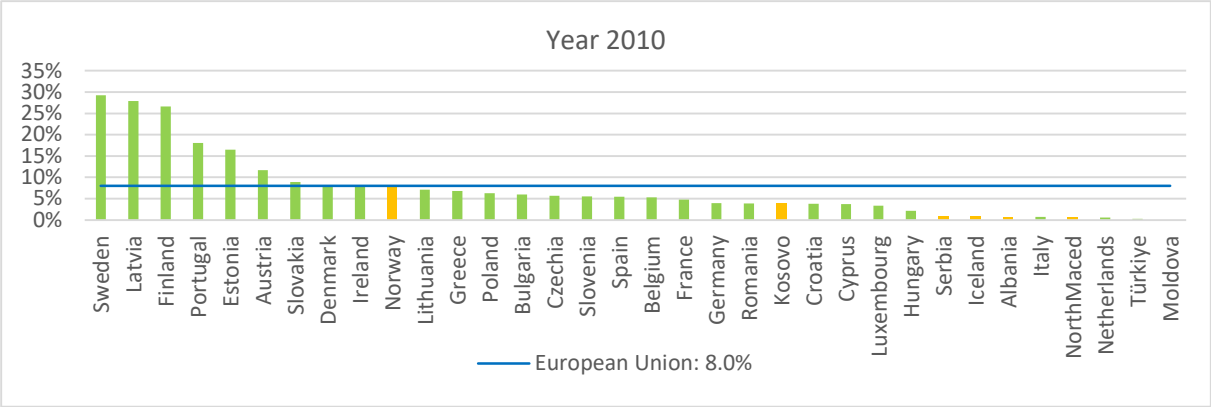

Figure 2. Shares of renewable energy in the total industry in European countries in 2010.

Source: Own calculations.

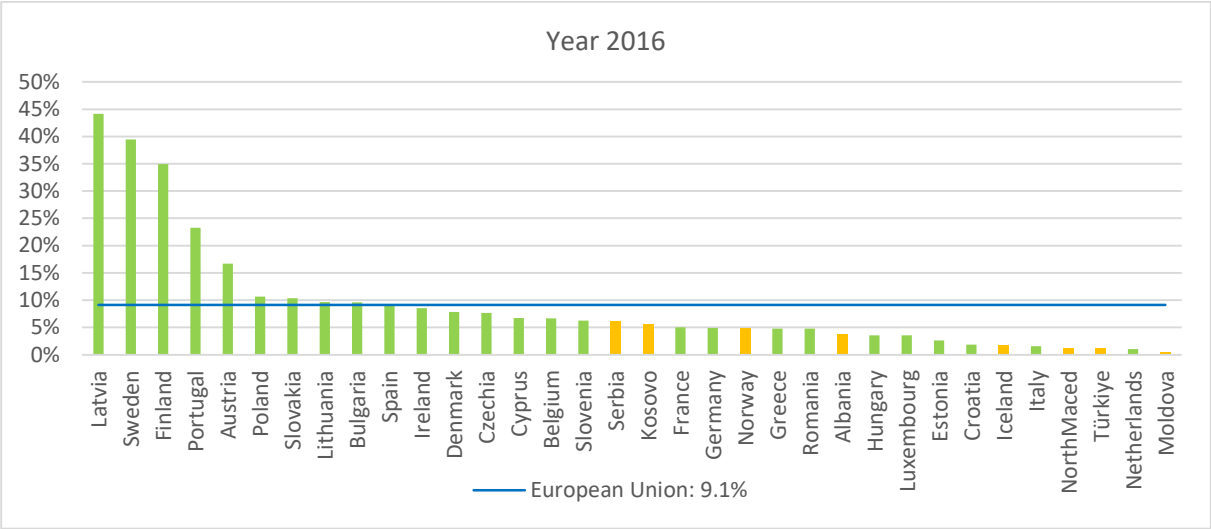

Figure 3. Shares of renewable energy in the total industry in European countries in 2016.

Source: Own calculations.

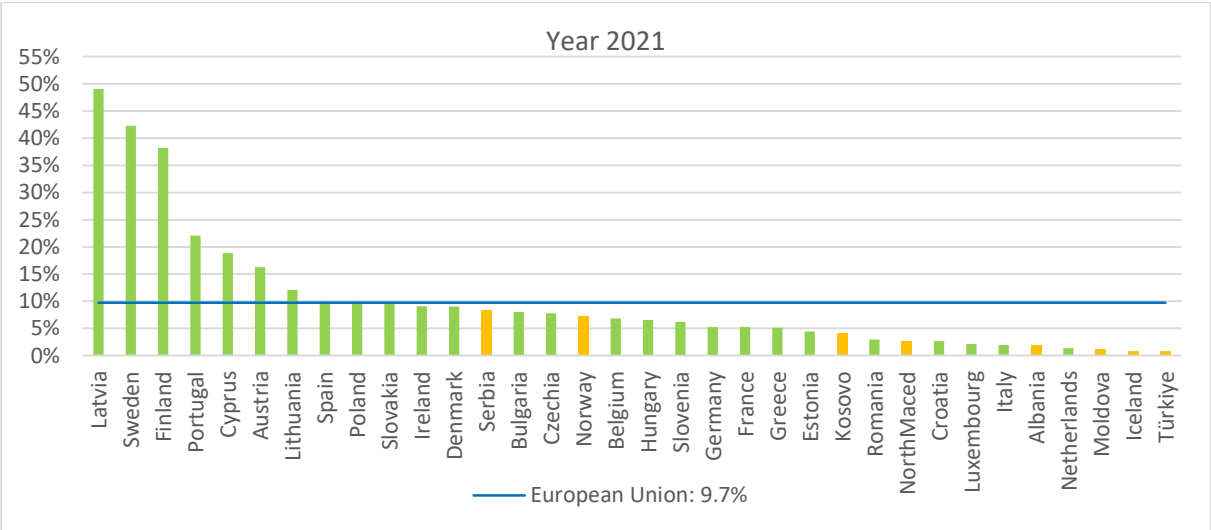

Figure 4. Shares of renewable energy in the total industry in European countries in 2021.

Source: Own calculations.

Analyzing the above four charts, it can be concluded that there are several groups of countries. In the first group are inherent three countries: Latvia, Sweden, and Finland. Their development in the field under study had already taken place before the period analyzed here. Indeed, they have a share of renewable energy at the highest level (from 28-36% in 2010 up to 38-49% in 2021). All three are also European Union countries. The following countries had a share roughly at the level of the average share of European Union countries. This group includes Poland, among others. There is also a group, including e.g., Moldova and Turkey (non-EU countries), with shares well below this value. Comparing the subsequent charts, the different rates of share growth in different countries also become apparent. In general, countries with smaller shares at the beginning are likely to see greater growth. Cyprus is a case in point. However, this is not the rule. There are also countries with negative growth in the share of renewable energy in industry. An example of this is Portugal, which initially ranked close to the group with the highest share (which for them was 27% in 2010). However, in this case, there was not an increase in the share, but a decrease, and the share was as high as 22% in 2021 (which is a 31% decrease compared to 2010). **Figure 5** illustrates, for comparison, the total growth of the examined indicator over the entire period studied. As it turns out, as many as eleven countries met a decrease in the share of renewable energy in the industry in the years studied. Interestingly, only one of them is not a European Union country. Instead, three of the four countries with the highest growth rates (Cyprus, Moldova, Serbia and North Macedonia) were not members of the EU.

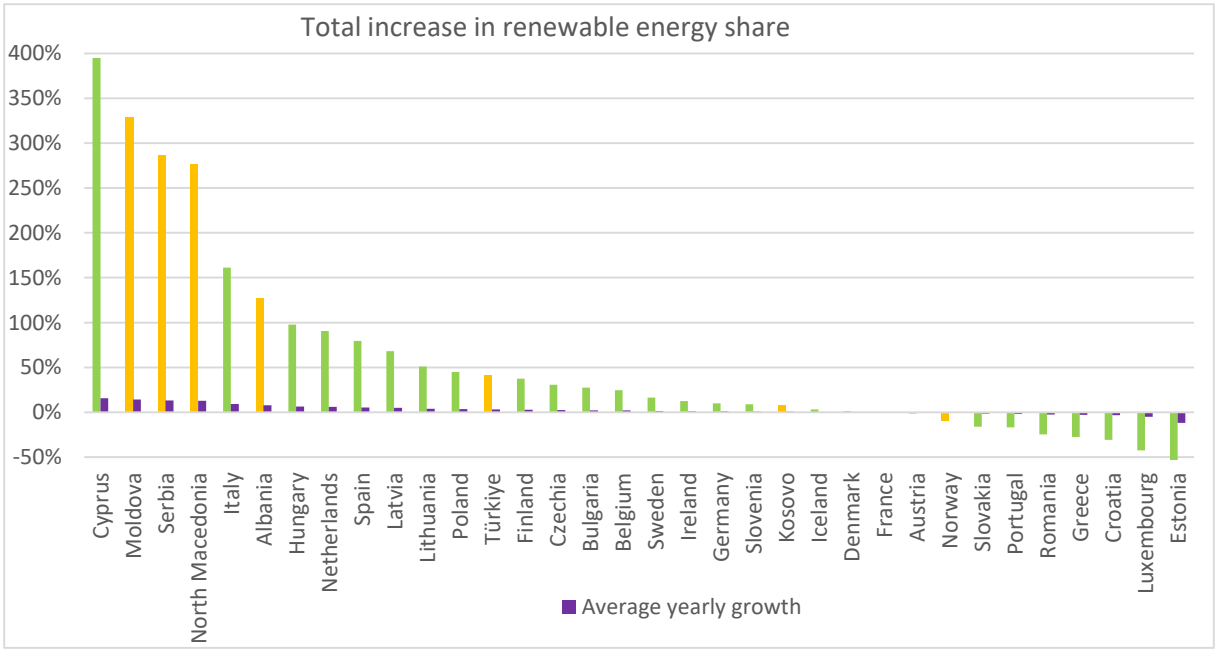

Figure 5. Total growth of renewable energy in the total industry shares in European countries from 2010 to 2021.

Source: Own calculations.

Finally, to answer the third research question of what group of European countries Poland belongs to in terms of the development of the share of renewable energy in the industry cluster analysis was carried out (**Figure 6**).

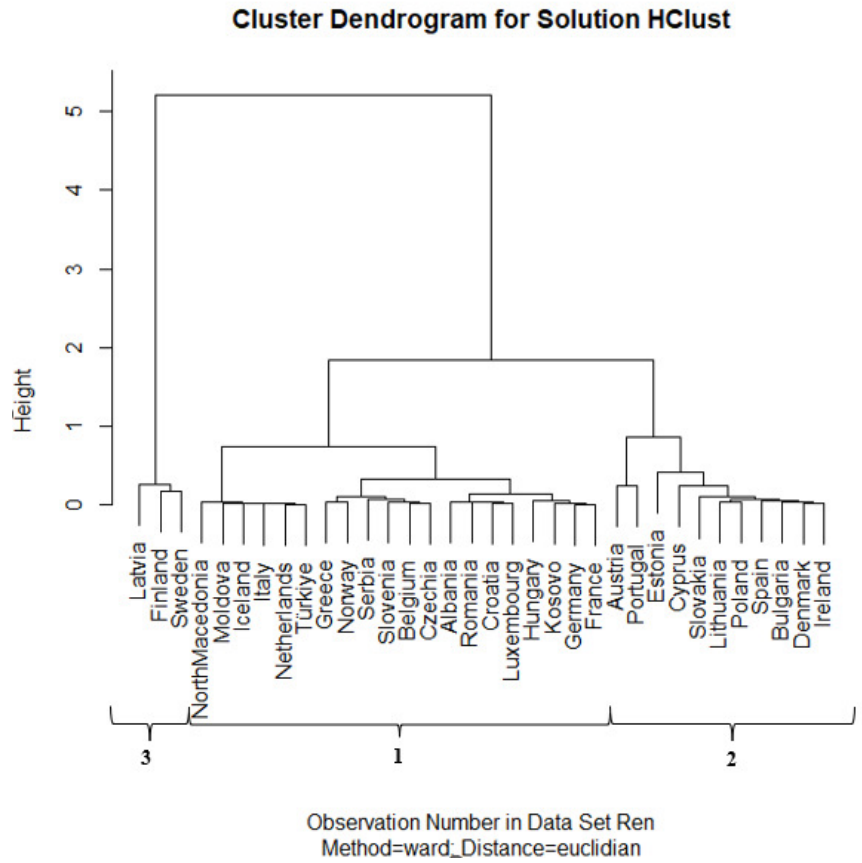

Figure 6. Dendrogram.

Source: Own calculations.

As a result of the cluster analysis, the countries studied can be divided into three groups. The first cluster included countries with the lowest average share of renewable energy in industry over the years studied (at 3.4% in 2010 to 4.1% in 2021). Remarkably, all the non-EU countries surveyed were in this group. Poland was placed in the second cluster, together with countries with a visibly higher level of the factor under study (at an average level of 10.1% in 2010 to 11.8% in 2021). The third cluster includes countries with the highest shares (at an average of 31.2% in 2010 to 43.2% in 2021). The levels of these shares at the beginning and end of the study period are illustrated in the box plots in **Figure 7**. To sum up, Table 2 is included.

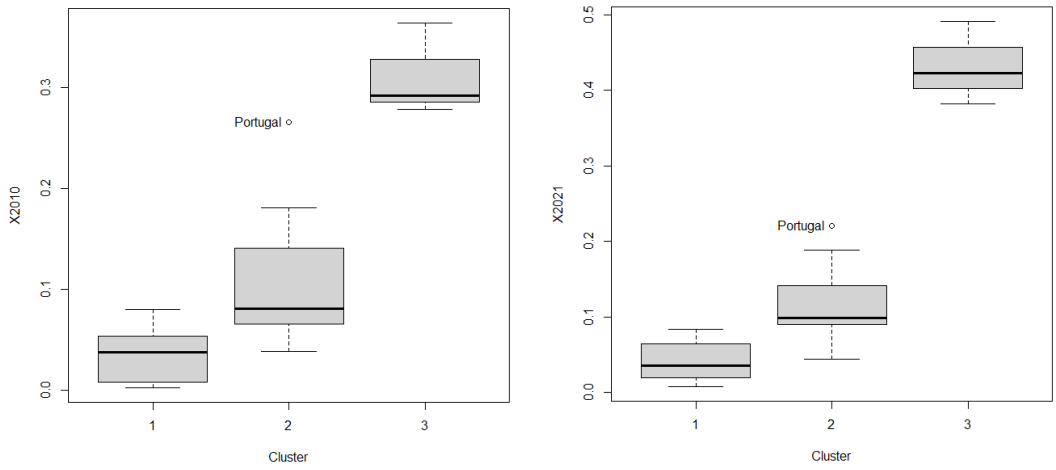

Figure 7. Boxplots of renewable energy shares in the industry by clusters in 2010 (left) and 2021 (right).

Source: Own calculations.

Table 2
Cluster comparison

Cluster No.	Mean share		Standard deviation		Median		Total growth
	2010	*2021*	*2010*	*2021*	*2010*	*2021*	
1	0,03395	0,04074	0.02417	0.02502	0.03768	0.03566	20.0%
2	0.10929 (0.09362)*	0.11760 (0.10782)*	0.06838 (0.04684)*	0.05206 (0.04136)*	0.08055 (0.08024)*	0.09881 (0.09827)*	7.6% (14.6%)*
3	0.31158	0.43203	0.04580	0.05472	0.29222	0.42287	38.7%

Note: * without Portugal.

Source: Own calculations.

The highest growth in the average share of renewable energy in the industry during the period under review was in the third group countries, at 38.7%. Also in the first group, the increase in average shares was quite large, at 20%, still, since the countries in this group started from a lower level this is not so evident in the graph. It is apparent that in these countries the development of renewable energy sources is just beginning. In the middle cluster countries, the increase was relatively the smallest at 7.6%. However, after removing Portugal from this group (which, due to the largest decline in the share of renewable energy during the period under review, can be considered an exception to the rule), the value turned out to be twice as large: 14.6%.

4. Summary

Polish industry has seen an almost steady increase in the share of renewable energy in total energy consumed. In 2020, the level increased by 85% compared to the 2010 level. However, in 2021, there was a significant decrease in the measure under study, by as much as

22% compared to the previous year. Considering 2021 as well, the total increase was 45%. Also, the share of renewable energy in industry in Poland was just about at the European Union average. Analyzing the states of the surveyed indicator in 2010, 2016 and 2021 of the 34 European countries surveyed, it was noted that Poland initially ranked 13th, reaching the highest position of 6th in 2016, to be ranked 9th in 2021.

As a result of the cluster analysis, the countries studied were divided into three groups. The first cluster included non-EU and other countries with the lowest average share of renewable energy in industry. This share fluctuated from 3.4% to 4.1% in the years studied, with an average growth rate of 20%. The second is EU countries with a significantly higher level of the studied factor (from 10.1% to 11.8%) but with the lowest relative growth rate (14.6%). The third cluster included EU countries with the highest shares (from 31.2% to 43.2%) and the highest growth rate (37.8%). Poland belonged to the second group.

Research showed, that renewable energy development was at different levels in examined countries. Although a general upward trend can be observed there were eleven countries with a decrease. Countries where this development has just begun have often significantly increased the share of renewable energy in industry. This group often included countries outside the EU, but not exclusively. On the other hand, some countries with slightly higher levels of this indicator did not show as much momentum at first and even declined. These studies show that underneath the studied indicator there is additional information not always disclosed. Not only the European but also the global trend of increasing the share of renewable energy is a fact. On the other hand, the different rates may be the result of different geographic as well as socio-political conditions in each country. Hence uneven growth rates and even declines. This issue certainly requires more extensive analysis in the near future to help understand the phenomenon under study.

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SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

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THE ANALYSIS OF POINTS ASSIGNED TO SCIENTIFIC JOURNALS IN POLISH HIGHER EDUCATION EVALUATION PROCESS, IN JUXTAPOSITION TO THE SCOPUS LIST OF JOURNALS IN THE HIGHEST PERCENTILES

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Purpose: The main purpose of the paper was to explore the differences between the top tier journal list published by Scopus and the number of points assigned to scientific journals on the list published by the Polish Ministry for Higher Education. Moreover, the paper aims to highlight the changes that were made on the list in comparison to its previous version.
Design/methodology/approach: The subject of the research was the ministerial list of journals that assigns evaluation points to them, and the Scoups list of top tier journals. The data from those lists was analyzed comparatively, statistically and visually (with data visualization methods) using the R programing language and RStudio Software.
Findings: The analysis uncovers disparities in journal prestige between the ministerial list and Scopus due to multidisciplinary variations, posing a choice for researchers between high-point but narrow-impact ministerial list journals and broader-impact, high CiteScore percentile ones. Disciplines differ in journal availability and top-tier participation, with biomedicine leading and humanities lagging. Recent updates to the list altered scores for many journals, sparking fairness and stability concerns. A proposed solution suggests linking points to CiteScore percentiles for stability and predictability.
Research limitations/implications: The Scopus data used in this paper concerned only journals that had a CiteScore Percentile value of 90 or higher. Future research could compare the complete Scopus database to the ministerial list and calculate the correlation between the percentile score to the assigned points.
Practical implications: The publication helps to identify imperfections within the evaluation algorithm of scientific papers, and could be used in the future for improvement of the process.
Social implications: The social implications are mainly limited to the academia workers and scientists. It might influence their perception of the evaluation process.
Originality/value: The paper is addressed to the academia community, and offers it to obtain a clearer view of the reality within it has to function. It is trying to explain the conditions of the journal evaluation process and how it impacts publishing possibilities in the period within which the current list is valid.

Keywords: academia employees evaluation, science evaluation, journal ranking, ministerial list of journals, Scopus.

Category of the paper: Research paper.

1. Introduction

The Regulation of the Minister of Science and Higher Education dated November 7, 2018, regarding the preparation of lists of scientific monograph publishers, scientific journals, and reviewed materials from international conferences (Dz.U. 2018, poz. 2152), introduced a significant change in the scoring of scientific journals, thereby impacting the evaluation process of science and university staff in Poland. The first list prepared under the new rules in 2019 also introduced a new scoring scale, ranging from 20 to 200 points, as opposed to the previous scale of 5 to 50 points divided into three categories (A, B, and C). The initial list from July 31, 2019, was subsequently revised and the new content was published on December 18, 2019. In less than 2 years, on February 9, 2021, the Minister of National Education published a new list, followed by a change and correction of this list on February 18, 2021. The most recent update of the list of point-rated journals was published on July 17, 2023, and was the currently applicable version at the time of preparing this article.

The new scoring system allowed the assignment of points to scientific journals based on a single selected indicator from those available in the Scopus database (SJR, CiteScore, SNIP), rather than solely relying on the Impact Factor, as was the case before (although all these indicators are interconnected, as each is calculated based on the citation count). In case a journal is not in the Scopus database, there are alternative databases available for the assessors (Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index, Emerging Sources Citation Index, and the European Reference Index for the Humanities and Social Sciences). For each discipline, the advisory team responsible for journal assessment can choose a different indicator than the other teams. The algorithm for assigning points is based on calculating the percentile value of the journal's scientific impact indicator in a given discipline, which assigns a specific number of points to the journal for each percentile range according to the values presented in Table 1.

Table 1.
The percentile ranges for of the chosen factor for assigning points on the MEiN list

Points	Percentile range	
	From	To
200	97	100
140	90	<97
100	75	<90
70	50	<75
40	25	<50
20	0	<25

Source: (Dz.U. 2018, poz. 2152).

According to the law, if a journal is multidisciplinary, the number of points assigned to it is the average of all the ratings it received in individual disciplines, rounded to the nearest points category, provided that the difference between the highest and lowest number of assigned points

does not exceed two threshold points. In cases where the point difference is greater, the Science Evaluation Committee conducts additional evaluation of the journal. The team responsible for choosing the impact indicator and calculating the point value for the journal can propose a change in the assigned point value of up to two threshold points, following the criteria described in §13 of the Law (Dz.U. 2018, poz. 2152).

One of the problems that the adopted method of evaluating scientific journals may generate is their interdisciplinary nature. A journal that ranks well in one discipline (A), if also assigned to other disciplines (B, C, and D) where it does not excel, will be evaluated on average. This situation may lead to researchers in discipline A losing the opportunity to achieve a high score for publications in a journal highly regarded in their discipline (which may cause a sense of injustice). On the other hand, representatives of disciplines B, C, and D will not be "tempted" by a high score journal for which there are better equivalents in their disciplines.

The Scopus database also has its own journal impact indicator within each discipline (the division is different from that in the ministerial list), which is the CiteScore Percentile. This is a straightforward indicator that assigns a given CiteScore result of a journal to the appropriate percentile value among other journals in that discipline. This indicator is used, among other things, in the Excellence Initiative – Research University *(Inicjatywa Doskonałości – Uczelnia Badawcza* - IDUB) program and when allocating funds within quality programs at universities (MPPŚ, 2022; AGH, no date; BUŁ, no date).

Discrepancies between the ministerial list and the Scopus database, as well as the differing significance of a given journal in various disciplines and the resulting averaging of point values, can lead to cases where journals of great importance in a particular discipline (both from a global perspective – Scopus, and a local one – within the national division) and therefore with significant influence in the IDUB program, will receive moderate or average point ratings. On the other hand, this may lead to cases where journals, despite having a low CiteScore Percentile result, will receive the highest point scores within a given discipline. Such cases might be seen as demotivating and lead to the feeling of injustice among authors who try to achieve global impact with their research and reach audiences through journals that are recognized as the best one internationally.

The ministerial list and the evaluation process has been subject to many debates among academia members (Kokowski, 2021; Drabek, Bemke-Świtilnik, 2020; Paiskowski, 2021) as well as in press and social media. One of the terms that evolved over the time was *pointosis* (pol.: “punktoza”), a pejorative term to describe the compulsive urge to gather more and more points by scientists, that results from them being assessed solely by this parameter (Obserwatorim Językowe UW, 2020) or as a publication strategy employed by academia workers that is set on dealing with point based evaluation of their work (Kulczycki, 2017). Kulikowski and Antipow (2020) argue even that *pointosis* has become a (negative) cultural value. Even though when the second iteration of the ministerial list was published, the ministry site announced the “*pointosis*” was over (MEiN, 2019), after few years the problem did not

disappear (Publicystyka, 2022). For the time of writing this paper the lastly published version of the ministerial list was still new (3 weeks), therefore sources with full reactions and interpretation of the list were very limited. Hower, Myśliwiec (2023), a polish scientist and a popular YouTube creator published a clip with his reaction to the new list, in which he discusses the main issues he (and his friends) found. Among the problems he mentions are highly unexpected increases in points in particular cases, mismatching disciplines assigned to journals and high scores for papers that do not require their texts to be written in English.

2. Materials and methods

In light of the presented observations in the introduction, the aim of this article was to determine the extent of disparities between the highest ratings assigned to scientific journals in the ministerial list and the highest CiteScore Percentile results in the Scopus database for the same entries within specific scientific disciplines. Additionally, the analysis examined the number of available publishers in specific disciplines, the distribution of points assigned to them, and the dynamics of point changes made in the third iteration of the list compared to its previous version.

The research model is based on a commonly employed approach (Dzwigoł, 2018; Dzwigoł, Trzeciak, 2023). Consequently, to fulfill the primary objective of the article, the following research questions were adopted:

RQ1. What is the distribution of points in relation to the Scopus top tier list?

RQ2. What is the distribution of points and top tier journals in scientific disciplines?

RQ3. What was the dynamics of changes in the scoring of scientific journals?

For the purpose of the analysis, data sets from three sources were downloaded and combined into a single data set. The first one was the list of points assigned to scientific journals published by the Polish Ministry of Education and Science on 17-07-2023 (MEiN, 2023). The second one was the previous version of the index from 21-12-2021 (MEiN, 2021). The last data set was a list of scientific journals that were assigned to the highest percentile (90 or higher, by CiteScore Percentile, in at least one of the assigned areas) in 2023 on Scopus, prepared and made available by the Silesian Technical University's Library (Biblioteka PŚ., 2023).

The combined lists created a data set that consisted of 34,351 observations. The data set contained all data from the newest ministerial list, as well as all records from the Scopus list (merged in cases when two records concerned the same journal). The dataset was supplemented with the number of points assigned to given journals in the previous ministerial list in cases where a journal was not removed from the newer version (it happened with 7 journals). The data was analyzed using the R language and RStudio environment software.

3. Analysis and results

3.1. Overall characteristics of the data set

As mentioned in the Materials and Methods section, there are 7 journals that were on the 2021 ministerial list but are no longer included in the current (2023) list, and the analyzed data set does not contain them. Table 2 shows the titles, number of points, and scientific disciplines of those journals.

Table 2.
List of journals that were dropped from the 2023 MEiN list

Title / *(English translation if the original title was in Polish)*	**Points in 2021**	**Discipline/s**
Hematologia (Hematology)	100	biomedical engineering, pharmaceutical sciences, medical sciences, health sciences, life sciences
Journal of Physical Education and Sport	70	biomedical engineering, physical culture sciences, health sciences, pedagogy
Pielęgniarstwo w opiece długoterminowej. Kwartalnik międzynarodowy / *(Nursing in long-term care. International Quarterly)*	20	medical science, health science
Prace Komisji Historii Nauki Polskiej Akademii Umiejętności / *(Works of the History of Science Commission of the Polish Academy of Arts and Sciences)*	40	history
Review of Comparative Law	70	legal sciences
Romanica Olomucensia	20	literary studies
Seksuologia Polska / *(Polish sexology)*	40	pharmaceutical sciences, medical sciences, health sciences, sociological sciences

Source: Authors own work, based on MEiN (2023) and MEiN (2021) lists.

As one can notice, the journals excluded from the new list do not pertain to a single discipline, nor were they highly rated (only one had 100 points assigned). In fact, the number of journals added to the ministerial list is over ten times higher (78), and all of the new positions are on the Scopus list.

More than a tenth (10.93%) of all the analyzed records are journals that are both on the current ministerial list and the Scopus top 10 percentile list. The majority (88.97%) of records in the data set concern journals that are on the ministerial list but not on the Scopus top 10 list, and 33 (0.1%) journals from Scopus were not included in the ministerial list (Table 3 shows the titles).

Table 3.
List of journals that are not on the 2023 MEiN list, but are on the top tier Scopus list.

Title	Percen-tile	Discipline (by Scopus)	Publisher
Advanced Powder Materials	99	Metals and Alloys	KeAi Communications Co.
Advances in Agronomy	99	Agronomy and Crop Science	Elsevier
Advances in Applied Mechanics	99	Computational Mechanics	Elsevier
Advances in Motivation Science	99	Psychology (miscellaneous)	Elsevier
Advances in Experimental Social Psychology	97	Social Psychology	Elsevier
Advances in Geophysics	97	Geophysics	Elsevier
Human-Machine Communication	97	Social Sciences (miscellaneous)	Communication and Social Robotics Labs
World-Systems Evolution and Global Futures	97	History	Springer Nature
Advances in Ecological Research	95	Ecology, Evolution, Behavior and Systematics	Elsevier
Fish Physiology	95	Animal Science and Zoology	Elsevier
Linguistic Approaches to Literature	95	Literature and Literary Theory	John Benjamins Publishing Company
New Comparisons in World Literature	95	Literature and Literary Theory	Springer Nature
Advances in Virus Research	94	Infectious Diseases	Elsevier
Advances in the Study of Behavior	94	Animal Science and Zoology	Elsevier
Brill Studies in Greek and Roman Epigraphy	94	Classics	Brill
PSU Research Review	94	Social Sciences (miscellaneous)	Emerald Publishing
Reviews in Mineralogy and Geochemistry	94	Geochemistry and Petrology	Mineralogical Society of America
Studies in Costume and Performance	94	Visual Arts and Performing Arts	Intellect Ltd.
eScience	94	Materials Chemistry	Elsevier
Advances in Food and Nutrition Research	93	Food Science	Elsevier
Advances in Insect Physiology	93	Insect Science	Elsevier
Alkaloids: Chemistry and Biology	93	Biochemistry	Elsevier
Investigating Medieval Philosophy	93	Religious Studies	Brill
SciPost Physics Lecture Notes	93	Statistical and Nonlinear Physics	SciPost Foundation
Advances in Entrepreneurship, Firm Emergence and Growth	92	Economics, Econometrics and Finance (miscellaneous)	
Nano Research Energy	92	Chemistry (miscellaneous)	Tsinghua University Press
Whiteness and Education	92	Cultural Studies	Taylor & Francis
Archeological Papers of the American Anthropological Association	91	Archeology (arts and humanities)	Wiley-Blackwell
Handbook of Experimental Pharmacology	91	General Pharmacology, Toxicology and Pharmaceutics	Springer Nature
Advances in Southeast Asian Studies	90	Cultural Studies	Society for South-East Asian Studies
Benjamins Translation Library	90	Literature and Literary Theory	John Benjamins Publishing Company
Medical sciences (Basel Switzerland)	90	General Medicine	NLM (Medline)
Progress in Medicinal Chemistry	90	Pharmacology	Elsevier

Source: Authors own work, based on MEiN (2023) and MEiN (2021) lists.

It is worth noting that most of the top-tier journals not included in the ministerial list are Elsevier titles, which one might assume is a renowned publisher. The reason for this might be the fact that many of those Scopus titles are actually book series rather than regular journals.

3.2. The distribution of points in relation to Scopus top tier list.

From the algorithm used to assess journals on the MEiN list results from one factor that is related to citations of the journal, similar like the CiteScore Percentile on Scopus. Figure 1 shows a graph of the points' distribution in the respective top-tier categories (the categories are exclusive, meaning that the Top 10 category does not include journals classified as Top 5 or Top 1 – thus, the percentile ranges between 90th and 94th, and the Top 5 category does not include journals from the 99th percentile).

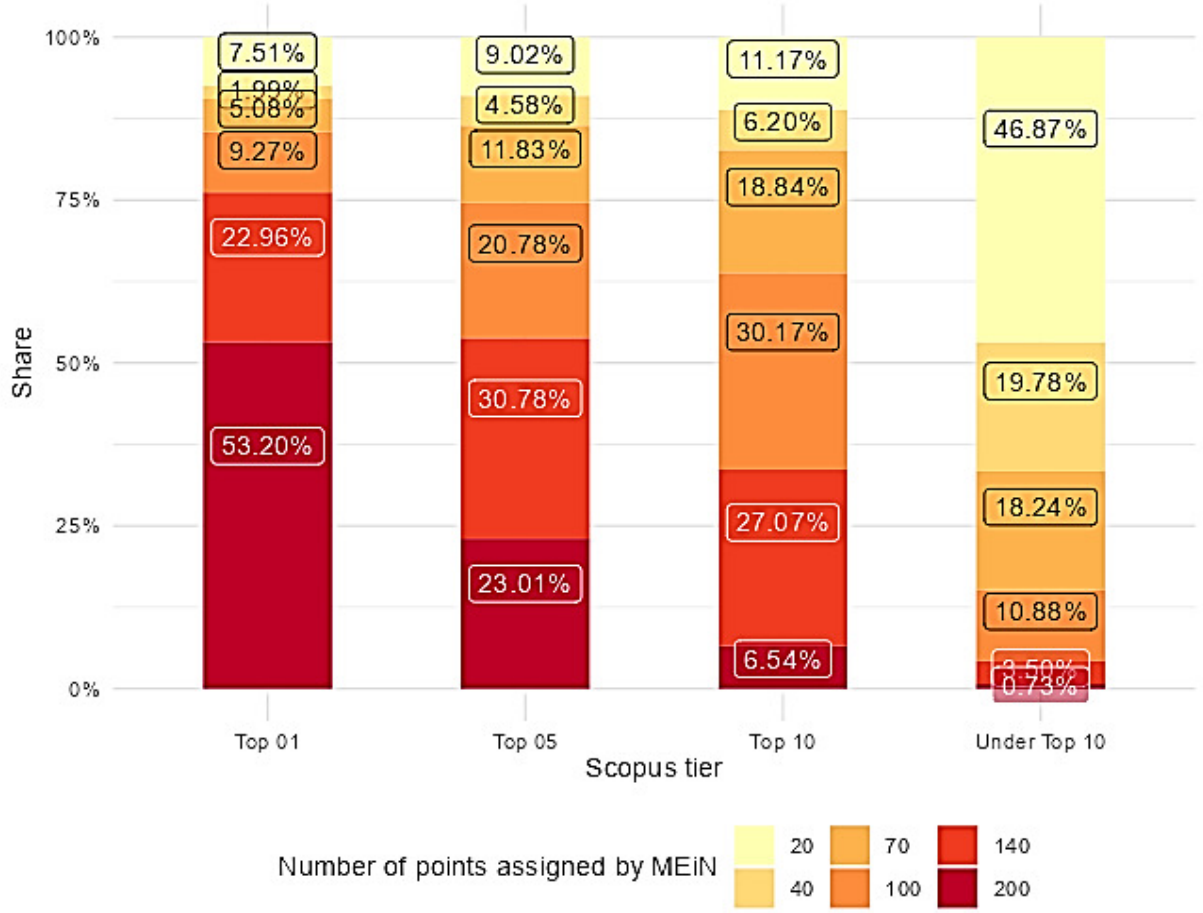

Figure 1. The share of points in each Scopus journal tier.

Source: Authors own work, based on MEiN (2023) and Scopus top tier journals list (Biblioteka PŚ., 2023).

The results show that over half (53.2%) of the highest (99th) percentile journals from Scopus were assigned 200 points. However, it is somewhat surprising that some journals in this category were given less than 100 points, and 7.51% (equivalent to 34 journals) received only 20 points. It is also concerning that nearly two-thirds (66.39%) of journals in the range between the 90th and 94th percentile (Top 10) were assigned 100 points or fewer.

3.3. The number of pointed and top tier journals in scientific disciplines

The new ministerial list distinguishes 53 scientific disciplines (compared to the previous list, which counted 44 of them), and the number of journals assigned points for each of them varies significantly. The majority of journals from the ministerial list are multidisciplinary. The mean number of disciplines covered by a journal is 21.65. The median is 19, the 1st quantile is 10, and the 3rd quantile is 28. The highest number of disciplines for a journal was 51, noted in one case, while the lowest value of this variable was 1, occurring in 2642 cases. Figure 2 shows the number of journals assigned points available in each discipline, divided into individual point categories.

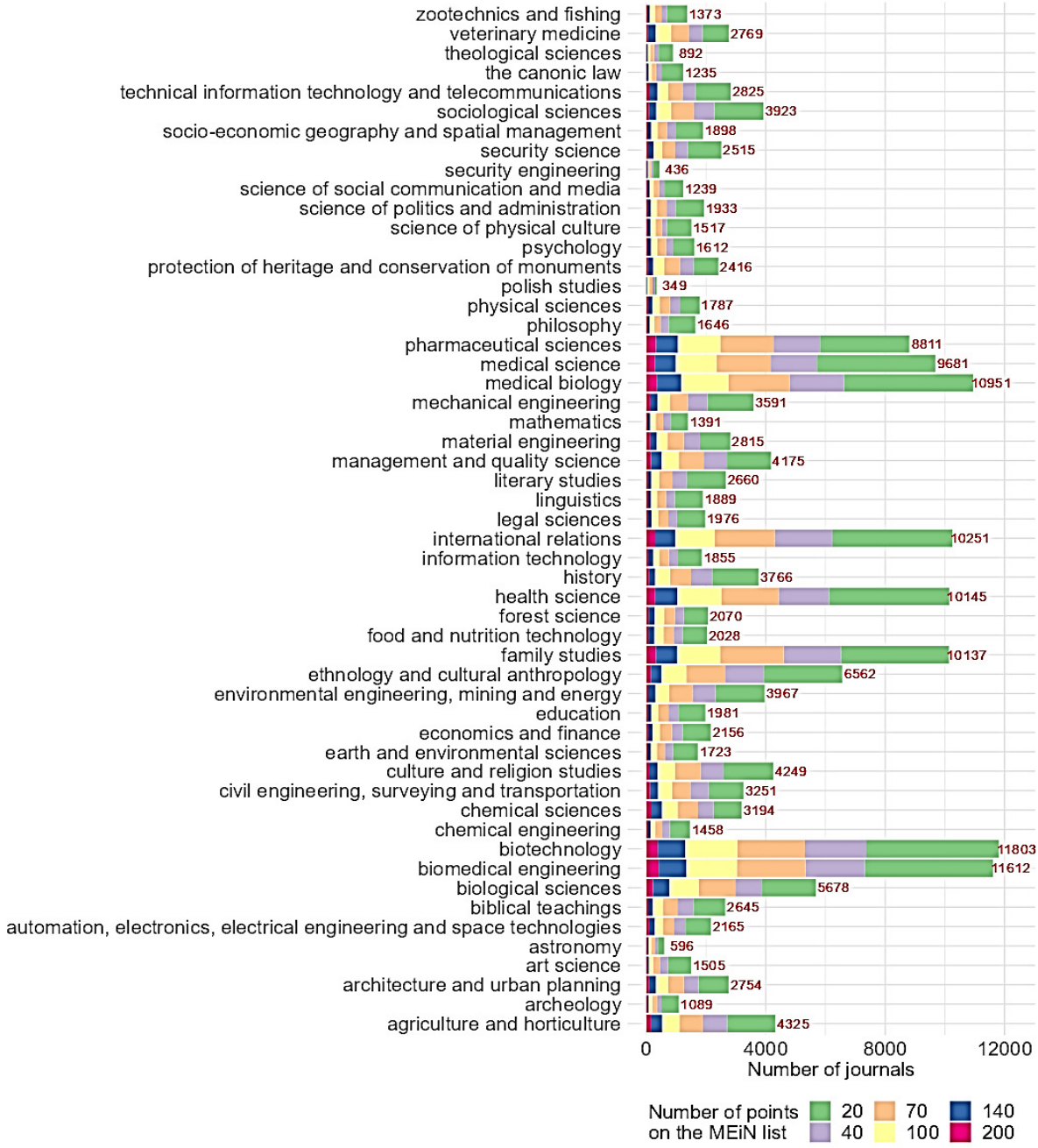

Figure 2. The number of journals available in each discipline with given number of points.

Source: Authors own work, based on MEiN (2023).

From the graph, it is clear that disciplines in the field of medical and health sciences (including pharmacological studies, medical studies, medical biology, health science, biotechnology, and biomedical engineering) have the widest spectrum of available journals with assigned points for scientists to publish in. This might indicate that disciplines from this fields are currently among the fastest developing ones and are strongly emphasized by publishers. Interestingly, two other disciplines, international relations and family studies, have nearly the same number of available journals as the medical ones. It is worth noting that Polish studies is the discipline with the fewest number of journals with assigned points available.

Although disciplines have varying ranges of journals to choose from, the proportion of journals with a given number of points also varies within them. To visualize this more clearly, the boxplot graph in Figure 3 shows the distribution of points within disciplines.

As shown in Figure 3, the differences between disciplines lie in the 3rd quartile – for the majority of them, the value of this statistic equals 70, meaning that 75% of journals in that discipline do not exceed this threshold. The 1st quartile is equal to 20 in each discipline, except for Polish studies, for which it equals 40. This implies that Polish studies is the only discipline where 75% of journals were assigned at least that many points. The mean number of points for Polish studies is also the second highest (66.7) and least varying (standard deviation = 34.53), surpassed only by chemical studies (69.91).

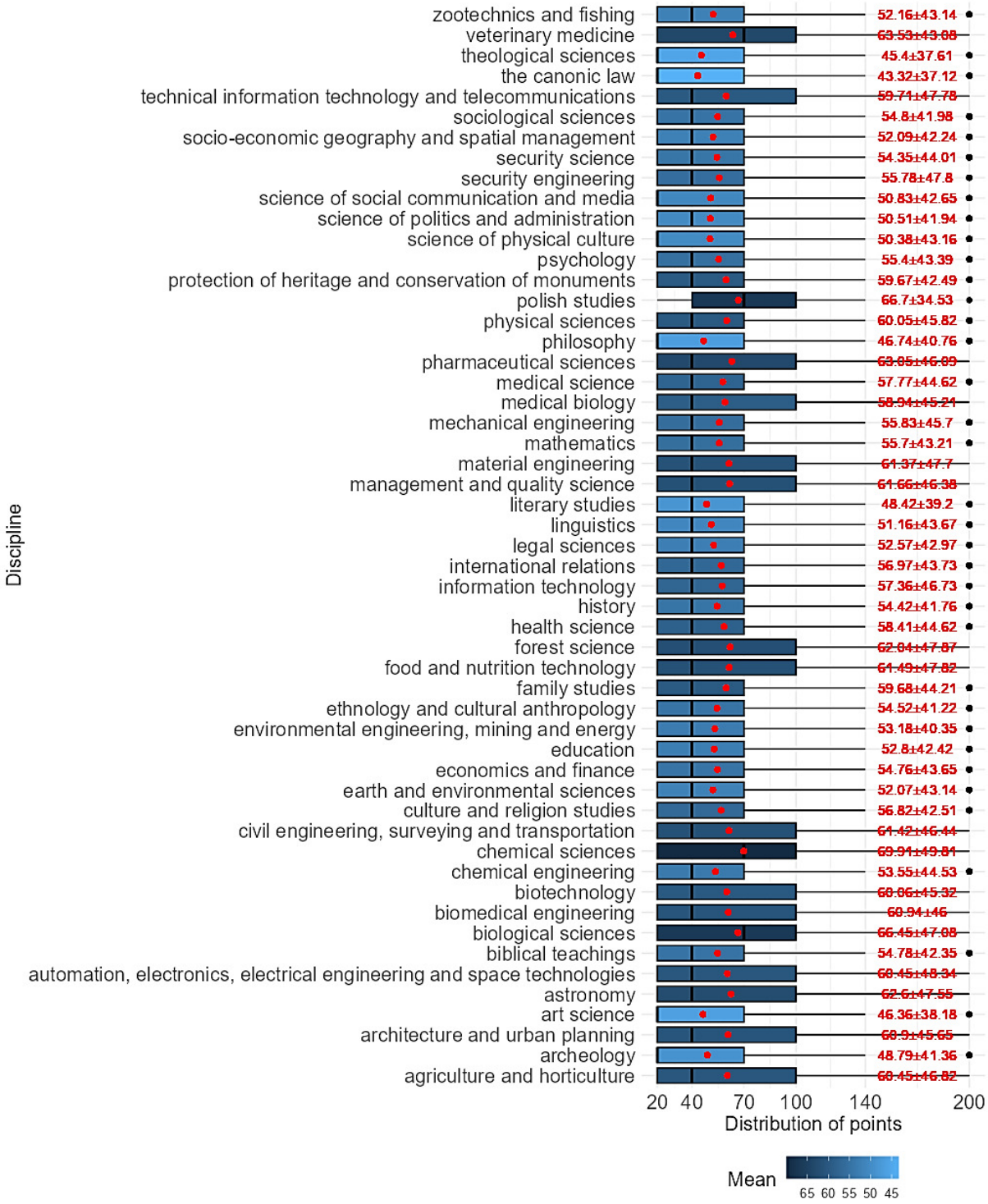

Figure 3. The distribution of points assigned to journals in listed disciplines, and the average number of points for each discipline.

Source: Authors own work, based on MEiN (2023).

While the graph in Figure 2 shows the scale of available journals, it does not clearly indicate the share of journals with 200 points in each discipline. Therefore, Table 4 contains the percentage share of journals assigned 200 points in each discipline, along with the share of top-tier (90th percentile or higher on Scopus) journals for each discipline and the share of 200-point journals on the top-tier list.

Table 4.
The share of 200 point journals, top tier journals, and 200 pts journals in top tier in each discipline

Discipline	200 pts share	Top tier share	Share of 200 pts journals in top tier	Discipline	200 pts share	Top tier share	Share of 200 pts journals in top tier
agriculture and horticulture	3,84%	0,44%	91,57%	linguistics	3,23%	0,07%	57,38%
archeology	2,30%	0,03%	56,00%	literary studies	1,92%	0,04%	25,49%
architecture and urban planning	3,27%	0,20%	86,67%	management and quality science	3,71%	0,31%	83,23%
art science	1,59%	0,02%	25,00%	material engineering	4,58%	0,30%	88,37%
astronomy	4,19%	0,09%	100,00%	mathematics	2,59%	0,04%	58,33%
automation, electronics, electrical engineering and space technologies	4,43%	0,24%	89,58%	mechanical engineering	3,70%	0,29%	85,71%
biblical teachings	2,65%	0,09%	61,43%	medical biology	3,15%	0,86%	90,14%
biological sciences	3,93%	0,61%	92,83%	medical science	2,88%	0,68%	89,25%
biomedical engineering	3,52%	0,98%	89,00%	pharmaceutical sciences	3,61%	0,77%	89,31%
biotechnology	3,19%	0,91%	89,36%	philosophy	2,25%	0,04%	59,46%
chemical engineering	3,22%	0,09%	80,85%	physical sciences	3,69%	0,16%	89,39%
chemical sciences	5,42%	0,47%	92,49%	polish studies	0,57%	0%	0,00%
civil engineering, surveying and transportation	3,75%	0,28%	87,70%	protection of heritage and conservation of monuments	2,40%	0,07%	60,34%
culture and religion studies	2,35%	0,13%	65,00%	psychology	2,23%	0,07%	80,56%
earth and environmental sciences	2,50%	0,08%	81,40%	science of physical culture	2,11%	0,07%	84,38%
economics and finance	2,74%	0,09%	71,19%	science of politics and administration	2,43%	0,07%	72,34%
education	2,42%	0,09%	81,25%	science of social communication and media	2,10%	0,04%	76,92%
environmental engineering, mining and energy	1,84%	0,14%	80,82%	security engineering	4,13%	0,04%	88,89%
ethnology and cultural anthropology	2,24%	0,20%	66,67%	security science	2,82%	0,11%	70,42%
family studies	3,11%	0,49%	72,38%	socio-economic geography and spatial management	2,21%	0,08%	80,95%
food and nutrition technology	3,80%	0,17%	87,01%	sociological sciences	2,22%	0,15%	78,16%
forest science	3,86%	0,23%	93,75%	technical information technology and telecommunications	3,79%	0,24%	86,92%
health science	2,92%	0,72%	89,19%	the canonic law	1,21%	0,02%	66,67%
history	2,36%	0,11%	58,43%	theological sciences	1,35%	0,01%	41,67%
information technology	3,34%	0,13%	85,48%	veterinary medicine	1,88%	0,09%	75,00%
international relations	2,96%	0,47%	72,94%	zootechnics and fishing	2,48%	0,05%	70,59%
legal sciences	2,33%	0,06%	58,70%				

Source: Authors own work, based on MEiN (2023) and MEiN (2021) lists.

Polish studies seem to be in the least favorable position, with the lowest share (0.57%) of journals assigned 200 points, and no top-tier publications available. However, it is understandable that the top-tier list contains journals that make significant contributions to the global state of science, whereas Polish studies are more relevant locally in Poland. Similar low shares can be observed in literary studies, legal studies (which again focus on the local legislation of the country), theological sciences, and the discipline of canonic law.

The highest share of journals assigned 200 points occurs in chemical studies (5.42%), followed by material engineering (4.58%), automation, electronics, electrical engineering and space technologies (4.43%), and astronomy (4.19%). In none of the disciplines does the share of journals on the Scopus top-tier list exceed 1%. The highest value can be observed for biomedical engineering (0.98%) and biotechnology (0.91%). Management and quality science have a relatively high share of journals assigned 200 points (3.71%), but only 0.31% of all journals assigned to this discipline are in the top 10 Scopus percentiles.

One might expect that if a journal was assigned 200 points, it is also an internationally top scoring journal. In most cases, this statement is true to some extent. However, as one can read from the fourth column of Table 4, not all 200-point journals are in the top-tier list. Only in astronomy are all of the highest pointed journals also in the top 10 highest percentiles on Scopus. Disciplines related to the Polish language and culture, as well as religion, note the lowest scores in this regard. This might suggest that they received additional points not based on their parametric scores but rather based on their locally perceived importance by the ministry.

In management and quality science, 83.23% of journals assigned 200 points by the ministry are also on the Scopus top-tier list. This might also lead to a reversed question – are there some journals on the Scopus top-tier list that received less than 100 points, suggesting that they are undervalued? The answer is yes: there are 1097 journals on the ministry list that have 70 or fewer points but are on the top-tier list. For management and quality science, there are 225 such cases (56 with 20 points, 44 with 40 points, and 125 with 70 points).

3.4. The dynamics of journal grade change

The new ministerial list changed the scores of 3070 journals (including the change from not having any points), with the most frequent difference (1809 cases) being 20 points. The majority of this number comprises journals that were not on the previous list and were added in 2023. The second most common difference was a change by 30 points, indicating that those journals advanced either from 70 to 100 points or from 40 to 70 points. Detailed data is presented in Table 5.

Table 5.
The number of journals with given score change on the 2023 list compared to the previous one from 2021

Difference in points	Number of journals with given difference	Number of journals that were not on the 2021 list	Difference in points	Number of journals with given difference	Number of journals that were not on the 2021 list
-180	2	-	60	100	-
-120	8	-	70	78	37
-80	25	-	80	36	-
-50	50	-	100	58	15
-20	75	-	120	19	-
0	31248	-	130	18	-
20	1809	1585	140	8	8
30	483	-	160	4	-
40	231	90	180	6	-
50	48	-	200	12	12

Source: Authors own work, based on MEiN (2023) and MEiN (2021) lists.

The data in Table 5 clearly shows that for the majority of journals, the number of assigned points was not changed in comparison to the previous list. One can also observe that there were more point upgrades than downgrades on the new ministerial list, in cases where changes occurred. The mean change in points for journals that had a change in assigned points was an increase of 33.03 points. The most notable changes include 10 cases in which journals were upgraded from 20 or 40 points to 200 points, as well as 10 downgrades from 200 and 140 points to 20 points. Table 6 presents the titles of those journals

Table 6.
The journals with highest (positive and negative) difference in points

Title	Points 2023	Points 2021	Difference	issn	eissn
Automatyka, Elektryka, Zakłócenia	200	20	180	2082-4149	
Chemistry-Didactics-Ecology-Metrology	200	20	180	1640-9019	2084-4506
Clinical and Experimental Hepatology	200	20	180	2392-1099	2449-8238
Journal of Agricultural Sciences	200	20	180	1391-9318	2386-1363
Nature Food	200	20	180		2662-1355
Żywność. Nauka. Technologia. Jakość.	200	20	180	2451-0769	2451-0777
Disaster and Emergency Medicine Journal	200	40	160	2451-4691	2543-5957
Ecological Chemistry and Engineering S - Chemia I Inżynieria Ekologiczna S	200	40	160	1898-6196	1898-6196
E-Informatica Software Engineering Journal	200	40	160	1897-7979	2084-4840
Rocznik Teologii Katolickiej	200	40	160	1644-8855	
Journal Of Abnormal Psychology	20	140	-120	0021-843X	1939-1846
Wiley Interdisciplinary Reviews-Developmental Biology	20	140	-120	1759-7684	1759-7692
American Journal Of Physical Anthropology	20	140	-120	0002-9483	1096-8644
Antioch Review	20	140	-120	0003-5769	2326-9707
English Literature In Transition 1880-1920	20	140	-120	0013-8339	1559-2715
Esaim-Mathematical Modelling And Numerical Analysis-Modelisation Mathematique Et Analyse Numerique	20	140	-120	0764-583X	1290-3841

Cont. table 6.

International Journal of Environmental Research and Public Health	20	140	-120	1660-4601	1660-4601
Materials Science & Engineering C-Materials for Biological Applications	20	140	-120	0928-4931	1873-0191
Biotechnology for Biofuels	20	200	-180	1754-6834	1754-6834
Future Of Children	20	200	-180	1054-8289	1550-1558

Source: Authors own work, based on MEiN (2023) and MEiN (2021) lists.

Some interesting increases in points assigned by the ministry concern three journals with Polish titles: (1) 'Automatyka, Elektryka, Zakłócenia,' (2) 'Żywność. Nauka. Technologia. Jakość.,' and (3) 'Rocznik Teologii Katolickiej.' The first two journals accept papers in both Polish and English, with 'Automatyka, Elektryka, Zakłócenia' being a technical and scientific magazine. While the author does not attempt to undermine the national scientific value of these journals, as they are not within the field of the author's expertise, it's worth noting that the highest possible grades might be expected to be reserved for journals dedicated exclusively to international audiences and addressing issues of global significance. Among the top 10 journals with the highest positive changes in points, as mentioned in Table 6, the majority (8 out of 10) are run by Polish publishers. The two exceptions are (1) 'Nature Food' and (2) 'Journal of Agricultural Sciences.' Only one journal from Table 6 is assigned to the management and quality discipline - the 'International Journal of Environmental Research and Public Health' (MDPI).

The mean change in points assigned to all journals overall is equal to 1.34 points. Of course, this score is relatively low because points were not changed for most of the journals (91.05%). When calculating the mean change in points among journals that underwent a change, the mean value equals 31.3. Figure 4 presents a column chart illustrating the average point gain for journals assigned to specific scientific disciplines. The chart includes data for all journals within each discipline, as well as exclusively for those journals that experienced a change in their scores.

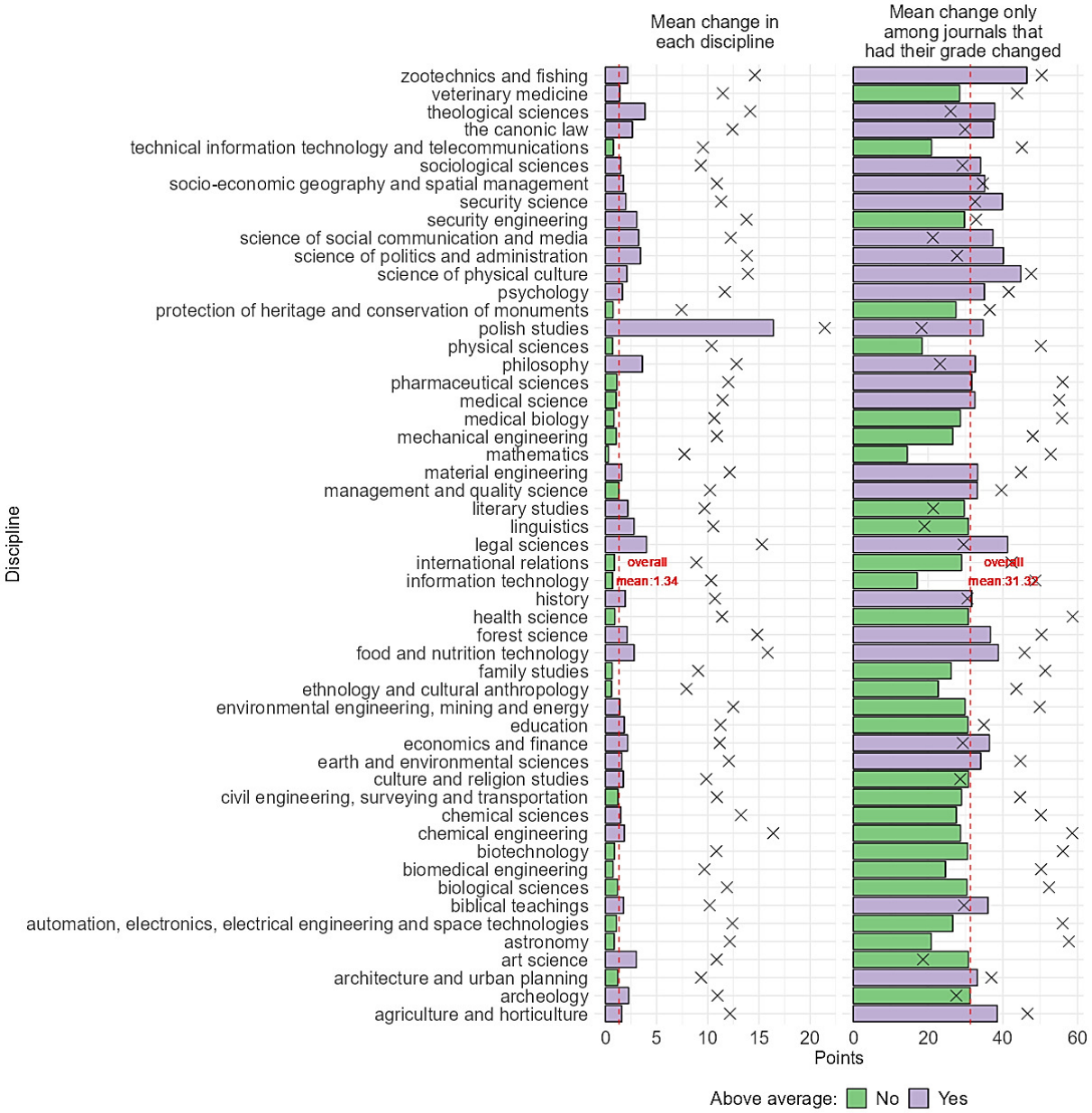

Figure 4. The overall average change of points (left) and the mean of change (right) in each discipline (x marks the standard deviation value).

Source: Authors own work, based on MEiN (2023) and MEiN (2021).

When it comes to the scale of the overall change of points within given scientific disciplines, Polish studies have undergone the most notable change. The mean number of points assigned to journals from this discipline has risen by 16.4 points. The second and third highest scores in this matter were significantly lower but still noticeably above the general average of 1.34. The disciplines in this regard are philosophy (3.61 average gain) and theological science (3.86). The lowest average gain of points was noted for mathematics (0.30), ethnology and cultural anthropology (0.60), and family studies (0.65).

Although Polish studies had the highest average growth of points, when considering only journals that had their points changed within a discipline, then the discipline of zootechnics and fishing had the highest average growth of points (46.4), followed by the science of physical

culture (44.8), and legal sciences (41.3). From this perspective, mathematics again gained the least (14.4), as well as information technology (17.1) and physical sciences (17.1).

4. Discussion and summary

As a result of the analysis, answers to the research questions were obtained.

RQ1. What is the distribution of points in relation to the Scopus top tier list?

Due to disparities between disciplines on both Scopus and the ministerial list, as well as variations in the significance of multidisciplinary journals within different fields (which subsequently influences point allocation), the significance and prestige (interpreted as the number of assigned points and CiteScore percentile) of individual journals often significantly differ between the ministerial list and Scopus. Such inconsistency frequently places researchers in the dilemma of choosing where to publish their research results. On one hand, they must maximize points for periodic evaluations and research assessment (which involves selecting highly-pointed journals on the ministerial list), while on the other hand, they may have to forego high point allocation in favor of journals with high CiteScore percentiles, aiming to enhance their parameters (e.g., h-index), reach a global audience, or contribute to the goals of the Excellence Initiative – Research University program.

RQ2. What is the distribution of points and top tier journals in scientific disciplines?

Significant disparities arise between disciplines in terms of the number of journals available for publication. In this regard, fields related to biotechnology and medicine enjoy the widest spectrum of publishing options, often surpassing the number of available journals in other disciplines. A similar variation can be observed regarding the participation of journals with the highest possible point allocation and those at the top of the CiteScore percentile list in Scopus. Humanities and theological disciplines exhibit the smallest presence in this realm. Therefore, basing on the distribution of points in each top tier category, one might say that the number of points assigned to scientific journals on the MEiN list is not tightly related to the CiteScore Percentiles.

RQ3. What was the dynamics of changes in the scoring of scientific journals?

The latest list introduced 1261 new journals to the index and revised the scores of 1809 journals (meaning that every twentieth journal had its score altered). The majority of changes involved point increases, with only a minor number (160) of journals experiencing score reductions. While many cases saw modest increases (by 20 points), there were instances of substantial changes (by 160 or even 180 points). On one hand, a substantial increase might be deemed unfair to representatives of disciplines without such alterations, while on the other hand, concerns might arise that during the preparation and review process, a journal could undergo a drastic downgrade, endangering authors by not accumulating sufficient points for their evaluation, thus intensifying the "*pointosis*" effect.

Addressing these concerns does not have straightforward or universal solutions. However, a potential starting point could involve tightening the connection between assigned points and the CiteScore Percentile. For example, the points assigned to a journal based on the percentile calculated by the evaluation committee (after taking into account also the importance of a journal on the local arena) could be compared to the points it would receive if the CiteScore Percentile were applied instead. If the difference would exceed a two-level threshold, the points could be limited to that level (similar to the processes when the discipline committee pleads for a change during the journal evaluation process). A similar limit could also be considered for increasing or decreasing the assigned points to prevent any journal from rising or dropping by more than two threshold points. This approach would introduce predictability and stability to the academic environment, constituting a minor yet impactful step toward mitigating the "*pointosis*" issue.

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A METHOD OF ASSESSMENT OF A SUSTAINABLE PRODUCT – THE CONCEPT AND ITS IMPLEMENTATION FOR PARTS AND SUBASSEMBLIES OF AGRICULTURAL TRANSPORT MEANS

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Purpose: The belief that there is an economic demand for results of an application nature was the main inspiration to undertake the research, the main goal of which is to develop a set of criteria defining a sustainable product and, on this basis, to prepare a method for its evaluation.
Design / Methodology / Approach: In the theoretical layer, the method of reconstruction and interpretation of the literature on the theory of sustainable production will be used, while in the design layer, a research procedure based on a creative discussion conducted among deliberately selected field experts (competent judges) will be initiated. At the practical level, it is suggested to develop and use a method in the practise of enterprise - assessment of selected parts and technical components of agricultural transport means in terms of defined criteria (characteristics).
Findings research established what criteria a product must meet to be attractive from the manufacturer's point of view, on the one hand (economic criteria) and, on the other hand, to meet the demands resulting from the sustainable development policy (socio-environmental issues). The method developed to evaluate a sustainable product was tested in the practise of companies in the agricultural machinery sector. On this basis, it was estimated to what extent the analysed parts and components of technical means of agricultural transport meet the postulates adopted under the developed method. Thus, the authors present a complex approach and broadly understood assessment and related criteria that predispose a product to be "sustainable".
Research limitations/implications: There are many ambiguities in the interpretation of the concept of a sustainable product. This term has an ambiguous meaning. Defining a sustainable product is as difficult as its precise differentiation in enterprise implementation processes. Despite many attempts to reconcile the positions among researchers, there is no clear agreement on the meaning of this concept. What is a sustainable product and, consequently, what methods should it be tested for? The above issue determined the initiation of directional research aimed at obtaining an answer to this question.
Practical implications: The developed method will influence the adaptation of products to the requirements of a sustainable and resource-efficient circular economy and reduce the amount of waste in the production process. Thanks to the publication, the company has a chance to notice ecological problems much more broadly and, by influencing them, indirectly reduce the

burden on the natural environment. The implementation of the method will result in a change in the approach to ecological problems from the end of the production process to the source of the production process (process design).
Social implications: When choosing a specific product, consumers receive a tool that allows them to define the orientation of the companies that produce it on environmental and social issues. This approach accelerates the process of greening production companies operating in the agricultural machinery sector.
Originality/value: This work presents procedures and tools that allow the identification of key characteristics of a sustainable product and the method of parameterizing them in relation to parts and technical components of agricultural transport means. The developed proprietary profile of sustainable product features is the starting point for improving the assortment database management processes. In the context of the research subject, the developed assessment model can be used to improve the product portfolio of companies in the agricultural machinery sector and related sectors.

Keywords: sustainable product, environment, economics, society, agricultural transport.

Category of the paper: Research paper.

1. Introduction

How is the concept of a sustainable product recognised by representatives of agricultural machinery sector enterprises operating in Poland (production of technical means of agricultural transport)? What criteria (postulates) for assessing a sustainable product should be taken into account when making its overall assessment and how to define a scale estimating each of them?

The above questions and the belief that there is an economic demand for utilitarian results were the main inspiration for undertaking research, the main goal of which is to define a list of criteria for a sustainable product and, on this basis, to prepare a method for its evaluation. Achieving such a goal requires the formulation and implementation of partial goals, which are defined as follows:

- At the theoretical and design level – a literature search on the subject in direct relation to the sustainable product; the authors intend that this will be expressed in a hypothetical set of criteria for assessing the product in terms of features that constitute its sustainability; in the further research procedure, these criteria will be subject to expert assessment;
- On the empirical level, the use of the method in the practise of enterprises from the machinery sector; an assessment of the selected product group will be carried out, taking into account the differentiation criteria.

The theoretical and empirical nature of the publication determines the research methods to be used. In the theoretical layer, the method of reconstruction and interpretation of the literature on sustainable production will be implemented, while in the design layer, a research procedure based on a creative discussion conducted among selected experts, representatives of enterprises

in the sector under research (production of parts and technical components of agricultural transport means), universities (University of Life Sciences) and research and development units (Poznań Institute of Technology).

The purpose of the work is to show a broader perspective on product evaluation in the context of sustainable production; provide practical tips in this regard. The above is determined by the fact that enterprises are increasingly faced with the dilemma of whether to focus on low-cost production (not necessarily taking into account socio-environmental requirements) or whether to reorient their key resources towards highly professional production in the "economy-environment-human" paradigm. What are the advantages and disadvantages of this? What conditions must be met to move towards sustainable production? These and a number of other questions became the basis for the authors to undertake research in the field of sustainable product assessment, especially since there is an obvious need to explore and create theories in the area of "sustainable" forms of organising the production process.

The complexity of the description and quantification of existing conditions in the field of sustainable product assessment makes this issue an important theoretical and practical problem that bothers management staff and business owners, especially those who see the need for change. That is why work aimed at filling the existing knowledge gap is so important. In the context of the above, the authors decided to conduct a series of studies, the subject of which was an attempt to model a product evaluation method using desiderata reflecting its level of sustainability.

2. Literature query

The literature search on the subject has been an inspiration to carry out more business-orientated research and has enabled the confrontation of research conclusions and observations with the published findings of outstanding researchers. Due to the desire to examine the most well-recognised trends and standardise the approach when formulating evaluation criteria, the analysis of Polish and English-language publications was used. The two largest indexing databases (Web of Science and SCOPUS) played a key role in the literature review. However, it was also decided to include scientific texts written in Polish and to reflect specific features of the market. Therefore, the publications catalogued in EBSCO and BazEkon were also included in the final database. The selection of databases was determined by the availability of publications covering the subject of research and their academic quality.

The lists of publications in each base are very broad (over a hundred thousand of papers and books) and multidisciplinary, located in natural sciences, engineering, economy, and business. Since defining characteristics based on the literature is very difficult (individual researchers create broad lists of evaluation criteria, without rankings, using various terms and interpreting

them differently). The authors, based on their knowledge and experience, limited their reading lists to works within management and business areas, available in full-text and corresponding to the research goal. Moreover, it was considered obligatory (taking into account the purpose of the research) to reduce the amount of available information, presenting only key conclusions from the perspective of the research process:

- Maturity in the area of effective product implementation is expressed by the company's ability to effectively select products so that their implementation supports the company's goals and strategy (Jabbour et al., 2015; Susiati et al., 2023; Hapuwatte, Jawahir, 2021; Albino et al., 2009; Munoz-Pascual, 2019; de Jesus Pacheco et al., 2019);
- As the sustainability of the product portfolio increases, the organisation's sustainability increases, and resources are used more effectively (Aibar-Guzman et al., 2022; Melander, 2017; Tao, Yu, 2018);
- A sustainable product is an expression of the commonly held belief that economic efficiency, pro-environmental activities, and human orientation are a guarantee of increasing the efficiency of an enterprise's operations (de Medeiros et al., 2022; Eslami, Krishnan, 2023; Tischner, Charter, 2017; Hernandez, 2019);
- Offering a sustainable product means that the company focusses on features that are key to buyers and consistent with the requirements of the socio-economic environment (Bangsa, Schlegelmilch, 2020; Villamil et al., 2022; Wang, Su, 2022; Song, Sakao, 2017; Saeed et al., 2019);
- Shaping a sustainable product occurs in a reactive model: first, the needs and requirements of the environment are identified, and then a product taking them into account is developed (Li et al., 2021; Howard, Hadfield, 2006; Schulte, Hallstedt, 2017);
- Profit is important and desirable, but it is emphasised that it cannot be treated as the only direction of implementing the development strategy in every situation and at all times (Zhang et al., 2020; Chiu, Chu, 2012);
- When assessing a sustainable product, a number of methodological problems emerge that must be solved (Watkins et al., 2021; Jiang et al., 2021; Schulte, Knuts, 2022; Tischner, Charter, 2017; Chen, 2018; Badurdeen et al., 2018; Mesa et al., 2019);
- Problems with assessing a sustainable product result mainly (but not only) from the fact that we are still dealing with a multitude of various directions, trends, approaches, and definitions that are incompatible with each other (Liu et al., 2020; Hallstedt, Isaksson, 2017; Ocampo et al., 2020).

The difficulties in measuring the factors determining a sustainable product also arise from the fact that individual researchers who create lists of determinants most often rely on descriptions in the literature. There is no reference to practical needs in this regard. According to the authors, diagnosing the evaluation factors selected in this way is too general, artificial, and unclear, not to say, detached from reality, because the evaluation criteria change over time

and should be modified situationally, adequately to the requirements of the socio-economic environment and the market.

3. Research framework

3.1. Sustainable products from the perspective of companies

There are many unclarities in the interpretation of the term "sustainable product". This term has an ambiguous meaning. Defining a sustainable product is as difficult as accurately differentiating it in enterprise implementation processes. Despite many attempts to agree on the perspectives of management researchers and practitioners, there is no clear consensus on the meaning of this concept. What is a sustainable product and, consequently, what methods should it be tested for? The above issue determined the need to carry out directional research aimed at obtaining an answer to the question: How is the concept of a sustainable product understood by representatives of production enterprises in the agricultural machinery sector operating in Poland (production of parts and technical components of agricultural transport means)? The research was carried out during direct creative conversations with deliberately selected experts. The interview was conducted according to the scenario implied by the research needs. The form of a free, led by a researcher, and driven by the research goal conversation was adopted. In relation to the assumptions and concepts presented in the literature and based on the experience gained from their companies, the experts were asked to present their own definition of a sustainable product. Expert discussions were conducted during face-to-face meetings held from 22 to 23 September 2023.

When interviewees were selected, their professional experience was taken into account. In each case, these were professionally active people who actively participated in the implementation processes of technical parts and components of agricultural transport means. The authors' intention was to collect proposals for defining a sustainable product, which in the future gave rise to modelling criteria and an evaluative scale. The discussion of criteria in relation to their hierarchy of importance and interpretation of a sustainable product was the key to further research.

Expert interviews and a detailed search of the literature on the subject indicate that a sustainable product is characterised by:

- medium-term perspective and high probability of achieving significant benefits in the form of profit, taking into account environmental and social standards,
- diversity, which causes them to be classified into different categories,
- income perspective, which is a derivative of potential value (the greater the value of the product for the customer, the greater the chances for sustainable development; however,

full customer orientation requires offering not only products, but a specific value for the market segment),

- cost accounting based on actual, not catalogued standards of labour intensity, applied technologies, and the resulting consumption of raw materials,
- specific expectations regarding the features of products (including quality) offered at given prices (proper response to these expectations encourages most customers to make purchases),
- striving for the highest quality of the product by using available solutions and resources (the relationship between the level of quality and price as well as possible services provided with the product are one of the main factors determining the sustainability of the company),
- maximising the properties of the product ensuring uninterrupted ability to work for the longest possible period of time,
- a bundle of interrelated physical features, usability, and benefits.

Taking the above as an interpretation, this study assumes that a sustainable product consists of physical features and elements that determine the strength of perception of the product by potential buyers, as well as by competitors and suppliers, i.e. in the case of parts and technical components of agricultural transport means, durability, reliability, quality, aesthetics, price, and technical solutions. These elements are assumed to be not permanent categories. Changes or modifications to the components of this level depend primarily on technological progress, evolution of consumption patterns, and socio-environmental norms. This means that the elements accompanying the core of a sustainable product should be a variable combination adapted to the needs, preferences, and requirements of the market, while enabling the product to be distinguished among competitive offers.

Ensuring the quality and durability of the product (through the entire cycle, starting from resource and material acquisition, through its production, processing, transport, storage to purchase by the consumer, and recycling) is a premise that significantly determines a sustainable product. It also implies a relatively high degree of meeting the requirements resulting from market needs, taking into account the latest achievements and experience in the processes of design, construction, production, and operation. Therefore, it influences the level of modernity throughout the product's life cycle, which is important from the perspective of a sustainable product.

A sustainable product is a "relationship-based" product in which the consumer is simultaneously involved in the process of creating and promoting the product. During the research, it was found that customers are the ones who, in a sense, create the value of the product (components and parts) they receive. In this sense, the customer's actions consist of the broadly understood individualisation of the value composition (customisation), i.e., taking actions aimed at obtaining values tailored to their needs and expectations. That is why increasingly efficient and modern production technologies that are neutral (not harmful) to the environment

are so important in the production process of parts and components. New methods of organising production (aimed primarily at eliminating any losses resulting from production processes) significantly define a sustainable product.

In the context of a sustainable product, attention was paid to its compliance with EU directives. In the case of producers of components and parts for agricultural trailers, compliance with the regulations on technical conditions and vehicle equipment (traffic on public roads) and compliance with environmental standards, which are a prerequisite for sustainable production, are crucial.

The above characteristics are the objective opinions, views, and judgments of field experts invited to the research, which constitute the basis for formulating assessment parameters important from the perspective of a sustainable product.

3.2. Research framework

In the ongoing scientific discourse, the view is often expressed that the current level of innovation of Polish enterprises undoubtedly does not match the expectations and ambitions of the global market. According to the authors, this view is completely unjustified, although the Polish industry must make the effort to implement innovative and sustainable products to sustain the opportunity to develop. Undoubtedly, new development perspectives are currently being created in which combining the achievements of various fields of knowledge or searching for an appropriate place for cooperation between enterprises and the research and development sphere is not only possible but also necessary. In the authors' opinion, the basic value and development opportunity of enterprises can and should be openness to interdisciplinary implementation projects. In the context of the above, the authors consider it advisable to search for research topics (using the full potential of the fields of management and quality sciences and engineering and technical sciences) wherever such potential can and should be used.

The starting point of the presented research are the authors' experiences, which illustrate the possibility of adapting the results obtained in interdisciplinary research to the needs of newly identified problems defined in management practise. Nowadays, whenever it is assumed that production will be adjusted to the dynamically changing customer requirements (responsive production), it should be ensured that in each case a product tailored to the customer's needs is created. Therefore, in addition to personalising the final product, the issue of agile reorganisation of production depending on changes in the economic situation of the market is also important. Meeting the challenges related to low-emission production will be an important point on the development roadmap of modern enterprises. It is the responsibility of companies to take appropriate actions to increase the efficiency of creating new products and managing their circulation. Increasing environmental pressure and decreasing natural resources will force the closure of the raw material cycle and the reuse of previously treated resources as waste. This is a serious challenge and requires a number of adjustments in the production area.

This is a big technological challenge for enterprises because the circular economy will need new materials and new methods of product design (eco-design).

The evaluation of a sustainable product and an attempt to base its improvement on this concept requires the development of a set of boundary conditions and assumptions and their appropriate management. Such a concept requires adaptation to the specificity of a specific sector and its representatives. So far, no research work has been carried out to organise and develop in a comprehensive way the issues related to the assessment of sustainable products, especially in the context of companies producing parts and components of technical means of agricultural transport (agricultural machinery sector).

Due to the multidimensionality and diversity of the concept of "sustainable product", assessment is an extremely complex undertaking that requires a holistic approach. It should be emphasised that when defining the basic designations for assessing a sustainable product and determining its level, they cannot be treated solely in the category of barriers and limitations. Individual categories are the foundations ensuring the coherence of the assessment system and defining the level of product adaptation to the requirements of the environment, and not factors limiting the validity of its implementation.

It seems that the complexity of the problems and the little scientific research so far justify treating these issues as important. Based on a literature search on the subject, there is an obvious lack of holistic studies that would comprehensively and completely cover the issues discussed in detail in relation to the indicated sector and at the same time would attempt to identify the cognitive gap (lack of measurement method).

3.3. Research goals, questions, and assumptions

The study conducted research whose main objective was to define a set of criteria to define a sustainable product and, on this basis, to prepare a method for its assessment. Achieving the main goal required the formulation and implementation of theoretical (cognitive), methodological, and practical partial goals (Table 1).

Table 1.
Partial Goals Definition

Goal		Tasks
Theoretical and Cognitive	Producing a catalogue of postulates reflecting a sustainable product (significantly articulated in the literature on the subject)	Literature search on the concept of sustainable production
	Producing a catalogue of postulates reflecting a sustainable product (essentially articulated by selected field experts)	Expert research (brainstorming, crushing method)
Methodical	Specifying the procedure for forming the evaluation method, taking into account key postulates, and the mechanism for determining their hierarchy.	Testing the method among selected competent judges
Practical	Determining the level of achievement of key criteria from the perspective of a sustainable product (assessment methods).	Evaluation of selected parts and technical components of agricultural transport means (object: technological trailer)
	Recommendations and Key Conclusions	

Source: own work.

The research will specify the criteria that the product must meet in order to be attractive from the manufacturer's point of view on the one hand (economic criteria) and, on the other hand, to meet the demands resulting from the sustainable development policy (socio-environmental issues). The method developed to assess a sustainable product will be tested in the practise of enterprises in the agricultural machinery sector. Selected parts and components of technical means of agricultural transport will be assessed. The object of the investigation is a technological trailer (Figure 1).

Figure 1. Research object - Fortschritt technological trailer T-088.

Source: ZPCZ Fortschritt internal documents.

The assessment will verify the possibility of using the method in the practise of enterprises, on the one hand, and, on the other hand, the level of fulfilment of the criteria by selected parts and components (implementation of the postulates adopted within the developed method). Thus, the authors present the complex topic of broadly understood assessment and related criteria that predispose a product to the name "sustainable".

In the context of the conducted analyses, research questions were formulated (Table 2).

Table 2.
Research Questions

No.	Research Questions	Verification Approach
P_1	What requirements described in the literature should be taken into account when formulating a method for assessing a sustainable product?	Literature query + Expert assessment + Verification in Busness Practise
P_2	Do the results of the assessment of technical parts and components of agricultural transport vehicles reflect the defined assessment criteria?	Analysis of selected parts and subassemblies
P_3	Do the tested parts and components meet the criteria to be classified as a sustainable product?	
P_4	What should be the level of implementation of the selected criteria in relation to technical parts and components of agricultural transport means?	Expert Verification

Source: own work.

The belief that there is an economic demand for results of an applied nature, on the one hand, was the main inspiration to carry out the research, and on the other hand, it became the starting point for formulating two assumptions (Table 3).

Table 3.
Research assumptions (presumption)

Assumption 1	The assessment method developed as a result of expert discussion reflects key factors from the perspective of a sustainable product.
Assumption 2	The method of assessing a sustainable product is a compilation of predictors, on the one hand, directly related to the product (e.g. cost, quantity, inputs), and on the other hand, it takes into account elements of the production environment (e.g. ecological and environmental conditions, such as post-production waste and the possibility of its use in another production process) and human resources used in its life cycle process.

Source: own work.

The presented research covers the issues of sustainable products, but it is important that they provide at least a minimum of guidance for those who want to evaluate the product portfolio in their company. It seems that the relatively little scientific recognition and complexity of the problems that occur in business practise justify treating these issues as a subject of research, which is reflected in this publication and the assumptions related to it.

4. Methodology development

To identify and adopt criteria for a sustainable product and define a scale to assess each of them, the knowledge of 11 experts was used as part of the relevant research (Table 4). A creative discussion was held among nine experts directly related to production companies operating in the agricultural machinery sector. When selecting the discussants, their professional experience (9 people) and their research and scientific experience (2 people) were taken into account. In each case, these were people who were actively active professionally participating in the implementation processes of the companies or institutions from which they come or for which they work (Table 4).

Table 4.
Expert Catalogue

<table>
<tr><th>Symbol</th><th>Expert</th><th>Field of expertise</th><th>No.</th><th>Age</th><th>Professional experience</th><th>Enterprise size</th></tr>
<tr><td>B.P., IK, PN, GW, TPP, HK, BH.</td><td>Owners (enterprises in the agricultural machinery sector)</td><td rowspan="3">Organisation and management: developing and implementing strategic goals, including ensuring sustainable growth.</td><td>7</td><td rowspan="4">30-40
2 persons

41-50
6 persons

60 and more
3 persons</td><td rowspan="4">Less than 15 years
1 person

More than 15 years
10 persons</td><td rowspan="4">Small (less than 50 employees)
3 persons

Medium (51-250 employees)
4 persons

Large (more than 250 employees)
4 persons</td></tr>
<tr><td>J.K.</td><td>Product manager</td><td>1</td></tr>
<tr><td>W.B.</td><td>Chairman of the Board</td><td>1</td></tr>
<tr><td>T.W.</td><td>Academic</td><td>Organic cultivation, sustainable and sustainable development, agricultural mechanisation</td><td>1</td></tr>
</table>

Cont. table 4.

K.B.	Researcher (PIT – Łukasiewicz)	Product safety certification declarations of conformity	1			

Source: own work.

During the main session, three key stages were established, the implementation of which determined the achievement of the goals implied by the research, including: (1) formulating tasks to be solved during the session, (2) conducting an idea generation session, and (3) collecting proposals for sustainable assessment criteria. product and defining an evaluative scale for each of them (discussing the criteria in relation to their hierarchy of importance and how to interpret them). It was agreed that each expert has the right to comment on the topic discussed. It was also noted that in addition to presenting your own ideas, it is worth developing and combining the ideas of other participants. The better the group's cooperation, the greater the probability of success. Closing the session, the final assessment of the results was formulated. In the next stage, the research authors wrote down all evaluation criteria mentioned by the interlocutors (they grouped similar ideas) and refined the scale of their evaluation in a given area. This way, the final shape of the evaluation form was established (Table 5). The selected criteria are not permanent categories. The authors are aware that the selection of individual factors is always a matter of convention and depends on the needs of its authors or the institution for which the evaluation sheet is created.

Table 5.
Assessment of sustainable products - description of criteria

No.	Criterion	Scale
K_1	Implementation cost	5 – Implementation does not require large expenditures (preparation of instruments, purchase of specialised production means, acquisition of new knowledge). It is low risk and difficult to imitate. 4 – Implementation requires specific inputs for its implementation. It is low risk and difficult to mimic (entry barriers). 3 – Although the implementation does not require significant outlays, it is burdened with a relatively high risk of the emergence of competitors (entry barriers) and is easy to mimic. 2 – Although implementation requires relatively large expenditures to implement, it is high risk and relatively easy to copy. 1 – Implementation requiring a large scope of research and development work and large financial outlays; relatively high risk; very easy to mimic.
K_2	Return period for invested funds	5 – Immediate return on implementation costs. 4 – Reimbursement of implementation costs within a period of up to 6 months. 3 – Reimbursement of implementation costs in 6 to 12 months. 2 – Reimbursement of implementation costs over a period of 12 to 18 months. 1 – Reimbursement of expenditure incurred on implementation over a period of more than 18 months.
K_3	First Implementation Duration	5 – Average implementation time less than 21 working days. 4 – Average implementation time 22-30 working days. 3 – Average implementation time 31-40 working days. 2 – Average implementation time 41-50 working days. 1 – Average implementation time over 50 working days.

Cont. table 5.

K_4	Efficiency – profit related to cost	5 – Profit is 91-100% of the costs incurred. 4 – Profit is 81-90% of the costs incurred. 3 – Profit is 71-80% of the costs incurred. 2 – Profit is 61-70% of the costs incurred. 1 – Profit is less than 60% of the costs incurred.
K_5	Participation of raw material in the manufacturing process	5 – The share of raw material cost is less than 30% of the total production costs. 4 – The share of raw material costs accounts for 30-39% of the total production costs. 3 – The share of raw material costs accounts for 40-49% of the total production costs. 2 – The share of raw material costs is 50-59% of the total production cost. 1 – The share of raw material costs is above 60% of the total production costs.
K_6	Opportunity of re-production	5 – Delivery at least once a month (cyclical sales). 4 – Quarterly delivery. 3 – Delivery at least twice a year. 2 – Delivery at least once a year. 1 – Delivery at intervals longer than 1 year.
K_7	Single-delivery/ batch size	5 – One-time delivery/production above 500 pieces. 4 – One-time delivery/production of 301 to 400 pieces. 3 – One-time delivery/production of 201 to 300 pieces. 2 – One-time delivery/production of 100 to 200 pieces. 1 – One-time delivery/production less than 200 pieces.
K_8	Environmental Conditions	5 – Completely no harmful impact on the environment. 4 – Limited harm to the environment, although there are some opportunities to improve the production process and product. 3 – Noticeable environmental impact; There are visible opportunities for product improvement. 2 – Significant harm to the environment. 1 – Very harmful to the environment.
K_9	Work environment	5 – Safety is ensured at a very high level and counteracts the burdensome and unfavourable effects of elements of the working space, thus ensuring **ideal working conditions for the operator.** 4 – Safety is ensured at a good level and the burdensome and unfavourable effects of elements of the work space are counteracted, thus ensuring optimal working conditions for the operator. **There is some room for improvement.** 3 – Sufficient safety and prevention of unfavourable and burdensome influences on workspace elements. The operator's working conditions are average. There are visible signs of improvement. 2 – Safety and counteracting burdensome and unfavourable influences of low-level workspace elements. **It only works in theory**; it is not reflected in practise. 1 – Safety and counteracting the burdensome and adverse effects of workspace elements are **practically non-existent.**
K_10	Scope of technological operations	5 – Efficient and modern production technologies that are neutral to the environment (no technological operations emitting pollutants) 3 – Efficient and modern production technologies relatively neutral to the environment (technological operations that emit certain pollutants, e.g., dust (limited ability to counteract pollution). 1 – Production technologies that are not neutral to the environment (technological operations that emit high levels of pollution (low possibility of counteracting pollution).

Cont. table 5.

K_11	Waste generated	5 – The product is characterised by efficiency in the management of raw materials throughout its life cycle. Possibility of using generated waste. The product is designed in such a way that it is recyclable. 3 – The product has limited efficiency in managing raw materials during its life cycle. Limited possibility of using generated waste and recycling. Including technological options in the product development process that allow the harmless disposal of materials that are not subject to reuse. 1 – The product has very low efficiency in managing raw materials during its life cycle. Little possibility of using generated waste and recycling. Limited inclusion in the product development process of technological options that allow harmless disposal of materials that are not subject to reuse.
K_12	Durability, product reliability	5 – The product has the ability to fulfil the intended functions over a long forecast period (over 5 years). 3 – The product has the ability to fulfil the intended functions within the average forecast period (1-5 years). 1 – The product has the ability to fulfil the intended functions within a short forecast period (up to 1 year).
K_13	Type of delivery	5 – Independent, specialised, universal, self-sufficient product (long-term implementation perspective). 4 – Dedicated product; delivery for first assembly (cyclical order guaranteed by an annual contract). 3 – A specialised product tailored to a specific type and technical model of a means of transport (replacement for currently manufactured machines). 2 – A specialised product tailored to a specific type and technical model of a means of transport (replacement for machines no longer produced). 1 – Product delivered once (on special order).
K_14	Safety symbol, standards, directives, and approval	5 – The product complies with the EU directives. Has a risk analysis and risk assessment for the purposes of issuing an EC declaration of conformity **(formally verified product).** 3 – The product complies with EU directives. However, there are no formal tests on hazards and risk assessment for the purposes of issuing an EC declaration of conformity **(the product meets the conditions but has not been formally verified).** 1 – Although the product complies with the specification (value in use), it has not been evaluated in terms of meeting the requirements related to EU directives. Lack of hazard studies and risk assessment (no assessment).
K_15	Flexibility	5 – The client co-creates the values of which he is the recipient; the client's actions involve the broadly understood individualisation of the value composition (customisation). 3 – The manufacturer creates values whose recipient is the customer; the customer's actions involve taking actions aimed at obtaining values tailored to their needs and expectations (customisation). 1 – The manufacturer creates values whose recipient is the customer; the client does not take direct actions aimed at obtaining values tailored to his needs and expectations (customisation).

Source: own work.

Implementation may end with an assessment of varying levels of satisfaction, corresponding to the degree of achievement of a given criterion or the lack of its implementation. In this sense, we are talking about the value of the product, understood as the benefit that the manufacturer can achieve as a result of implementing a sustainable product.

In the proposed evaluation method, to determine the significance of the adopted criterion, an appropriate weight index was assigned (Table 6). It was necessary to obtain reliable information regarding the validity of the criteria. The weights were adopted on the basis of the

authors' knowledge and experience. They fully reflect the opinions expressed by the experts invited to participate in the research.

Table 6.
Criteria and their importance (weight)

No.	Criterion	Weight
K_1	Implementation cost	0,06
K_2	Return period for invested funds	0,05
K_3	First Implementation Duration	0,06
K_4	Efficiency – profit related to cost	0,10
K_5	Participation of raw material in the manufacturing process	0,09
K_6	Opportunity of re-production	0,07
K_7	Single-delivery/ batch size	0,06
K_8	Environmental Conditions	0,07
K_9	Work environment	0,09
K_10	Scope of technological operations	0,05
K_11	Waste generated	0,09
K_12	Durability, product reliability	0,08
K_13	Type of delivery	0,05
K_14	Safety symbol, standards, directives, and approval	0,05
K_15	Flexibility	0,03
Total		**1,00**

Source: Own work.

Evaluation of a product consists of many elements that have a specific value for the manufacturer. The higher this value is from the manufacturer's point of view, the greater the chance of achieving satisfactory results in the form of profit, which, according to the authors, is the basic determinant of the efficiency of using the resources at the manufacturer's disposal. Therefore, profit in relation to the expenditure incurred should be an important criterion for assessing opportunity (weight 0.10). The payback period of the invested funds is equally important (weight 0.05).

In the method modelled for the purposes of this study, based on the points awarded, the following categories of opportunity differentiation were proposed (Table 7).

Table 7.
Product categories - Qualification conditions

Category	Product descriptor	Assessment range	Characteristics	Recommendations
A+	Highly sustainable	4,00-5,00	Every component of the assessment is at the highest level.	Key elements of portfolio; presented and implemented first; attractive from the perspective of the criteria used (long-term perspective)
A	Sustainable	3,00-3,99	Every component of assessment is at a high level; however, there is some space for improvement.	Important elements of portfolio; presented and implemented with available capacity. Perspective product
B	Qualified	2,00-2,99	Components of the assessment are acceptable; however, there is a need for improvement.	Individual approach dependent on the value of a single category.

Cont. table 7.

C	Disqualified	1,00-1,99	Most of the assessment components are at a low level, and do not meet the requirements.	Not important element of a portfolio; not attractive to manufacturers

Source: Own work.

Developing an appropriate product rating category should be one of the organisation's ongoing learning activities. Therefore, the boundary conditions presented in this study are only intended to indicate to companies the direction of such activities, with particular emphasis on the selection of individual differentiation criteria. This will allow the selection of a product of significant value from the point of view of a given company, on the one hand, and, on the other hand, which fits into the globally adopted sustainable development policy. In the future, it may be the basis for formulating assessment tools taking into account detailed criteria for ESG strategies.

5. Methodology implementation – A Case Study

5.1. Characteristics of the assessed object

The subject of the evaluation is the side wall of an agricultural trailer (Figure 2). Based on participant observation, guided interview, market research, and document analysis, the authors obtained the necessary information. The research referred to in this part of the study was made possible thanks to the courtesy of the "Fortschritt" company based in Września (Greater Poland Voivodeship), which produces parts and components intended, among others, for agricultural trailers.

Figure 2. Side wall of an agricultural trailer - subject of assessment.

Source: ZPCZ Fortschritt information materials.

The selection of the part that was evaluated was purposeful. The following part of the study presents the process of assessing a sustainable product from the manufacturer's perspective according to the adopted method. The evaluation was carried out by a five-person team. The experts were: the plant owner, production manager, technologist, and the authors of this study.

5.2. Object assessment

The presented case was a specific qualitative study of organisational and technological phenomena. The authors are aware of the fact that the conducted analyses of individual cases (assessments) are less useful for establishing cause and effect relationships, but they are useful for finding explanatory variables worth considering and suggesting mechanisms by which these variables influence the result or formulation of research questions, which will then be subjected to further analysis due to their value. Taking the above into account, the analysis was carried out with the participation of one of the enterprises. Research results are presented in Table 8.

Table 8.
Assessment results

Nr	Criterion	Weight	Points	Assessment
K_1	Implementation cost	0,06	3	0,18
K_2	Return period for invested funds	0,05	4	0,20
K_3	First Implementation Duration	0,06	5	0,30
K_4	Efficiency – profit related to cost	0,10	3	0,30
K_5	Participation of raw materials in the manufacturing process	0,09	2	0,18
K_6	Opportunity of re-production	0,07	5	0,35
K_7	Single-delivery/ batch size	0,06	1	0,06
K_8	Environmental Conditions	0,07	4	0,28
K_9	Work environment	0,09	5	0,45
K_10	Scope of technological operations	0,05	3	0,15
K_11	Waste generated	0,09	5	0,45
K_12	Durability, product reliability	0,08	5	0,40
K_13	Type of delivery	0,05	5	0,25
K_14	Safety label, standards, directives, and approvals	0,05	3	0,15
K_15	Flexibility	0,03	5	0,15
Total				**3,85**

Source: own work.

As part of the assessment, the indicated product receives 3.85 points, which predisposes it to be called a sustainable product in the context of the adopted criteria. The side wall of the technological trailer, which is the basis for the assessment (Figure 2), should constitute the core of the company's offer, although the possibility of improving the product and the related production process should be considered. The product has a long-term perspective. Although its implementation does not require significant expenditure (implementation costs), it is burdened with a relatively high risk of the emergence of competitors (relatively easy entry barriers). The above translates into the number of 3 points awarded in the *Implementation cost* category. The *return period for invested funds* is relatively short. A period of no longer than 6 months is indicated, which translates into 4 points under this criterion. Detailed analyses have shown that the implementation time of the side wall (due to the technology used) is less than 21 business days (taking into account the first implementation). The above is expressed in five points under the *First implementation duration* category.

Detailed analyses have shown that the profit in relation to the costs of producing the agricultural trailer wall, although relatively high, only indicates 3 points under this criterion. Similarly, *Participation of raw material in manufacturing process* predisposes to awarding only 2 points under the adopted assessment procedure.

The product received a high rating in the *Opportunities of re-production* category - the maximum number of points (5). However, the S*ingle delivery (batch size)*" is so small (less than 200 pieces) that only one point was awarded in the category. Limited harmfulness to the environment means that the product receives 4 points under the *Environmental conditions* criterion. Although there are opportunities to improve the production process and reduce harmful pollutants, it should be noted that this is due to the possibility of using increasingly modern welding methods and the related reduction of welding smoke, which is a mixture of welding gases and dust. Moreover, it was assumed that pollutants resulting from the melting of metals, their evaporation, and oxidation under the influence of the plasma arc, will never be neutral to the environment. The composition of welding dust depends on the welding method and on the welded and auxiliary materials, which should determine the number of points in this stage of assessment. Regardless of what has been said, you should always check whether a given welding station meets environmental protection requirements in this respect. This is related to the next stage of assessment regarding safety and counteracting the burdensome and unfavourable impacts of elements of the workplace. During the investigation, it was found that the manufacturer provides working conditions for the operator at a very high level. Thus, the product receives 5 points in the category *Design of work systems in accordance with the recommendations of conceptual ergonomics*. The product received very high ratings in categories important from the research perspective: *Waste generated*, durability, *product reliability*, *Type of delivery,* and *Flexibility*. As part of the evaluation of individual criteria, the maximum number of points is indicated (5). As for the assessment under the *Safety symbol, standards, directives, and approval* criterion, at a given moment, from the recipient's perspective, it is not necessary to obtain a certificate for this product. However, as for all products traded on the agricultural machinery market, it is a matter of time, because the product delivered to the European market will impose such requirements. Currently, the product receives 3 points under K_14, similarly to the K_10 criterion, i.e., *Scope of technological operations*.

5.3. Conclusions

The research conducted by the authors of the article predisposes them to present important conclusions. The products on the market for agricultural machinery (parts and components of technical means of agricultural transport) are characterised by various parameters (often different) parameters, which, according to the authors, result in different perceptions of their attractiveness from the point of view of a given criterion. The study covered a product that was characteristic in many respects. Therefore, in the future, the study should cover products

different in terms of: (1) use (purchase) of the appropriate type of raw material (sheet, steel bar, ductile casting, etc.), (2) purpose, (3) technological process, (3) price, (4) volume of supplies, (5) type of destination. This is important in the context of defining the assessment parameters and making them more detailed. Therefore, the authors are aware of the fact that the developed concept may raise some doubts (different perception of product evaluation parameters or imperfections in the methodology for assessing product attractiveness), however, the article is intended to constitute a proposal, a starting point (seed) and encourage further research in this direction. and scope. The authors, with full awareness and responsibility, address an appeal to practitioners, manufacturers, because they should also make an effort - develop methodologies and learn appropriate methods of operation - which in the future will certainly be reflected in the preparation of a method for assessing a sustainable product free from defects and shortcomings.

6. Summary

The article presents the author's concept of product assessment in terms of meeting the requirements of sustainable development. The concept was based on literature research and the authors' practical experience. The developed concept was verified by assessing the selected product. The conclusions of the assessment are diagnostic in nature, but the assessment is concluded with recommendations regarding product management and its place in the manufacturer's portfolio.

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ADAPTING DONATION OPTIONS TO DONOR EXPECTATIONS: POLISH VS. AMERICAN NONPROFITS

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Purpose: The aim of this study is to identify the differences in methods of donations – both in cash and in-kind – among the largest American and Polish nonprofit organisations in the online environment.
Design/methodology/approach: The study focused on examining a selection of the one hundred largest nonprofit organisations from both the United States and Poland. These organisations were selected using comprehensive databases and accessible financial, as well as activity reports. Employing a quantitative approach, the research analysed the websites of these organisations to identify diverse strategies employed for soliciting cash and in-kind donations using the content analysis method. Essential statistics related to the variables being studied were computed, and non-parametric tests were employed to validate hypotheses.
Findings: This paper focused on determining the relationship between the number of cash and kind donation methods offered by nonprofit organisations and the total revenue earned by the organisations and revenue from private donations. The paper demonstrated that the American organisations with the highest revenue are more professional with respect to possibilities for online donations and, at the same time, more homogeneous (i.e. there are no fundamental differences between larger and smaller organisations in this regard). Moreover, compared with Polish organisations, they adjust better to the environmental requirements by introducing various donation methods (e.g. shares, mutual funds, cryptocurrencies, etc.).
Research limitations/implications: Only one hundred of the largest American and Polish organisations were examined. Most of them are defined by one parameter only – the revenue amount. The study analysed only the nonprofit organisations' websites, without taking into consideration other online environment components, e.g. social media.
Practical implications: Nonprofit organisations can consider – on a benchmark basis – introducing specific solutions regarding the obtaining of cash and kind donations. This can raise the donation amounts and, in consequence, improve the effectiveness of accomplishing the organisation's mission.
Social implications: Nonprofit managers can obtain knowledge of other methods of acquiring donations by the use of the Internet. This will make their organisations' activities more professional, thereby reinforcing the development of civil society in Poland.
Originality/value: Comparisons of American and Polish nonprofit organisations with respect to proposed methods of online cash and kind donations have not been diagnosed. Therefore, considerable differences were identified whose reasons should be the object of further in-depth scientific exploration.

Keywords: nonprofit organisation, online donation, ways of giving.
Category of the paper: Research paper.

1. Introduction

Each organisation needs resources in cash and in-kind to pursue its goals. However, various organisation types acquire them in various ways. The difference between for-profit and nonprofit organisations has long been recognised by the law in terms of revenue generation and reporting requirements (Blouin et al., 2018, p. 2). Although nonprofit organisations, like for-profit ones, can acquire revenue commercially (through the sale of goods or services), they often obtain them from donations. This, in turn, results in reporting requirements – firstly, it is supposed to win donors' trust, and secondly – these are legal requirements associated with tax preferences.

This paper analyses the largest nonprofit organisations in the USA and in Poland in terms of their revenue. Like nonprofit organisations in Poland, those in the USA conduct a variety of activities (they provide healthcare, feed, educate, provide shelter, look after and inspire people). Currently, the nonprofit sector is the third largest employer in the USA. This is due to the large number of nonprofit organisations – over 1.7 million active ones. There is a widespread culture of charitable giving in the USA. It is estimated that as many as 60% of all American households participate in some kind of charitable giving. Online donations are also very popular in the USA. It is estimated that 51% of wealthy donors prefer to donate online, and the popularity of this donation channel is growing - in 2020, online giving grew to become 13% of all charitable giving and in 2021, that number increased by another 9%, which gives a total increase of 42% over three years (Nonprofit Statistics, 2023).

There were over 138 thousand NGOs registered in Poland in December 2021 (this does not mean that there are so many active ones) – a great majority of them are societies and foundations (Fakty o NGO [Facts on NGO], 2022). Altogether, all nonprofit organisations in Poland generate over 1% of the GNP (Organizacje nonprofit [Nonprofit organisations], 2021). Like American nonprofit organisations, those in Poland conduct diverse and multi-disciplinary activities. A great majority of nonprofit organisations – 81.4% – conducted only statutory activity free of charge. The remaining 18.6% of the entities stated that they conducted paid statutory or business activities, 2.9% of which earned funds from both sources. The total revenue generated by NGOs exceeded 34 billion PLN in 2020. The two most numerous groups of entities – societies and foundations – earned a revenue of 28.4 billion PLN, which accounted for 82.4% of all the funds accumulated by nonprofit organisations (Działalność stowarzyszeń… [Activities of associations…], 2020).

One can see that Polish and American nonprofit organisations operate in various areas and they have different reach and forms of statutory activities. However, they act for the public good without striving for profit. Despite some similarities, one can expect many differences in their everyday operation. This concerns fundraising actions and methods of acquiring donations from individual donors – irrespective of who the donor is (an individual or an enterprise) and whether the donations are in cash or in kind. The economic condition, characteristics of donors, cultural factors and many others play a crucial role in inspiring the creation of various models of financing nonprofit activities and offering various methods of giving donations to specific organisations. Therefore, an analysis of the methods of making online donations to Polish nonprofit organisations, as well as comparing them to entities operating in other countries (especially in those advanced economically and culturally), can be helpful for their further development and charitable activities. Moreover, this is an intriguing area of interest for many researchers covering nonprofit organisations – especially since there is a gap in this area in the Polish scientific achievements.

Therefore, the aim of the study presented in this paper is to identify the differences in cash and kind donation methods in the largest American and Polish nonprofit organisations in the online environment.

This paper is structured as follows: the beginning of Section 2 describes the basic issues dealt with by researchers studying online donation acquisition by nonprofit organisations (e.g. the role of trust, benefits from Internet use, etc.). The theoretical background for formulating the study hypotheses is presented in Section 2.2. The research methodology is described in Section 3. Section 4 presents the findings of a study conducted among the 100 largest American and Polish nonprofit organisations in terms of revenue, and Section 5 contains a discussion of the findings. The paper ends with conclusions together with the identified limitations of the research.

2. Conceptual background

2.1. Literature review

Nonprofit organisations play a crucial role in solving social, environmental and humanitarian issues. However, in order to operate effectively in and for the environment, they have to possess suitable resources. In other words, to fulfil their social mission and create social value, nonprofit organisations may earn some income from selling goods and services, but they also rely on funds (sometimes entirely) from donations, gifts in kind, and volunteer work (Moore, 2000). An important role has been played by the donations made over the Internet for many years. E-philanthropy, or e-giving, is defined as using the Internet to make or collect donations (Jillbert, 2003, p. 5).

Studies on Internet and website use in acquiring donations focus on several crucial issues. Gaining a potential donor's trust is one such issue (Prashar, Gupta, 2023; Behl et al., 2023; Hou et al., 2021; Alhidari et al., 2018; MacMillan et al., 2005; Sargeant, Lee, 2002; Andaleeb, Basu, 1995), which has been emphasised in American studies (Kaurov et al., 2022; Francioni et al., 2021; Shin, Chen, 2016; Shaz, Hillyer, 2010) and other studies in which the USA was compared with other European countries (e.g. Evers, Gesthuizen, 2011). The issue of trust in online donations has also been described with respect to the specific conditions of Poland (Wojciechowski, 2009; Pawlikowski, Wiechetek, Majchrowska, 2022; Schiffling, Piotrowicz, 2022). Discussions on trust in online donations stress the importance of an organisation's transparency for potential donors (Ortega-Rodríguez, Licerán-Gutiérrez, Moreno-Albarracín, 2020; Gálvez Rodríguez, Caba Pérez, Dumont, 2013; López Godoy, 2012) and practical issues of designing and constructing websites in a way aimed at gaining trust and encouraging people to make donations (Küchler, Hertel, Thielsch, 2020 Bennett, 2009; Boyd, 2003; Hooper, Stobart, 2003). The importance of the website is emphasised not only in regard to getting donations but also to the organisation's overall image (Saura, Palos-Sanchez, Velicia-Martin, 2020; Huang, Ku, 2016; Kensick, 2003). However, one should know exactly the characteristics of potential donors in order to adjust the website's appearance and functionality to their preferences. This is similar to the operations of commercial enterprises, which use market surveys to persuade customers to buy their products. Therefore, donor characterisation is another important issue discussed in regard to online donations (e.g. Shier, Handy, 2012; Bekkers, 2010). It is also important to clearly understand what a nonprofit organisation gives to its donor (what values and benefits). This focuses on prestige (Paramita et al., 2020; Samek, Sheremeta, 2017; Harbaugh, 1998), empathy (Aji, Muslichah, 2023; Kasri, Indriani, 2022; Liu, Suh, Wagner, 2018), and the donor feeling good (Paxton, Velasco, Ressler, 2020; Cryder, Loewenstein, Seltman, 2013). However, discussions on acquiring online donations by nonprofit organisations should not ignore the importance of creating suitable functionalities to adapt the methods of giving donations to a potential donor's profile and habits. Obviously, this applies to the websites of nonprofit organisations, especially since specific functionalities are also associated with trust and the way the organisation is perceived by a potential donor. This may apply to such issues as the dialogism of websites (Olinski, Szamrowski, 2017; Ingenhoff, Koelling, 2010; Kent, Taylor, 1998) and managing relations with donors (Olinski, Szamrowski, 2020; Pressgrove, McKeever, Collins, 2015; Waters, Feneley, 2013) as in commercial CRM systems.

Acquiring donations through various online channels can be a cheaper alternative compared to getting them in the real world (Nageswarakurukkal, Gonçalves, Moshtari, 2020; Ozdemir, 2010; Pollach, Treiblmaier, Floh, 2005; Hager, Rooney, Pollak, 2002). There may be more positive effects of acquiring online donations (e.g. Hou, Zhang, J., Zhang, K., 2022; Salido-Andres et al., 2021; Blouin, Lee, Erickson, 2018). Therefore, it is not surprising that this subject matter has been in the sphere of interest of many researchers and practitioners dealing with

nonprofit organisations for many years. In consequence, all comparisons between specific types of organisations, as well as between organisations from various countries with different customs and economic and cultural conditions there, may provide valuable input, which will help to understand and streamline the operation of nonprofit organisations in the online environment.

2.2. Formulating hypotheses

Nonprofit organisations play a crucial role in solving social, environmental and humanitarian issues. However, to accomplish their goals, they need sufficient resources in cash and in kind. Therefore, the resource dependency theory is the major theory that explains nonprofit organisation operations (which, in this regard, are no different from commercial organisation). The theory was developed by Pfeffer and Salancik (1978). For nonprofit organisations to conduct effective activities for their environment, they have to receive sufficient resources – in kind or in cash. The resource dependency theory is the direct basis for the environment dependence theory, which subsequently leads to the organisational adaptation theory (Sarta, Durand, Vergne, 2021; Abatecola, 2012). Due to the specificity of nonprofit organisation operations, donations from individuals and from other organisations are one of the more important methods of resource acquisition. However, such organisations must be skilful in reaching their potential donors to be effective in donation acquisition. Moreover, they must adjust the ways of giving donations to the donors' preferences and possibilities. To put it briefly, they have to adapt strategically to the environment. Organisation adaptation to their environment in order to thrive, or at least to survive in it, has been the central issue of the theory of organisations for many decades (Doz, Prahalad, 1991, p. 149). Adaptation is one of the most pervasive concepts in organisational theory and strategic management (Sarta et al., 2021, p. 44). Obviously, there are no universal methods or rules which guarantee an organisation's success under all kinds of conditions. This fact lies at the basis of the success of the contingency theory, which has emerged primarily as a reaction to universal principles and relationships prescribed by classical management writers (Van de Ven, Drazin, 1984, p. 8). Contingency theory is an approach to studying organisational behaviour that explains how factors such as technology, culture, and the external environment influence the design and function of organisations (Islam, Hu, 2012, p. 5159). Structural contingency theory argues that organisational structure needs to fit the three contingencies of the environment, size, and strategy (Donaldson, 2001, p. 2). Thus, the contingency theory paradigm postulates that organisational outcomes are the consequences of a fit or match between two or more factors (Van de Ven, Drazin, 1985). This also applies to nonprofit organisations and to their adaptation of donation methods to potential donors' preferences and expectations. Therefore, the more methods of giving donations that are offered by an organisation on the market, the better its financial results should be. This is the decisive argument for putting forward the following hypothesis:

H1a: There is a positive relation among the largest American nonprofit organisations between the number of donation methods applied and these organisations' total revenues.

A positive impact of the number and diversity of the donating possibilities should be observable not only in American but also in Polish organisations. The widely recognised theories, such as the resource dependency theory or the contingency theory, are universal, and they apply to organisations operating in various countries (especially those with market economies, and Poland is one of them). Polish nonprofit organisations often operate in highly competitive markets, with examples including competition for the 1.5% of the personal income tax which an individual can donate to a public benefit organisation. This creates a specific, highly competitive market (Czetwertyński, 2016). Therefore, the following should be assumed in a similar manner to American nonprofit organisations:

H1b: There is a positive relation among the largest Polish nonprofit organisations between the number of donation methods applied and these organisations' total revenues.

Basing their activities on private sources can reduce the dependence on the public sector, which is stressed by many authors who deal with this subject matter (e.g. Pizzini, Sterin, 2023; Robbins et al., 2022; Han, 2017; Frumkin, Keating, 2011; Carroll, Stater, 2008). Moreover, the donation methods analysed on the websites of the largest American nonprofit organisations are largely targeted at private donors (be they individuals or corporations). Therefore, the relationship between the diversity of such methods and the revenue from private donations should be particularly distinct. Hypothesis H2a therefore states:

H2a: There is a positive relation among the largest American nonprofit organisations between the number of donation methods applied and these organisations' total revenues from private sources.

Like with the American organisations, the donation methods identified on the Polish organisations' websites are targeted mainly at individual donors. Some of them are focused on individuals (e.g. the last will, tax return online), while others are more universal and try to acquire financial resources regardless of whether it is from individuals or from other legal entities. However, those are independent private entities. In a similar vein, hypothesis H2b states:

H2b: There is a positive relation among the largest Polish nonprofit organisations between the number of donation methods applied and these organisations' total revenues from private sources.

To conclude, according to these hypotheses, the donation possibilities identified on the American and Polish nonprofit organisations' websites lead to revenue diversification, which does not cause the crowding-out effect (Nikolova, 2015; Borgonovi, 2006; LeRoux, 2005; Enjolras, 2002); thereby contributing to the revenue increase.

3. Research methodology

One hundred of the largest American and one hundred Polish nonprofit organisations in terms of their revenue, and, specifically, certain specific groups of these organisations, were included in this study. On the American side, those were organisations referred to as 501(c)(3). The name refers to a provision of the American Internal Revenue Code – IRC (Pub. L. 99-514, §2, Oct. 22, 1986, 100 Stat. 2095 1954, ch. 736, 68A Stat. 3, 1986). If an organisation meets the requirements of the provision and is registered with the Internal Revenue Service (IRS), it benefits from certain tax preferences. By being included in the online IRS list of tax-exempt organisations, it does not pay federal income tax, which is why a potential donor is aware that his/her cash or kind donation will be used in full for the operation of the nonprofit organisation and consolidating of the so-called "civil society". The 501(c)(3) organisations include various entities, e.g. corporations, trusts, unincorporated associations and others. Their main characteristic features also include the fact that the donations given to them are tax-deductible. Therefore, these are organisations operating in a fiercely competitive market for donations from individuals and other organisations (e.g. enterprises). Consequently, a distinct market emerges, characterised by the interplay of donation supply and demand. In this context, they share similarities with Polish public benefit organisations. Hence, an analysis of these organisations was conducted within the Polish context. The public benefit organisation (PBO) operation is described in the Act on public benefit activity and voluntary service of 24 April 2003 (Journal of Laws, No. 96, item 873, 2003). Like 501(c)(3) in the USA, a PBO in Poland can have various legal forms. They are mainly associations and foundations, but they can also be joint-stock companies or limited liability companies whose activities are not aimed at earning profit and other entity types. Like 501(c)(3) organisations, PBOs have certain preferences and facilities. One of the major ones is the possibility of seeking to receive 1.5% of personal income tax. There is also competition between organisations in this sphere, which resulted in a kind of "market for 1.5%". There was an estimated 9,400 PBOs at the end of 2021. They accounted for 9.7% of all active nonprofit organisations (Organizacje pożytku publicznego, 2022).

Polish and American databases were used in order to select the 100 largest organisations in the USA and in Poland in terms of their revenue (Forbes, 2022; Ranking PBO, 2022), and subsequently, the data were compared to the reports prepared by individual organisations. An analysis of the financial reports and those of the organisations' activities helped to verify the data and to identify the revenue sources in the American and Polish organisations. Therefore, the annual cumulative financial report for the 501(c)(3) organisations (i.e. so-called Annual Extracts of Tax–Exempt Organisation Financial Data) was analysed. The Annual Extracts of Tax contain the data that the organisations must report annually to satisfy the tax requirements. The financial reports contain such data as income, expenses, assets, liabilities and other operation-related data. The data are used both by the IRS in the USA and by the

individuals concerned (e.g. researchers, journalists, donors) who want to evaluate the operation and the financial stability of an organisation. With the data, one can check how organisations utilise their resources, how effective they are and how they pursue their mission, how they adapt to the environment, etc. Verification of the financial data in Poland was based on the financial reports and those of the organisation activities filed by the PBO. The PBO report database is maintained by the National Freedom Institute – Civil Society Centre. All PBOs are obliged to file the report of their activities and their financial reports (and this obligation applies to all the public benefit organisations, regardless of whether they are entitled to receive 1.5% of personal income tax or not). The financial data for 2021 are obtained in this manner.

The next stage of the study covered the identification of the methods for donation given to specific organisations by their website analysis. It was not important whether the donor was an individual or an enterprise – the point was to identify the possibilities proposed by the nonprofit organisation in which individuals or organisations can support the organisation by donating funds. The sources of the organisation's revenue which were not donations (in cash or in-kind) were not analysed. This includes such instruments of acquiring financial resources as income from property, running an online shop or revenue from other business activities. The analysis of Internet websites covered the period of April-May 2023.

Following the creation of a list of the largest American and Polish nonprofit organisations in terms of their revenue, an analysis was performed (by the content analysis method) of the entities' websites. A specially constructed sheet was used for the purpose in which specific content was entered from the websites, or a digit was entered, depending on whether the element was present or not. The course of the research process is illustrated in Figure 1.

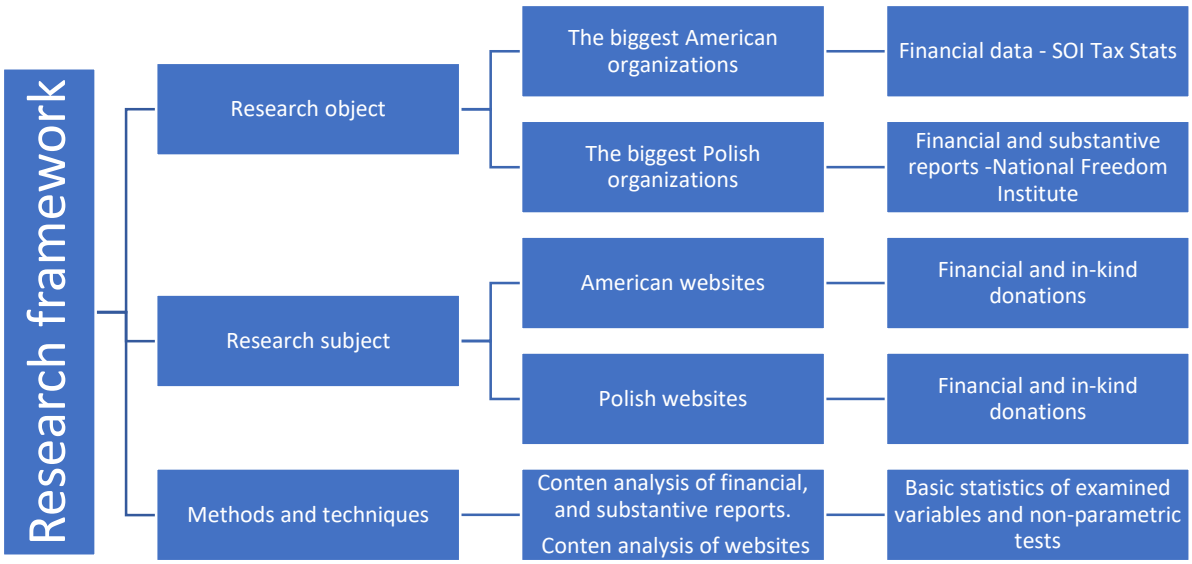

Figure 1. Research framework.

Source: own elaboration.

Statistical analyses were performed with the IBM SPSS Statistics 28 package in order to verify the research hypotheses. The basic statistics for the quantitative variables were calculated with the Kolmogorov–Smirnov test, which showed that the distribution of all the variables under study was extremely different from the normal distribution. For this reason, it was necessary to perform the analysis with the use of non-parametric tests. These analyses were performed with the Kruskal-Wallis tests.

4. Research results

4.1. Identification of the donation methods in the American and Polish nonprofit organisations

The website analyses of the largest American and Polish nonprofit organisations in terms of their revenues helped to identify several methods of donation acquisition by these organisations (Table 1). The following donation methods were identified with respect to the American organisations:

- Online transfer – this includes various technical methods of money transfer, e.g. by a bank transfer, payment with a credit card or others, and various payment methods (e.g. PayPal, Apple Pay, Venmo, Google Pay).
- Donate stock (and mutual funds) – the technical details of this donation form may differ, but it usually involves completing a simple form, which is followed by receiving a message with further instructions: the name of the brokerage company, DTC (Depository Trust Company) number of the brokerage company, name and the account number as well as the phone number and the broker contact name. One can also contact one's broker and ask him to initiate a "broker to broker" transfer. Subsequently, the donor's broker can transfer the stock directly to the nonprofit organisation. The transfer technique applied by nonprofit organisations is similar to mutual funds.
- Employee matching gifts – a corporate scheme in which employers financially "replenish" the donation that their employees give to nonprofit organisations (i.e. they transfer the same amount of money that their employee decided to give).
- Planned giving (legacy, will) – a form of donation for a nonprofit organisation. This enables one to give larger donations to a nonprofit organisation, which are given during the donor's life or upon his/her death as part of the general financial planning (which also includes the tax issues) and/or legacy donor; if the donation has a form of a bequest, it is included in a different group: legacy/will. Donations in this form may include artwork, partnership interests, personal property, life insurance, a retirement plan, etc.

- Donor-Advised Fund – a charitable investment account whose only purpose is to support charity organisations that the donor cares about. The account is managed by the sponsor organisation – the donor only suggests how to invest his assets and where to transfer them. The donor receives tax relief upon the payment.
- Donate product – a nonprofit organisation receives support in kind from the donor. These may be products that the donor transfers directly (or sends) as well as those purchased in a nonprofit organisation's shop – in this case, the end customer always receives the product rather than money.
- Donate by cheque (post, email) – there is information on the organisation's website about the possibility of making a donation by cheque or by mail, together with a suitable form to fill out and send, i.e. it involves posting a cheque or a money transfer. The process is simple, although it requires devoting some time by the donor, as he/she has to fill out a check or money order at a post office, and this will be subsequently sent to the address of the indicated nonprofit organisation. Only after this is done will the organisation deposit the cheque in its bank account.
- Donate cryptocurrency – transferring digital currencies as donations to nonprofit organisations can be effected in a variety of ways, e.g. organisations can use a cryptocurrency payment processor, e.g. BitPay. A donation is transferred directly to the organisation's wallet with a P2P transaction, or it can be transferred through the donor's investment fund. Cryptocurrency donations are tax-deductible, in the same way as property, per guidance from the IRS, etc.
- Donate from your IRA – payment from the IRA (Individual Retirement Account), which is paid out directly from the donor's IRA to a qualified nonprofit organisation.
- Legacy/will – the donor makes a donation in his/her last will to a specific nonprofit organisation after his/her death.
- Donate your vehicle – donating a car to a charitable organisation. This can be done by contacting the organisation or by filling out an online donation form. The charitable organisation will arrange to collect the car or will ask the donor to deliver it to a specific place. However, the donor will get a receipt which can be used while filling out a tax return.
- Donate real estate – some nonprofit organisations accept donations of real estate, but transferring, managing and sale of real estate requires specialist skills, so not every organisation is ready to do it. Therefore, organisations prepared for this process provide detailed information and documents on their websites and ask donors to contact them. Some charitable organisations accept real estate donations with liabilities and use their know-how to resolve such issues. This instrument can also involve donating land to charity – i.e. it does not have to be a building.

- Donate by phone – transferring part or whole amount of payment for text messages to a specific nonprofit organisation under an agreement with the telecom operator.
- E-cheque – an electronic version of a paper cheque used for online payments. The specificity of the e-cheque lies in a specific type of electronic fund transfer for payment processing.

The website content analysis revealed the following methods of donation acquisition applied by the 100 largest Polish organisations:

- Traditional bank transfer – this involves making a bank transfer by the donor. The organisation's details are on its website, including the bank account number, to which a donor can make a transfer from his/her account – either online or at a bank branch.
- Online transfer – the transfer data are completed automatically, and the donor is guided step by step on his/her computer until the payment is effected.
- Tax return online – this mechanism involves a specially developed programme for filling out a tax return, available on the organisation's website. The programme helps one to prepare a tax return and automatically enters the organisation's details for transferring 1.5% of the personal income tax. The system is consistent with the current regulations of the "Polish Deal" [Polski Ład], and it contains a verifier of the entered data correctness. It also provides one with an Official Acknowledgement of Receipt.
- Donate by Facebook – one can make a donation through Facebook by means of a link on a nonprofit organisation's website. In this manner, one can give funds to the organisation directly from its website (by clicking the "Make a donation" button), or one can do it by joining the collection on Facebook.
- Subaccount – this enables an organisation to acquire financial resources from various sources but for a specific purpose, i.e. for a defined recipient, e.g. a sick child, an animal that needs help, or another purpose.
- Donate product – this instrument was presented with a description of the donation methods for American nonprofit organisations. It works in a similar manner in Polish organisations – this includes donations in kind, such as food, toys, equipment, etc.
- Transferring part of the funds during a purchase – a potential donor makes a purchase at a specific shop through an application, and part of the money is donated to a specific nonprofit organisation.
- Legacy/will – like in American organisations, there is an instruction (a form, a contact request, etc.) on making a donation of part of someone's financial or material property in the form of the will to enable the continued pursuit of the organisation's mission.
- Donation instead of gift – a suggestion that guests should support a specific nonprofit organisation instead of giving presents (e.g. flowers for a wedding or another ceremony). Proof of the support or a specific item brought to the event to pass it on to the organisation is a tangible effect of support.

- Donate by phone – this instrument was presented with donation methods for American nonprofit organisations. This kind of support is not basically different from the method used in the USA.
- Auctions – there are specific items sold and bought at auction, and the revenue is transferred to chosen nonprofit organisations. Nonprofit organisations can encourage others not only to take part in the bidding but also to join the action and to put up their own items for sale.
- Help platform – maintained by an external organisation, it allows a user to choose a social purpose or a nonprofit organisation that they want to support financially. After registering in the Portal, the platform operators verify the credibility of the donation receiver.

Table 1.
Ways of donating to the largest American and Polish nonprofits

No.	Donations - USA	Number of organizations	No.	Donations - Poland	Number of organizations
1.	Online transfer	95	1.	Traditional bank transfer	72
2.	Donate stock (and mutual funds)	55	2.	Online transfer	58
3.	Employee matching gifts	51	3.	Tax return online	48
4.	Planned giving	47	4.	Donate by Facebook	28
5.	Donor-Advised Fund	39	5.	Subaccount	27
6.	Donate product	37	6.	Donate product	22
7.	Donate by check (post, email)	32	7.	Transferring part of the money while shopping (e.g. Fanimani)	8
8.	Donate cryptocurrency	31	8.	Legacy/will	6
9.	Donate from your IRA	28	9.	Donation instead of gift	5
10.	Legacy/will	23	10.	Donate by phone	4
11.	Donate your vehicle	15	11.	Licytacje (np. Allegro Charity)	3
12.	Donate real estate	14	12.	Platforma pomocy (np.siepomaga.pl)	3
13.	Donate by phone	13			
14.	E-check	10			

Source: own elaboration.

A total of 100 largest American nonprofit organisations applied 14 methods of making donations – these methods appeared 490 times on the websites of nonprofit organisations, with the online transfer, donate stock and employee matching gifts appearing the most frequently. These methods appeared fewer times – 284 – in Polish organisations. Therefore, American organisations not only use more methods of giving donations, but they also do it more frequently – each mechanism was used 35 times on average in the case of American nonprofit organisations and fewer than 24 times in Polish ones.

4.2. Identification of similarities and differences in the donation-making methods

There may be some similarities between American and Polish nonprofit organisations, but differences in the methods of acquiring donations by entities in both countries prevail. Only four methods of making donations out of the 14 identified on the websites of American nonprofit organisations and 12 on those of Polish ones are used in both countries (Fig. 2).

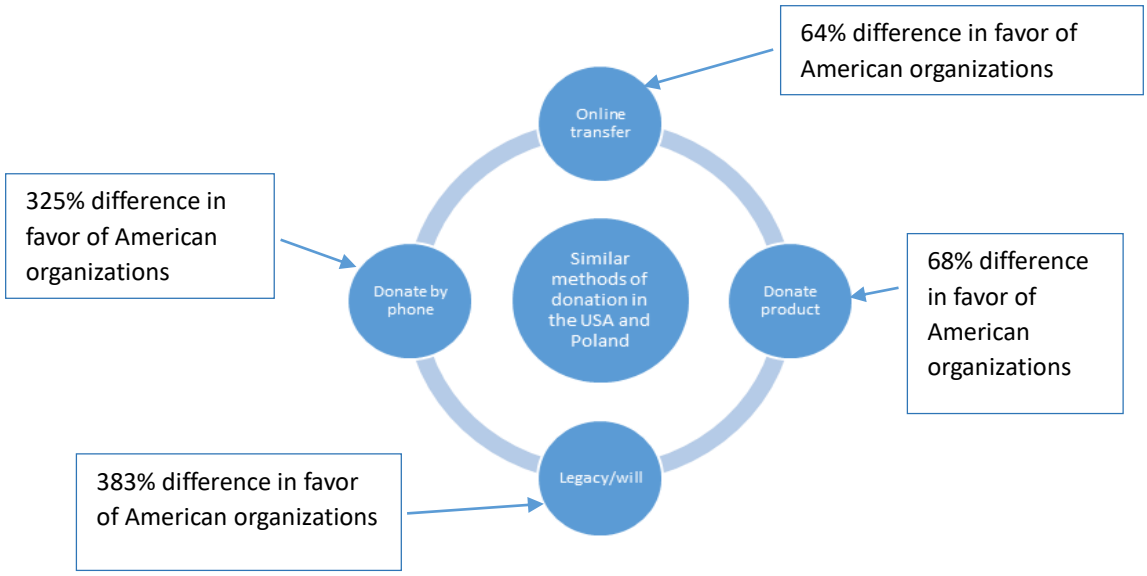

Figure 2. Methods of acquiring donations in the USA and in Poland – the similarities in both countries.

Source: own elaboration.

Online transfer is used more often by American organisations, but most of their Polish counterparts also use it. The "Donate product" mechanism is used more often by American organisations – more than one-third of the organisations propose this method of making donations, and one-fifth of Polish ones. American organisations propose a donation by phone more than three times more frequently, and the difference in the case of wills is even greater (this method is used by American organisations four times more frequently).

When it comes to the differences in the methods of acquiring donations proposed on the websites of organisations from both countries, ten mechanisms proposed by the American organisations are practically absent from the websites of their Polish counterparts, and eight mechanisms applied in Poland are not used by American organisations (Fig. 3).

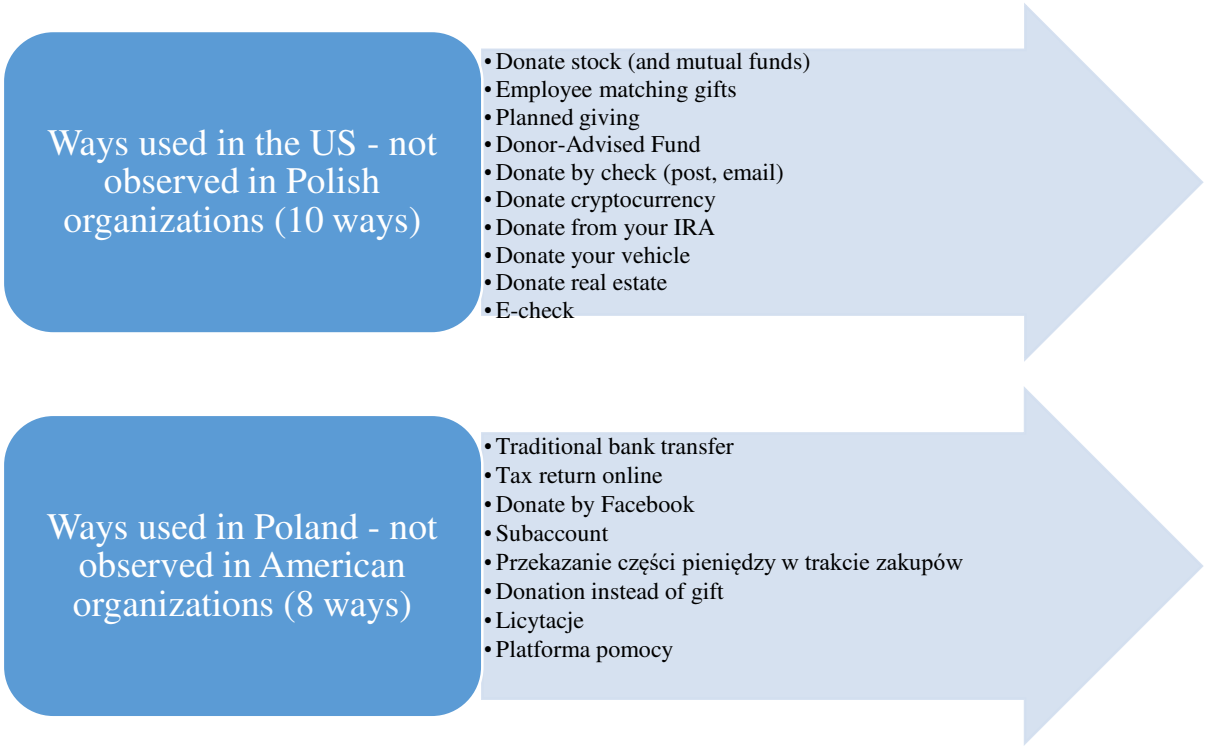

Figure 3. Methods of acquiring donations in the USA and in Poland – the differences in both countries.

Source: own elaboration.

The first example is the possibility of donating shares or other stock. The "Donate Stock" option is absent from the websites of the largest Polish organisations, whereas it is very popular in their American counterparts (i.e. it is used by most American organisations). It is similar to "Employee matching gifts" (over half of the American organisations offer this option) and "Planned giving" (it is used by nearly half of the organisations). The following are a little less popular in the USA: "Donate by check", "Donate cryptocurrency", and "Donate from your IRA" (these options are applied by nearly 30% of American organisations, but none in Poland). The less popular methods of acquiring donations, not applied in Poland, but offered by the largest American organisation, include: "Donate your vehicle", "Donate real estate" and "E-check".

Most of the methods of making donations proposed by Polish nonprofit organisations are not used in the USA. Providing the account number and details for a bank transfer is very popular in Poland. This is the method applied by most organisations – it is practically non-existent in the USA. Moreover, there are applications for filling out personal income tax returns, which automatically suggest a specific organisation as a beneficiary of a donation, which is non-existent in the USA. Notably, Polish websites frequently feature a donation button that facilitates contributions through Facebook, a feature not commonly seen in American organisations. Moreover, Polish organisations have also embraced distinct approaches such as the utilisation of a dedicated "Subaccount", Fanimani, and the "Donation instead of gift" concept—elements that are notably absent in their American counterparts.

4.3. The donation methods and the organisation's revenue

The largest American and Polish nonprofit organisations differ with respect to the revenue earned. When it comes to the American organisations, the smallest entity did not achieve even 1% of the revenue of the largest one, whereas the ratio was 3% in Poland (Tab. 2). On the other hand, the difference is much larger with respect to the private donations in Poland compared with the USA. The ratio of the smallest to the largest organisation is marginal (0.001%)[1], whereas it is nearly 5% in the USA.

Table 2.
Basic descriptive statistics of the examined quantitative variables for the 100 largest American and Polish organisations

Specification	M	Me	SD	Sk.	Kurt.	Min.	Max.
American nonprofit organizations (in millions of USD)							
Total revenue	1839,65	574,501	3510,860	4,160	20,281	141,879	23280,025
Private donations	588,530	372,000	608,845	3,183	12,465	181,045	4059,886
Polish nonprofit organizations (in millions of PLN)							
Total revenue	48,207	26,419	64,028	4,228	22,897	15,588	484,496
Private donations	*20,720*	2,404	*62,200*	*5,428*	*33,654*	*0,005*	*480,659*

M - mean; Me - median; SD - standard deviation; Sk. - skewness; Kurtosis - kurtosis; Min and Max - lowest and highest values of the distribution.

Source: own elaboration.

Polish and American organisations were divided into four groups – with the total revenue taken as the criterion. Given the applied methods for acquiring donations, the differences between Polish organisations are greater (taking into account the arithmetic average) than among their American counterparts. A particularly distinct difference is seen between the two smallest and the largest group in terms of revenue (the mean and the median differ by a factor of two). As has been noted, the differences are smaller in the USA (Tab. 3).

Table 3.
The number of methods for acquiring donations in American and Polish nonprofit organisations broken down into groups according to the revenue criterion

Groups*- total revenue (in USD)	**Number**	**M**	**Me**	**SD**	**Sk.**	**Kurt.**	**Min**	**Max**
	American nonprofit organizations							
Group 1 – under 250 mln	12	4,00	4,00	1,907	0,661	0,590	1	8
Group 2 – under 500 mln	32	4,41	4,50	2,982	0,785	0,557	1	13
Group 3 – under 1 mld	23	6,04	7,00	2,654	-0,563	-0,454	1	10
Group 4 – 1 mld and more	33	4,91	5,00	3,116	-0,29	-1,260	0	10
Total	100	4,90	5,00	2,894	0,193	-0,742	0	13
Groups*- total revenue (in PLN)	***Polish nonprofit organizations***							
Group 1 – under 20 mln	29	2,14	2,00	1,505	1,503	2,709	0	7
Group 2 – under 30 mln	32	2,31	2,00	1,554	0,414	-0,389	0	6

[1] Private donations in Polish organisations include – apart from donations from individuals and legal persons, as well as collections, bequests, etc. – revenue from 1.5% of personal income tax. Inclusion of this source among private ones may be debatable, because these funds come from a part of the income tax. However, it is taxpayers themselves who decide which organisations will receive part of the tax they pay. Therefore, whether a specific organisation will receive the funds depends on a private, autonomous decision of an individual. Moreover, there is fierce competition on the 1.5% market between public benefit organisations.

Cont. table 3.

Group 3 - under 40 mln	11	3,45	4,00	1,968	-0,398	-0,772	0	6
Group 4 – 40 mln and more	28	4,07	4,00	2,638	0,282	0,441	0	9
Total	100	2,88	2,00	2,095	0,888	0,576	0	9

M - mean; Me - median; SD - standard deviation; Sk. - skewness; Kurt. - kurtosis; Min and Max - lowest and highest values of the distribution.

Source: own elaboration.

In order to verify whether there is really a statistically significant difference between the number of applied donation methods and the organisation size measured by the total amount of revenue, Kruskal-Wallis tests were performed for four selected groups of American and Polish organisations (Tab. 4). The test ($\chi2(3) = 6.571$, $p = 0.087$) does not confirm a relationship between these parameters in the case of the American organisations. In contrast, the test ($\chi2(3) = 13.231$, $p = 0.004$) confirms this relationship for Polish organisations. This relationship can be attributed to the differences between the largest group of organisations in terms of revenues (i.e. those with revenues in excess of 40 million PLN) and the two smallest groups (with revenue under 20 million PLN and between 20 million PLN and 30 million PLN). Therefore, a group of the largest organisations isolated from the 100 ones under study offers much wider possibilities for donation-making methods than those with the lowest revenue among the first hundred Polish organisations. Therefore, hypothesis 1a should be rejected, and hypothesis 1b should be accepted.

Table 4.
Pair comparison regarding the methods for acquiring donations, broken down into groups according to the revenue criterion

Groups *	**Test statistic**	**Standard error**	**Standardized test statistic**	**Significance**	**Adjusted significance ****
	American nonprofit organizations				
1-2	-3,464	9,760	-0,355	0,723	1,000
1-3	-21,341	10,267	-2,078	0,038	0,226
1-4	-9,545	9,719	-0,982	0,326	1,000
2-3	-17,877	7,882	-2,268	0,023	0,140
2-4	-6,082	7,153	-0,850	0,395	1,000
3-4	-11,795	7,832	1,506	0,132	0,792
Groups *	***Polish nonprofit organizations***				
1-2	-3,356	7,327	-0,458	0,647	1,000
1-3	-20,193	10,119	-1,995	0,046	0,276
1-4	-23,823	7,572	-3,146	0,002	0,010
2-3	-16,837	9,988	-1,686	0,092	0,551
2-4	-20,467	7,395	-2,768	0,006	0,034
3-4	-3,630	10,169	-0,357	0,721	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: see Table X.
**Significance values for multiple tests were adjusted using the Bonferroni method.

Source: own elaboration.

A similar diversity is observed when only revenue from private donations is taken into consideration (and it does not matter whether those are donations from individuals or from other organisations, e.g. enterprises). Given the basic parameters of the descriptive statistics,

American organisations are not as diverse as their Polish counterparts (e.g. the mean or median is similar in all the isolated American groups, whereas the extreme means differ by the factor of four – Tab. 5).

Table 5.
The number of methods for acquiring donations in American and Polish nonprofit organisations broken down into groups according to private donations

Groups*- total revenue (in USD)	**Number**	**M**	**Me**	**SD**	**Sk.**	**Kurt.**	**Min**	**Max**
	American nonprofit organizzations							
Group 1 – under 250 mln	25	4,76	5,00	2,185	0,073	-0,661	1	9
Group 2 – under 500 mln	38	4,79	5,00	3,231	0,428	-0,613	1	13
Group 3 – under 1 milliard	24	5,00	5,00	3,093	-0,115	-1,196	0	10
Group 4 – 1 mld and more	13	5,31	5,00	2,955	-0,058	-1,010	1	10
Total	100	4,90	5,00	2,894	0,193	-0,742	0	13
Groups*- total revenue (in PLN)	*Polish nonprofit organizzations*							
Group 1 – under 100 tys.	19	1,05	1,00	0,780	-0,096	-1,271	0	2
Group 2 – under 1 mln	25	2,20	2,00	1,472	0,477	-0,797	0	5
Group 3 – under 10 mln	25	3,12	3,00	1,616	0,112	-1,022	1	6
Group 4 – 10 mln and more	31	4,23	4,00	2,390	0,466	-0,323	0	9
Total	100	2,84	2,00	2,083	0,909	0,630	0	9

M - mean; Me - median; SD - standard deviation; Sk. - skewness; Kurt. - kurtosis; Min and Max - lowest and highest values of the distribution.

Source: own elaboration.

As with the donation methods and the total revenue, tests were conducted to diagnose the relationship between the number of donation-making methods proposed on the websites of nonprofit organisations and the revenue earned from donations, but restricted to private sources. The results resemble those of the studying of a relationship between the number of donation methods offered by the organisations and their total revenue. This means that the test ($\chi2(3) = 0.541$, $p = 0.910$) conducted for American nonprofit organisations did not reveal any differences between individual groups. The same test ($\chi2(3) = 31.858$, $p < 0.01$) conducted for Polish organisations revealed a difference between groups. This applies to group 1 (with the lowest revenue from private donations) and groups 3 and 4 (Tab. 6) and between groups 2 and 4.

Table 6.
Pair comparison regarding the methods for acquiring donations, broken down into groups according to the revenue criterion

Groups *	**Test statistic**	**Standard error**	**Standardized test statistic**	**Significance**	**Adjusted significance ****
	American nonprofit organizations				
1-2	0,624	7,425	0,084	0,933	1,000
1-3	-2,579	8,240	-0,313	0,754	1,000
1-4	-5,523	9,859	-0,560	0,575	1,000
2-3	-3,203	7,518	-0,426	0,670	1,000
2-4	-6,147	9,264	-0,664	0,507	1,000
3-4	-2,944	9,929	-0,296	0,767	1,000

Cont. table 6.

Groups *	*Polish nonprofit organizations*				
1-2	-19,445	8,694	-2,237	0,025	0,152
1-3	-33,665	8,694	-3,872	<,001	0,001
1-4	-44,605	8,323	-5,359	<,001	0,000
2-3	-14,220	8,080	-1,760	0,078	0,470
2-4	-25,160	7,679	-3,277	0,001	0,006
3-4	-10,940	7,679	-1,425	0,154	0,925

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: see Table X.
**Significance values for multiple tests were adjusted using the Bonferroni method.

Source: own elaboration.

Therefore, as with the total revenue, hypothesis 2a should be rejected, and hypothesis 2b should be accepted.

5. Discussion

5.1. Strategic adaptation to the environment

The study revealed great differences in the methods of acquiring donations between American and Polish organisations. American organisations are more active in this regard (i.e. they use more methods of making donations than Polish ones). The differences regarding the donation-making methods offered on the websites have an economic and legal basis. For example, the specific construction of the American Individual Retirement Account – IRA, with its legal limits and tax issues, as well as the types of IRA (e.g. traditional IRA and ROTH IRA for individuals and SEP IRA and SIMPLE IRA for company owners and self-employed individuals), create different possibilities for donations than the Polish pension system. Likewise, "Planned giving" involves sophisticated financial planning that considers the donor's individual circumstances, American tax regulations, and more.

This works in the opposite direction as well, e.g. a unique Polish solution involves donating 1.5% of one's personal income tax. The mechanism does not exist in the USA, hence the differences in the applied donation methods. Therefore, the mechanism often used on the websites of Polish organisations (i.e. an application for filling out a personal income tax return, which takes into account the latest changes in the law and automatically enters the details of a specific organisation) is not applied in the USA. Donating shares and stock is another issue. Obviously, the stock market is much better developed in the USA than in Poland. However, besides the fact that many Americans own shares, stock donations are also popular in the USA because they entitle the donor to tax relief. Making a stock donation to a charitable cause entitles one to apply for tax relief in the amount of the full market value of the stock and to avoid payment of tax on capital gain on the value increase). Other options for making donations may

also seem slightly exotic to a European (especially a Pole). Europe and the USA are two different worlds when it comes to motor vehicles. Primarily, cars are cheaper in the USA than in Europe (the difference is even greater, e.g. in Poland, when the real income of an American is taken into account), which is why 320 million Americans own over 265 million cars. Therefore, donating a vehicle in the USA may resemble an ordinary "Donate product" and is easier than in Poland (Liczba samochodów na świecie [Number of cars worldwide], 2016). Moreover, the standardised reception of real estate (buildings, land) by several American organisations is an unusual solution from the Polish perspective.

Apart from economic aspects, an important role is played by cultural issues. The ubiquity of cars in the USA is even called the "car culture" (How The Automobile Shaped American Culture, 2022).

Moreover, interestingly, the websites of American nonprofit organisations inform about and facilitate donations in cryptocurrencies (one in three American organisations remind us about such a possibility – there are often even tabs with the names of various cryptocurrencies). Polish organisations' websites do not mention such a possibility. There is also synergy between various instruments. For example, "online transfer", as mentioned in this paper, refers to various systems of sending and receiving payments over the Internet. These include Google Pay, Apple Pay, Venmo, PayPal and other systems. PayPal included cryptocurrency payments in its offer, and this system is present on the websites of 65% of the American nonprofit organisations in the study but only 7% in Poland. The wide popularity of the "employee matching gifts" mechanism can be included among the social issues. As many as 65% of large companies and 28% of medium and small ones make use of this mechanism, with as many as 84% of donors claiming that they are more willing to make a donation if they know that their organisation is in this programme. This also applies to the donation amount (Starr, 2015, p. 6). Therefore, it is not surprising that most organisations adapted quickly to this by introducing solutions on their websites to facilitate applying the matching gifts option. Interestingly, the websites of American nonprofit organisations do not have a habit of providing their bank account number and other details necessary for donors to make a bank transfer on their own. Americans are known for their practicality and efficiency in many aspects of life. This may be the key to this mystery. In Poland, a traditional bank transfer is the option most often offered by nonprofit organisations, whereas Americans regard entering their bank websites, copying the account number and other details as too tedious and, above all, unnecessary when one can make an online transfer.

5.2. Diversity of the largest American and Polish nonprofit organisations

Differences in the methods and number of donation methods offered by the American and Polish nonprofit organisations are not the only differences that can be observed when comparing the organisations in both countries. American organisations can be seen to be more uniform in this regard. This is because most of the top 100 American nonprofit organisations

apply similar ways of giving. Even their websites are more standardised than their Polish counterparts. For example, the donate button is placed at the top of the page (on the right) on 89% of the websites, and it is properly highlighted – with a different colour than the background in 86% of them. There is usually a "Ways of giving" tab next to the donate button, and this is also repeated at the bottom of the page – on the site map. Therefore, the greater diversity among Polish nonprofit organisations should not be regarded as a positive thing. The majority of American organisations exhibit a high level of professionalism. Even among the smallest entities, revenues surpass 200 million USD (with only one reporting 142 million USD, another 195 million USD, and the next in line with the lowest revenue still reaching 223 million USD). Therefore, there is no place among the 100 largest American organisations for "rough websites and missed market opportunities". All the organisations are highly professionalised in terms of management and acquiring donations from individuals and enterprises. Hence, the Kruskal-Wallis test showed no differences in individual groups. The situation with Polish organisations is slightly different. As many as 27 organisations earn a total revenue under 20 million PLN (i.e. under 5 million USD). Obviously, this may be a lot, given the Polish conditions. However, considering the fact that this includes public sources (EU projects, central and local government subsidies, etc.), some organisations do not attach enough importance to professionalising various ways of giving (this also applies to Internet websites). Therefore, there are considerable differences between the largest and the smallest Polish organisations (despite the fact that they are among the 100 largest). Interestingly, earlier studies of Polish organisations (covering the financial data for 2019) did not reveal any differences in individual groups regarding the use of the methods of earning placed on the websites and the total revenue earned (Oliński, 2022) – although in some cases, the results were close to confirming the relationship. The study embraced a wider range – not only the methods of acquiring donations but also commercial sources, such as business activity, running an online shop, paid public benefit activity, etc. Nevertheless, an explanation of this may include increasingly difficult public financing – this was affected by many factors. Such factors may include the Covid-19 pandemic, stagnating financial cooperation between local government units and nonprofit organisations (Kaczmarczyk et al., 2021) and other difficulties in acquiring public financing. Apart from that, as was mentioned earlier, the analysed statistics included the revenue from the 1.5% write-off from the personal income tax. According to the data, 1% of public benefit organisations receive 70% of the money (Górka, Kwiatkowska, 2022). This further exacerbates the disparity between organisations. Revisiting the year 2019 once more, it is worth highlighting the validation of the affirmative correlation between the operational methods employed by the largest Polish public benefit organisations and the proportion of revenue sourced from private channels within their overall revenue structure (Oliński, 2022). This research underscores that by constraining private contributions, one can similarly establish such a connection at a discernible magnitude. This suggests that Polish organisations capable of aligning with donor preferences and offering diverse avenues for contribution reap tangible financial benefits from this practice.

6. Conclusions

An increasing number of nonprofit organisations seek to benefit from private donations when seeking higher financial stabilisation and independence from the public sector. The Internet is one of the methods of informing about the ways of giving and a channel through which funds can be donated. In general, the largest American nonprofit organisations offer more ways of donating funds for them from a website than their Polish counterparts. This applies both to the number of methods and the number of organisations using the specific methods. Of particular note is the strategic adaptation of American nonprofit organisations to the environment and preferences and the financial situation of potential donors. Creating the possibility of donating shares and other stock or cryptocurrencies is a tangible example of this. Apart from the higher professionalisation of American nonprofit organisations, their larger diversity regarding the number of ways of giving should be noted. They are differentiated by the area of activity and solving specific social issues rather than technical solutions and website design.

This paper is the first attempt at comparing the largest American and Polish nonprofit organisations in terms of total revenue with respect to the ways of giving in the online environment. This aspect reflects how specific organisations adapt to socioeconomic conditions and follow the technological progress in modern market economies. However, this paper has a restriction of being limited to the largest American and Polish nonprofit organisations (with the organisation size being defined only by one parameter: the revenue amount). Studies on representative samples, including all nonprofit organisations (small and medium-sized among them), can bring different results. Therefore, this issue should be scientifically explored in future. Furthermore, the investigation outlined in this paper is constrained to the analysis of organisations' websites. Subsequent research endeavours should encompass social media platforms as well in order to provide a comprehensive overview of the genuine engagement of nonprofit organisations within the online sphere with respect to securing funds from donors.

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"QUO VADIS" CAPITAL ADEQUACY? – REFLECTIONS ON CAPITAL ADEQUACY MANAGEMENT IN BANKS ACCORDING TO BASEL REGULATIONS

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Purpose: The main purpose of the article is to present the effects of implementing the capital requirements recommended by the Basel Committee on Banking Supervision by banks around the world. The main identified research area is the evolution of banks' capital adequacy according to the Basel standards, i.e. banks' possession of an appropriate level of loss-absorbing capital (Tier 1/CET1, Tier 2), presented as a percentage of their risk-weighted assets (RWAs).
Design/methodology/approach: The research process consisted of a theoretical and cognitive stage and verification of the collected quantitative data. As part of it, the literature review methodology was used, applied to books, scientific journals, as well as reports and studies prepared by the Basel Committee on Banking Supervision. Therefore, the use of the method of Polish- and foreign-language literature studies was of key importance in the writing of the article. The application of this method was the starting point for the further part of the research process, during which the method of graphical data presentation and analysis with elements of comparisons was used.
Findings: The aim of the Basel recommendations is to strengthen the global banking sector's ability to absorb the financial consequences of a rapid deterioration of its economic situation, regardless of the cause, and to reduce the risk of spreading the consequences from the banking sector to the real economy. The research results confirm a significant increase in the capital base as a result of the implementation of the Basel capital recommendations: banks in Europe, the Americas and the rest of the world strengthened their capital in the years 2011-2022, but the growth rate was not the same for each region and type of capital.
Originality/value: Due to the fact that the process of unifying capital requirements among banks operating in different countries of the world, originating from economies with different degrees of advancement, is a difficult and multi-stage task, there is a need to constantly monitor progress in this area. This article contributes to the assessment of the effectiveness of this process and is the foundation for further analyses of the effects and dynamics of the Basel III reforms.

Keywords: capital adequacy, risk-weighted assets, Basel Committee on Banking Supervision.

Category of the paper: General review.

1. Introduction

Banks are economic entities that play a special role in national economies. Banking institutions can be classified as financial intermediaries that deal with the allocation of surplus liquidity between entities. They accept deposits from over-liquid entities and provide these funds to deficit entities in the form of loans and credits, which is crucial for growth of economies in micro- and macro-scale. A logical consequence of the fact that banks and banking sectors play an extremely important role in national economies is that this issue is of interest to the public and professionals. These matters are presented in many studies devoted to the issues of banking business security, as well as in measurements and assessments of the effectiveness of banks (Kunz, Heitz, 2021; Birge, Judice, 2013; Balcerzak et al., 2017; Fethi, Pasiouras, 2010; Sáez-Fernández, Picazo-Tadeo, Jiménez-Hernández, 2021; Tan, Floros, 2013).

The major trends of the last few decades, such as competition intensified due to the globalization process, the global financial crisis of 2007-2008 and its long-term consequences (Amendola et al., 2021; Wolters, Barbosa Do Couto, Felício, 2014) have increased the pressure in the financial sector. They have eroded public confidence in the banking institution (Fungáčová, Kerola, Weill, 2021). They forced banks to reconsider the need to better manage their capital (Bitar et al., 2021), monitor their risk more closely (Tóth-Laufer, Takács, Rudas, 2015) and develop technically advanced solutions to ensure customer security (Maček et al., 2019). The turbulent changes in the economy, caused primarily by the Covid-19 pandemic, have intensified the interest in risk in banking activity even more, and in particular in having adequate capital to cover possible losses, which is the subject of this article (Borri, di Giorgio, 2021; Kaiser, 2021).

Paradoxically, the phenomena mentioned above are not new to the economy. However, the approach of supervisors to the speed of response to disturbances in banking activity has definitely changed. Until the 1970s, it was widely believed that national supervisors could unilaterally monitor the safety and health of banks without referring to emerging trends, such as globalization. However, the rapid market changes of this decade have made regulators aware of the growing interdependence of banks around the world and the declining effectiveness of national controls. The two major banking crises in 1974, the fall of Herstatt Bank in Germany and Franklin National Bank in New York, were decisive in bringing about a complete change in the attitudes of national banking supervisors (Rost, 2009). The global effects of the collapse of these entities made the regulators realize that the traditional approach to banking security had become insufficient. In direct response to bank failures, the central banks of the G10 countries and Switzerland established the Standing Committee on Banking Regulations and Supervisory Practices in 1974. In 1990, this body was renamed the Basel Committee on Banking Supervision. The initial goal of its activity was to address ad hoc problems that emerged as a result of the crisis on international financial markets, to develop

general principles of banking supervision and to improve contacts between banking supervisors. Soon, capital adequacy standards became an important area of regulation of the banking sector, the importance of which increased when the Basel Committee defined the minimum capital requirements for banks in 1988 (Basel I) (Jones, 2020; Newman, Posner, 2018). This institution successively continues to work on unifying capital standards in order to ensure uniformity and security in the operation of banks around the world and the role of capital structure became crucial in enterprise safety (Różański, Bogołębska, 2022).

2. From Basel I to Basel IV - capital adequacy evolution for better risk absorption

The primary function of capital is to support the bank’s operations, to act as a cushion to absorb unexpected losses and asset drops that might otherwise cause the bank to fail, and to protect depositors and debt holders in the event of the bank liquidation (Lesambo, 2020). This assumption is related to two aspects of the operation of banks: the bank’s possession of a minimum level of own funds to support their activity and the adequacy of these funds to the level of risk.

Regulation of the level of equity in the form of minimum capital requirements is a common instrument used by banking regulators around the world. In the 1970s, in order to reduce the likelihood of financial failure, banking regulators required banks to hold a certain amount of equity measured as a percentage of their assets (International Monetary Fund, 2008). However, this solution turned out to be insufficient, which was confirmed, among others, by the crisis of savings and loan associations in the United States in 1989, related to the real estate market (Dorsey, Rockwell, 2018). The cause of this state of affairs was observed, among others, by Laeven and Valencia (Laeven, Valencia, 2013) who pointed out that advanced and emerging economies usually experienced greater losses in production than developing economies. Kroszner, Laeven, and Klingebiel suggest that these larger production losses are driven to some extent by deeper banking systems, making the banking crisis more destructive (Kroszner, Laeven, Klingebiel, 2007). As a consequence of the aforementioned crisis in the USA and its echoes around the world, an attempt was made to link capital requirements with assets exposed to banking risk. The result of these works was the first agreement on minimum capital requirements for banks, the so-called “Basel I”, which was concluded in 1988 (Basel Committee on Banking Supervision, 1988). It was addressed mainly to institutions operating internationally and had no legal force, but that did not prevent its propagation, or the enforcement of the recommendations, as it was commonly introduced into the applicable law by most countries in the world, in a manner specific to local banking and legal systems. The main idea of these regulations was for the bank to maintain an appropriate minimum ratio

of capital (mainly own funds) to risk-weighted assets (RWAs) at a level of 8%. Risk weights were assigned depending on the type of the debtor's exposure and belonging to a specific class of entities and the collateral held for this exposure.

Further changes were brought about by the collapse of the English Barrings Bank (Kunz, Heitz, 2021) as a result of unauthorized transactions contracted by one of its employees, which became a catalyst for a complete reconstruction of the applicable standards and creation of a comprehensive solution in the field of capital standards and bank risk management, taking into account a new type of risk – the operating risk (Basel Committee on Banking Supervision, 2001). The New Capital Accord (Basel II) was a revised version of the 1988 Capital Accord. It was published in 2004 and concerned the structure of assessing the capital adequacy of financial institutions (Basel Committee on Banking Supervision, 2004).

The structure of the new standards was based on three complementary pillars:

- Pillar 1: the minimum capital requirement;
- Pillar 2: the internal capital assessment process (ICAAP) and the supervisory review and evaluation process (SREP);
- Pillar 3: the obligation for banks to publish qualitative and quantitative information on capital adequacy, intended to eliminate asymmetry of information between market participants.

The first pillar (the minimum capital requirement) included the sum of capital requirements for credit, operational and market risks. In addition, the existing methods of determining the capital requirement for credit risk were modified. The method based on the appropriate classification of exposures to which fixed risk weights had been hitherto assigned, the so-called standardized approach, was improved by making the risk weights dependent on the ratings from recognized rating agencies. It was also allowed to use, after obtaining the consent of the competent supervisor, the so-called Internal Ratings Based Approach (IRBA), which was mainly based on internal estimates of the characteristics of credit exposures – the probability of default (PD), the exposure at default (EAD) and the percentage of loss in the exposure (loss given default, LGD). Among the methods of determining the capital requirement for operational risk, two simple methods based on ratios built on the bank's average financial results were introduced - the Basic Indicator Approach (BIA), the Standardized Approach (STA) and one more complicated - the Advanced Measurement Approach (AMA). The methods of determining the capital requirement for market risk have remained practically unchanged.

Despite a significant improvement of the prudential regime, introducing risk management standards and rules for setting capital requirements more correlated with the risk actually incurred by banks, and self-imposed market discipline requirements, Basel II did not prevent perturbations accompanying the financial crisis that began in 2007-2008. In response to these events, the Basel Committee prepared and published in December 2009 the first consultation documents on changes to the New Capital Accord (Basel Committee on Banking Supervision,

2009a, 2009b) which a year later, after the completion of public consultations and approval by the G20 countries, formed the text of new regulations referred to as "Basel III" (Basel Committee on Banking Supervision, 2010). The third part of the Basel Accords was aimed at strengthening banks' capital requirements by increasing liquidity and reducing leverage.

However, as noted by Huang (Huang, 2021) and Hoenig (Hoenig, 2012), the strengthening of the requirements was to be associated primarily with the increased capital burden incurred by banks around the world. Basel III required banks to have enough capital to cover unexpected losses and remain solvent in the event of a crisis. This rule was expressed as a percentage of risk-weighted assets (RWAs). The more risky the assets, the more capital the bank would be required to have. Depending on its quality and riskiness, the capital was divided into categories shown in Figure 1. According to the division, Tier 1 capital is used to cover losses in the solvent state of the bank. It allows the bank to continue its normal operations and ensures its liquidity. The qualitatively best Tier 1 capital is usually called "common equity Tier 1" (CET1). Tier 2 capital is used to cover losses in the event of the bank's insolvency. It allows the bank to repay depositors and preferred creditors when the bank becomes insolvent. The total capital that banks and investment companies are required to hold should be at least 8% of their risk-weighted assets. Of this, capital of the highest quality (common equity Tier 1) should correspond to 4.5% of the risk-weighted assets. In addition to the mandatory 4.5% common equity Tier 1, all banks must have a capital conservation buffer and a countercyclical capital buffer, i.e. they must accumulate enough equity in good times to absorb losses during a crisis.

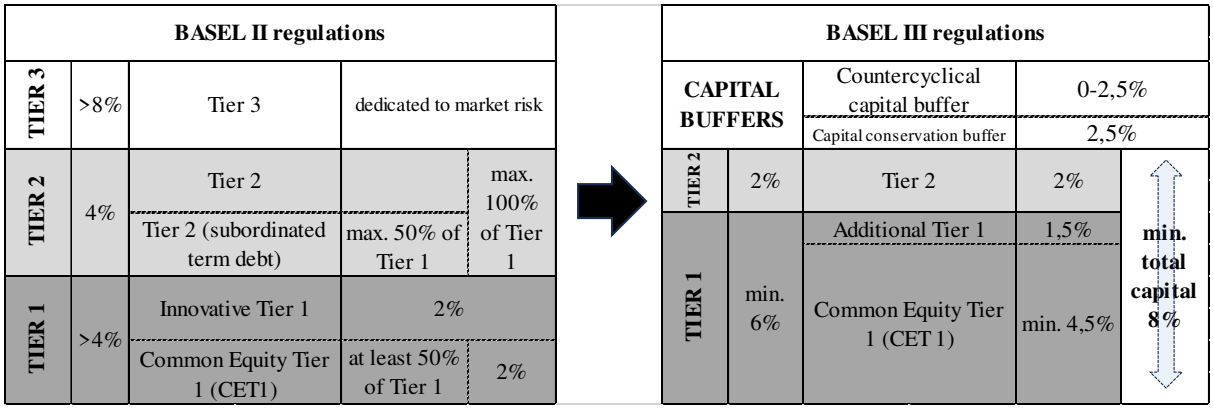


Figure 1. Evolution of capital structure under Basel II and Basel III.

Source: own elaboration on the basis of (Fereira, Jenkinson, Wilson, 2019).

Basel III has no "Tier 3" category, i.e. "short-term capital", and the "common Tier 1" category introduced a differentiation into the so-called "common equity Tier 1" (CET1), meaning equity from the issuance of ordinary shares and retained earnings, and "Additional Tier 1" meaning equity from the issuance of preferred shares and bonds without maturity dates (perpetuals). Tier 2 capital, i.e. subordinated debt, is still acceptable, but taking into account the fact that capital buffers may only be created from CET1, its importance is likely to be marginalized. The data summarized in Table 1 show a gradual increase in the minimum levels

of the indicators assumed by Basel III, starting from 2013. A particularly strong growth can be observed in the case of the share of capital of the first category in total capital. The table also includes the conservation buffer, which was increased by 0.625 pp from 2016 to its final value of 2.5% in 2019. This buffer consists of only the highest quality capital, i.e. CET1. Since 2019, a countercyclical buffer has also been in force, ranging from 0 to 2.5% of share capital or other capital capable of absorbing losses according to national regulations (Magdoń, 2015).

Table 1.
Basel III minimal capital requirements (as percentage of RWAs)

Phase* / Capital ratio	2013	2014	2015	2016	2017	2018	as of 2019
Minimum CET1 ratio (Common Equity Tier 1)	3.5%	4.0%	4.5%				4.5%
Capital conservation buffer	-	-	-	0.625%	1.25%	1.875%	2.5%
Countercyclical capital buffer	-	-	-	-	-	-	0-2,5%
Minimum Tier 1 capital	4.5%	5.5%	6.0%				6.0%
Minimum total capital	8.0%						8.0%
Minimum total capital plus capital conservation buffer	8.0%			8.625%	9.25%	9.875%	10.5%

* - all dates are as of 1 January.

Source: own elaboration on the basis of (Basel Committee on Banking Supervision, 2010).

Basel III was supposed to be introduced between 2013 and 2015, but its full implementation was extended several times in the wake of the Covid-19 pandemic – initially until January 1, 2022, then until January 1, 2023, and again, with transitional arrangements, until January 2028 (Mérő, 2021). The need for the extension also resulted from the introduction by the Basel Committee in December 2017 of the so-called "post-crisis reforms" which are unofficially considered Basel IV standards (Basel Committee on Banking Supervision, 2017). They were introduced to standardize the calculation of risk-weighted assets (RWAs) in order to provide greater transparency in the disclosure of regulatory capital and comparable capital ratios by banks. In practice, this meant the obligation to significantly increase capital and is treated in the literature as the next stage of securing capital adequacy of the banking sector (Basel IV) (Bodellini, 2019).

The need for banks to obtain capital of the highest quality will mean that the coming years may lead to further share issues or to limiting the scope of operations in order to reduce the off-balance sheet risk-weighted assets and liabilities. Due to the low pace of economic growth, it may be difficult to improve the capital position of banks, as it is recommended to accumulate assets for capital buffers, among others, in times of economic prosperity (Berger, Bouwman, 2013; Oyetade, Obalade, Muzindutsi, 2021).

The scope of the Basel III arrangements became the basis for examining their potential impact on the banking sector in many countries and the inspiration for the work on this article.

3. Analysis of capital adequacy of international banking sector after Basel III implementation

3.1. Data and methodology

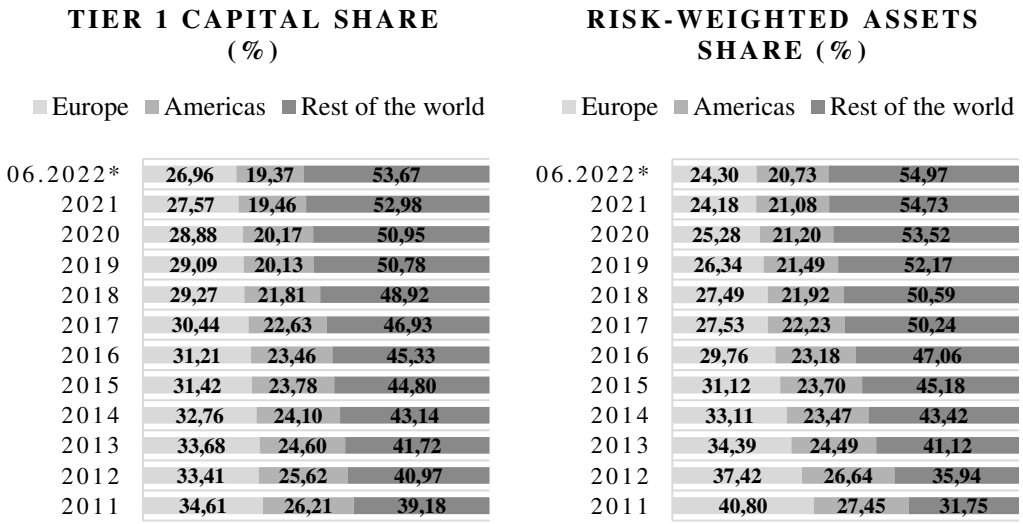
In order to assess the impact of the framework of the currently applicable capital standards (Basel III) on the capital adequacy of banks, the analysis used data collected by the Basel Committee on Banking Supervision as at June 30, 2022 (other data, starting from 2011, present the situation as at the end of December each year). The data was collected for 180 banks based on information provided by the banks and their national supervisory authorities and structured according to the following breakdown adopted by the Basel Committee:

- Group 1: 114 large international banks with Tier 1 capital exceeding the equivalent of EUR 3 billion at the reporting date, including 30 G-SIBs, i.e. global systemically important banks;
- Group 2: 66 other banks.

For the purposes of the empirical part of the article, data concerning only Tier 1 capital (including CET1), Tier 2 capital and risk-weighted assets (RWAs) were selected and systematized according to the geographical criterion dividing banks according to origin into three groups: European, South and North American, Others. Where the geographical breakdown was not possible to analyze for the entire research group, the results for Group 1 were used as the most representative due to the 97.53% share of this group in Tier 1 capital and 97.95% share of risk-weighted assets in the entire research group. On this basis, the process of adjusting the capital requirements of banks in the world to the Basel standards in the evolutionary dimension was assessed. For this purpose, the method of graphical presentation of the results and the synthesis of conclusions were used.

3.2. Results and discussion

At the outset, the share of banks from the three world regions in the level of Tier 1 capital and risk-weighted assets held was assessed. Figure 2 shows the share of Group 1 banks, broken down into Europe, both Americas and other countries, in Tier 1 capital and RWAs in the years 2011-2022. There are notable trends of reduction the share of Tier 1 capital in Europe and both Americas, and of increase of the share in the rest of the world. From the end of 2011 to June 2022, the share of European banks in Tier 1 capital decreased by 7.65 pp to 26.96% and by 16.5 pp to 24.30% in terms of RWAs. The Americas' share in Tier 1 capital decreased by 6.84 pp to 19.37%, while the share of RWAs decreased by 6.72 pp to 20.73%. At the same time, the share of banks from the rest of the world increased. The share of Tier 1 capital in this area increased to 53.67%, i.e. by 15.49 pp, and the percentage of RWAs in 2022 was close to 55% of the RWAs in Group 1 banks, which represented an increase in the share by 23.22 pp.



* - all years are as of 31 December except 2022.

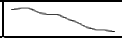
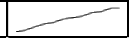
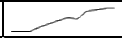
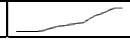
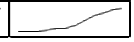
Figure 2. The share of banking Tier 1 capital and risk-weighted assets by regions over time.

Source: own elaboration on the basis of (Basel Committee on Banking Supervision, 2023).

Table 2 presents the evolution of the most important capital components of banks regulated by Basel III. As shown earlier in Table 1, most changes in capital ratios were to be implemented by the end of 2018, so it was important to examine how banks coped with this task. The analysis of Table 2 confirms the increase in capital base: banks in Europe, the Americas and the rest of the world significantly strengthened their capital, but the growth was not the same for each region. Since the end of 2011, the best-quality CET1 capital of European banks has increased by nearly EUR 469 billion, of American banks by EUR 301 billion and of the rest of the world's banks by EUR 1,491.5 billion (as at the end of December 2021). In the case of European banks, the increase in the absolute value of CET1 capital did not go hand in hand with the increase in the importance of this capital in the total of Tier 1 and Tier 2 capital. The share of CET1 in the capital structure has been decreasing cyclically and reached the smallest percentage in 2016, in favor of the additional Tier 1 and Tier 2 capital. Although CET1 in the rest of the world was almost three times higher at the end of 2021 than in 2011, the growth in Europe and both Americas was more smaller: 71.10% and 70.01%, respectively.

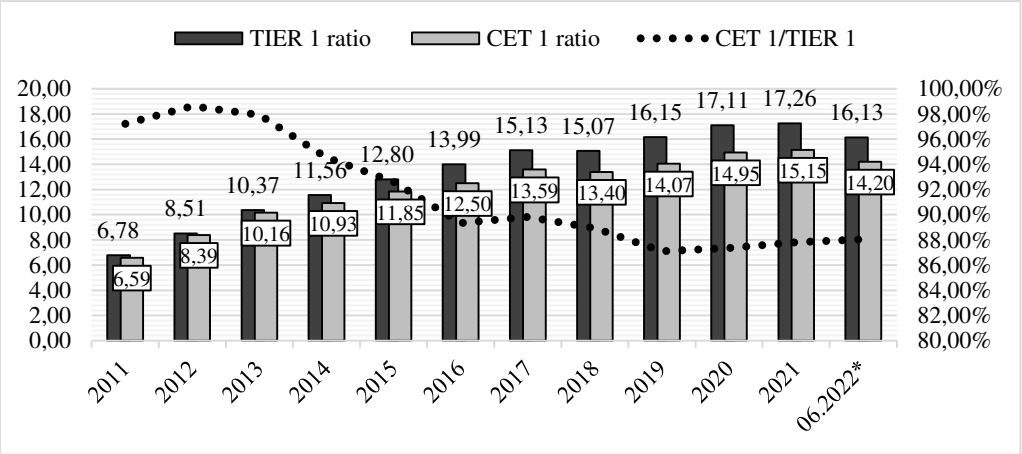
Additional Tier 1 capital showed some initial declines in 2011-2013 in Europe and the Americas, and a slight increase in the rest of the world. The increase in additional Tier 1 capital in the following years was more modest in Europe, and especially in US banks. A definitely opposite trend could be observed in the rest of the world's banks, where the value of this capital increased 39 times. However, when measuring the importance of additional Tier 1 capital in the total capital of all the banks, it has a share of about 10%. Tier 2 capital stock has increased from the baseline date of end-2011 for all banks except the Americas. This region saw a decline between 2011 and 2014, followed by a slight increase later on. Since the end of December 2021, only the rest of the world saw an increase in the share of Tier 2 (by EUR 37.8 billion), while Tier 2 capital of banks slightly decreased in Europe and the Americas.

Table 2.
Evolution of the Basel III capital components by regions over time

	Europe								
	CET1 (EUR bn)	Share in total Tier 1 + Tier 2	Change (2011=100)	**Add. Tier 1 (EUR bn)**	Share in total Tier 1 + Tier 2	Change (2011=100)	**Tier 2 (EUR bn)**	Share in total Tier 1 + Tier 2	Change (2011=100)
2011	**700,79**	87,43%	100,00%	**20,09**	2,51%	100,00%	**80,71**	10,07%	100,00%
2012	**782,01**	88,65%	111,59%	**10,98**	1,24%	54,65%	**89,14**	10,11%	110,45%
2013	**882,46**	83,66%	125,92%	**18,56**	1,76%	92,40%	**153,75**	14,58%	190,50%
2014	**947,08**	80,27%	135,15%	**54,48**	4,62%	271,22%	**178,30**	15,11%	220,92%
2015	**986,94**	77,14%	140,83%	**78,79**	6,16%	392,23%	**213,72**	16,70%	264,80%
2016	**1014,87**	72,73%	144,82%	**121,26**	8,69%	603,66%	**259,24**	18,58%	321,20%
2017	**1050,28**	76,10%	149,87%	**119,04**	8,63%	592,58%	**210,77**	15,27%	261,14%
2018	**1046,78**	74,98%	149,37%	**130,36**	9,34%	648,96%	**218,85**	15,68%	271,16%
2019	**1098,66**	74,05%	156,77%	**162,87**	10,98%	810,77%	**222,06**	14,97%	275,13%
2020	**1171,90**	75,11%	167,23%	**169,47**	10,86%	843,66%	**218,95**	14,03%	271,28%
2021	**1199,08**	76,21%	171,10%	**166,49**	10,58%	828,83%	**207,84**	13,21%	257,51%
06.2022*	**1169,76**	76,26%	166,92%	**158,89**	10,36%	790,98%	**205,34**	13,39%	254,41%
Trend line									
	Americas								
	CET1 (EUR bn)	Share in total Tier 1 + Tier 2	Change (2011=100)	**Add. Tier 1 (EUR bn)**	Share in total Tier 1 + Tier 2	Change (2011=100)	**Tier 2 (EUR bn)**	Share in total Tier 1 + Tier 2	Change (2011=100)
2011	**447,64**	69,24%	100,00%	**41,26**	6,38%	100,00%	**157,64**	24,38%	100,00%
2012	**506,93**	75,68%	113,25%	**38,74**	5,78%	93,88%	**124,12**	18,53%	78,73%
2013	**547,73**	79,18%	122,36%	**45,00**	6,51%	109,06%	**99,01**	14,31%	62,81%
2014	**595,44**	78,35%	133,02%	**66,18**	8,71%	160,39%	**98,33**	12,94%	62,37%
2015	**638,59**	76,62%	142,66%	**84,04**	10,08%	203,66%	**110,86**	13,30%	70,32%
2016	**666,22**	76,14%	148,83%	**95,15**	10,88%	230,59%	**113,57**	12,98%	72,04%
2017	**682,02**	76,13%	152,36%	**96,45**	10,77%	233,74%	**117,41**	13,11%	74,48%
2018	**685,07**	76,24%	153,04%	**96,49**	10,74%	233,83%	**117,03**	13,02%	74,23%
2019	**688,03**	76,48%	153,70%	**94,74**	10,53%	229,59%	**116,81**	12,99%	74,10%
2020	**743,60**	76,86%	166,12%	**101,68**	10,51%	246,40%	**122,22**	12,63%	77,53%
2021	**761,04**	77,91%	170,01%	**102,20**	10,46%	247,69%	**113,53**	11,62%	72,02%
06.2022*	**748,77**	77,44%	167,27%	**106,02**	10,97%	256,94%	**112,11**	11,59%	71,11%
Trend line									
	Rest of the world								
	CET1 (EUR bn)	Share in total Tier 1 + Tier 2	Change (2011=100)	**Add. Tier 1 (EUR bn)**	Share in total Tier 1 + Tier 2	Change (2011=100)	**Tier 2 (EUR bn)**	Share in total Tier 1 + Tier 2	Change (2011=100)
2011	**817,44**	91,54%	100,00%	**7,68**	0,86%	100,00%	**67,82**	7,60%	100,00%
2012	**970,88**	92,95%	118,77%	**4,40**	0,42%	57,38%	**69,25**	6,63%	102,10%
2013	**1114,23**	92,00%	136,31%	**8,39**	0,69%	109,26%	**88,53**	7,31%	130,52%
2014	**1281,20**	89,02%	156,73%	**33,00**	2,29%	429,87%	**125,01**	8,69%	184,32%
2015	**1459,76**	87,45%	178,58%	**61,96**	3,71%	807,21%	**147,48**	8,84%	217,45%
2016	**1561,04**	87,65%	190,97%	**83,60**	4,69%	1089,15%	**136,34**	7,66%	201,03%
2017	**1688,42**	83,99%	206,55%	**111,35**	5,54%	1450,61%	**210,44**	10,47%	310,27%
2018	**1829,19**	81,42%	223,77%	**122,97**	5,47%	1602,03%	**294,35**	13,10%	433,99%
2019	**1968,56**	76,48%	240,82%	**203,49**	7,91%	2650,99%	**401,83**	15,61%	592,46%
2020	**2102,67**	75,08%	257,23%	**245,40**	8,76%	3196,94%	**452,67**	16,16%	667,42%
2021	**2314,33**	73,88%	283,12%	**292,26**	9,33%	3807,46%	**525,91**	16,79%	775,41%
06.2022*	**2308,93**	72,73%	282,46%	**301,83**	9,51%	3932,21%	**563,72**	17,76%	831,15%
Trend line									

Source: own elaboration on the basis of the Basel Committee on Banking Supervision data.

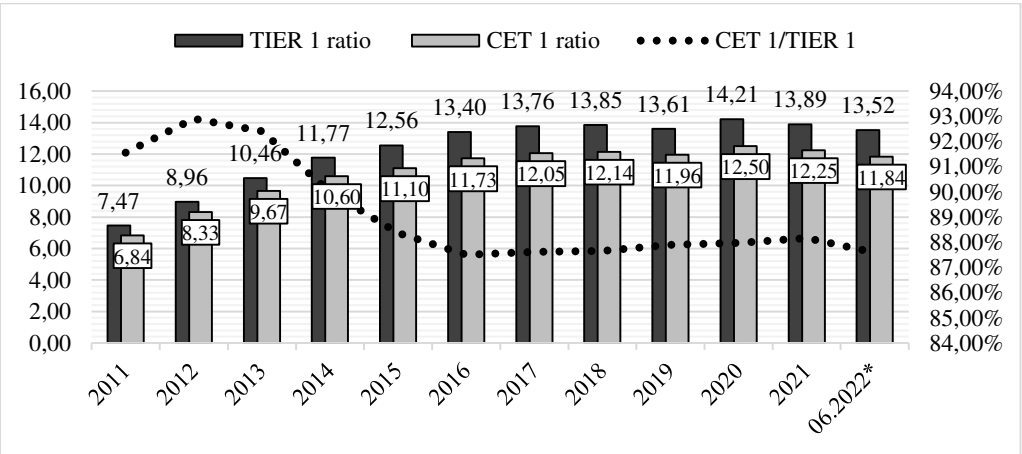
Basel III obligated banks to increase their capital reserves for protection against potential threats. Capital ratios, including Tier 1 "common capital" ratio and the highest quality CET1 ratio, are used to assess whether a bank has sufficient capital. CET1 is defined in banking regulations as capital of the highest quality. The Tier 1 (CET1) ratio shows the relationship between Tier 1 capital (CET1) and the bank's risk-weighted assets (RWAs). Risk-weighted assets are assets rescaled by the degree of risk associated with them, giving a total picture of the risk burdening the bank's portfolio. The Tier 1 (CET1) ratio increases when capital increases or when the value of risk-weighted assets decreases. An increase in capital may result, for example, from the issuance of new shares by the bank or from withholding the distribution of profits, and a decrease in risk may be a consequence of the sale of assets or replacing them with less risky ones. Figures 3-5 present the ratio of total Tier 1 and CET1 capital to RWAs and the percentage share of CET1 capital of the highest quality in common equity Tier 1 in the years 2011-2022.



* - all years are as of 31 December except 2022.

Figure 3. Basel III Tier 1 and CET1 ratios of European banks over time.

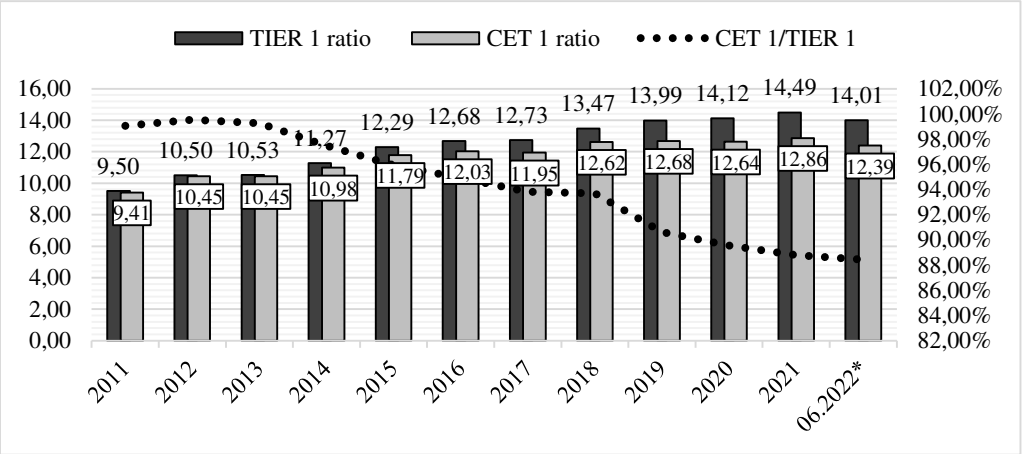
Source: own elaboration on the basis of (Basel Committee on Banking Supervision, 2023).



* - all years are as of 31 December except 2022.

Figure 4. Basel III Tier 1 and CET1 ratios of Americas' banks over time.

Source: own elaboration on the basis of (Basel Committee on Banking Supervision, 2023).



* - all years are as of 31 December except 2022

Figure 5. Basel III Tier 1 and CET1 ratios of other regions' banks over time.

Source: own elaboration on the basis of (Basel Committee on Banking Supervision, 2023).

In 2011, initial Tier 1 capital ratios were more than 2 pp lower in the Americas and Europe than in the rest of the world. However, capital ratios increased in Europe and the Americas more than in the rest of the world. As a result, the original situation reversed around 2014, when European and American banks started to have higher average core capital than banks in the rest of the world. In 2019, the capital ratios in the Americas decreased, becoming aligned with the capital ratios in other countries (outside Europe). Since then, the average Tier 1 starting capital ratio in the Americas has been close to that in the rest of the world. According to the report of the Basel Committee (Basel III Monitoring Report, 2022), the fluctuations in the value of the ratios are due to uneven changes in the level of Tier 1 capital and RWAs. A certain stabilization of the level of capital ratios in European banks can be seen in 2017-2018, and their slight decrease at the end of 2018, i.e. during the period of partial implementation of the Basel III provisions. The analysis of the data also shows that the Covid-19 pandemic did not radically affect the capital performance of banks – only American banks recorded a decrease in capital ratios in 2020-2022. A uniform trend since 2012 for all the banks has been the successive reduction of the share of CET1 capital of the highest quality in Tier 1 capital. This ratio dropped sharply in European and American banks (moderately in other banks) until 2016, but finally, in mid-2022, all banks maintained the percentage of CET1 capital in Tier 1 at around 88%.

4. Conclusion

The disturbances in the financial stability of the banks in the 1990s and earlier, as well as the experience of the financial crisis of 2008, have shown that the availability of broadly understood "capital" for banking activity is insufficient. This capital must be of appropriate quality, i.e. it is to provide security not only in the situation of the bank's normal operation,

but also (and even above all) it is supposed to absorb losses that the bank does not expect or expects as minimally probable for various reasons.

On December 7, 2017, the Group of Central Bank Governors and Heads of Supervision (GHOS) finalized the Basel III reforms, adding a number of changes aimed at restoring the shattered credibility in the calculation of RWAs and capital ratios of banks. Banks were obliged to maintain common equity Tier 1 ratios (including the CET1 capital of the highest quality), Tier 2 capital and total capital within the agreed minimum proportions. In addition, it was expected that banks would accumulate higher capital in good times, which they would be able to use in the event of losses (capital buffers). In addition, further, even higher capital requirements were imposed on banks recognized as globally and systemically important.

This study uses data collected by the Basel Committee on Banking Supervision for the years 2011-2022, on the basis of which it was assessed how the process of ensuring capital adequacy was carried out by banks around the world. The results confirm an approximately 67% increase in CET1 among European and American banks and an almost 3-fold increase among banks in the rest of the world. European banks consistently maintain the highest CET1 (as well as Tier 1) capital ratio. This state of affairs allows us to draw certain conclusions that may become a basis for further research. Banks' adaptation to the new regulatory requirements will require banks to choose one of the two most obvious solutions resulting from the construction of the numerator and denominator of capital ratios. The first one means increasing own funds by issuing shares. Equity is the most expensive source of financing for banks, by definition "condemned" to absorb unexpected losses. For this reason, investors expect a higher risk premium in the form of capital appreciation or an attractive dividend rate, which is not conducive to the return on capital of the banking sector - low prices imply weak demand from investors. The second way is to reduce risk-weighted assets, which in turn means a reduction in the money supply and the side effect of slowing down economic growth. In practice, this means a significant reduction in the lending activity of banks, resulting from the need to meet higher capital and liquidity requirements, and the possibility of an increase in the cost of money as a result of limiting its supply. Both solutions are bad and the only advantage is the fact that the implementation of the new requirements will take place gradually over a period of several years, and therefore these changes should not pose a threat to the banking sector and world economies.

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USING DEA AS THE BASIS FOR STRATEGY IN MAKING DECISIONS IN A COLLABORATIVE SITUATION

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Purpose: The aim of the article is the implementation of DEA in the building trade and the identification of effective and ineffective entities operating in this industry in the context for strategy of making decisions on cooperation.
Design/methodology/approach: The article presents the author's own research. The time horizon of the research is 2018 - 2022. Within this period, the following were specified: the period of boom and collapse in the building industry. Periods of boom and bust were determined on the basis of the indicator of the general economic climate in the construction industry. This indicator is calculated as the arithmetic average of simple indicators relating to the current and expected general economic situation of the company and takes values from -100 to 100. The research sample includes 25 organizations operating in the construction industry and the construction sector. These entities are listed on the Stock Exchange.
Findings: Identification of effective and ineffective entities operating in this industry can be a kind of signpost for orientation as to the strategy of making decisions on cooperation
Originality/value: In the Polish literature, there is a deficit of studies in the field of management and economics, the subjective scope of which is focused on construction companies. Most of the literature is focused on legal and technical issues. The management domain is relatively neglected.

Keywords: DEA, building industry, strategy.

Category of the paper: Research paper.

1. Introduction

The aim of the article is the implementation of DEA in the building trade and the identification of effective and ineffective entities operating in this industry in the context for strategy of making decisions on cooperation.

The choice of the organization of the construction industry was justified by the fact that according to Córdova and Alberto the construction industry is one of the main actors in the economy of developing countries. In those countries, a significant housing deficit is evidenced

and it is common that their countries create policies including direct budget appropriations or financing through financial institutions that tend to boost the construction industry, thus generating employment sources and an important movement of domestic raw materials (Còrdova, Alberto, 2018).

DEA calculates the efficiency of an organisation within a group relative to observed best practice within that group. The organisations can be whole agencies (for example, Departments of Health), separate entities within the agency (for example, hospitals) or disaggregated business units within the separate entities (for example, wards) (Steering Committee for the Review of Commonwealth/State Service Provision, 1997).

The DEA analysis in the construction industry has had many applications in different industrial sectors (Còrdova, Alberto, 2018). Specifically, in the construction sector, there are important contributions that have considered several variables for efficiency assessment and the creation of a business ranking.

Many studies have worked with data from the Asian region, where there is a close relationship between the domestic product and the growth of the construction sector (Chau et al., 2005; Chen, Tang, 2014; Dzeng, Wu, 2013; Devicenzi et al., 2015). Other important studies were developed in Italy, Greece, Portugal, and Jordan (Guerrini et al., 2013; Tsolas, 2011; Horta et al., 2010; El-Mashaleh et al., 2010).

Most aforementioned studies consider sales in their respective currency unit to be a production variable, and the work valued at money or number of employees according to the availability of information, equipment or technology, consumption of materials and certain intermediate resources are mainly considered to be factors or consumed resources. Some studies investigate in the following stage, the explanatory factors of the efficiency indices calculated, which are evaluated through correlations between the efficiency and technical and financial data. This is the case of (Moreno et al., 2014), who applied a three-stage model and established through a Tobit-type regression certain efficiency determinants; or the study of (De Araujo et al., 2012), who related the efficiency calculated with the volume of revenue. J. Lehtinen and T. Ahola noted that performance measures support the implementation of the organization's strategy (Lehtinen, Ahola, 2010).

In the Polish literature, there is a deficit of studies in the field of management and economics, the subjective scope of which is focused on construction companies.

2. Characteristics of empirical research

Empirical research was carried out in the period June 2022 - February 2023.

The aim of the research was to identify effective leadership from the perspective of external and internal clients in favorable and unfavorable conditions.

The aim of the research is to use DEA in the building industry and to identify effective and ineffective entities operating in this industry.

The time horizon of the research is 2018-2022. Within this period, the following were specified: the period of boom and collapse in the building industry. Periods of boom and bust were determined on the basis of the indicator of the general economic climate in the construction industry.

This indicator is calculated as the arithmetic average of simple indicators relating to the current and expected general economic situation of the company and takes values from -100 to 100. Simple indicators for most questions included in the surveys are calculated as the difference between the percentage of weighted positive and negative answers. A neutral answer is skipped (Bankier pl, 2023).

The indicator of the general economic climate in the construction industry in 2018-2022 is presented in Figure 1.

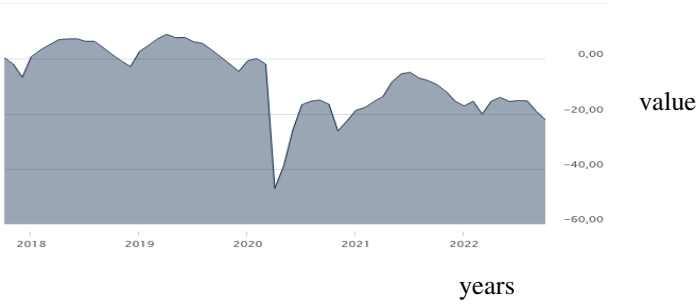

Figure 1. The indicator of the general economic climate in the building trade in 2018-2022.
Source: Bankier pl, 2023.

On the basis of Figure 1, it can be seen that the indicator of the general business climate is characterized by very large undulations in a relatively short period of time. The boom period in the construction industry is in the years 2018-2019. The downturn in this industry is in the years 2020-2022.

The research sample includes 25 organizations operating in the construction industry and the construction sector. These entities are listed on the Stock Exchange.

The characteristic of organizations is presented in Table 1.

Table 1.
The characteristics of organizations

Item	THE CHARACTERISTICS OF ORGANIZATIONS				
	year 2018 (pln thousand)	year 2019 (pln thousand)	year 2020 (pln thousand)	year 2021 (pln thousand)	year 2022 (pln thousand)
I.BUDIMEX S.A.:					
1. Sales revenue	7.387.137	7.569.663	8.382.240	7.911.192	8.619.054
2. Cost of manufacture of products sold	6.758.048	7.018. 111	7.445.207	7.077.395	7.746.611
3. Sales costs	30.650	30.478	31.273	11.733	13.530
4. Management cost general	229.593	198.992	276.966	269.011	317.153

Cont. table 1.

5. Other operating income	111.988	99.453	138.737	85.043	65.235
6. Other operating expenses	63.824	103.141	128.959	51.011	44.568
7. Financial income	28.291	60.127	34.708	13.583	131.961
8. Financial costs	40.118	50.949	51.385	46.239	45.589
9. Other income (costs)	-1.795	4.785	145	67	135
10. Net profit (loss) from discontinued activity	0	0	0	520.508	0
II.CNT S.A.:					
1. Sales revenue	1.393.910	1.108.463	324.915	386.669	797.124
2. Cost of manufacture of products sold	1.327.041	1.062.944	269.272	328.268	746.899
3. Sales costs	1.623	1.498	1.890	1.567	1.739
4. Management cost general	7.947	9.003	6.661	6.358	10.467
5. Other operating income	766	7.709	5.974	519	4.125
6. Other operating expenses	6.820	2.624	396	478	515
7. Financial income	786	862	413	67	6.010
8. Financial costs	24	39	180	108	132
9. Other income (costs)	0	0	0	0	0

Note: Technical manufacturing cost = direct materials + direct labor + variable departmental costs + fixed departmental costs**:** (Zielke, 2023).

Discontinued activity - Part of the company's activity, which in a given financial period was resold, successively liquidated or abandoned - most often due to one of the following reasons: the market for this type of activity was insufficient or uncertain, the share of the activity in the total profit of the enterprise turned out to be unsatisfactory (or - even worse - it brought losses), the activity was not in line with the strategic direction chosen by the enterprise, it was possible to sell it at a profit. Since the end-of-period balance sheet reflects the situation after disposal, the accounting for a discontinued operation is concentrated in the income statement, which shows the results achieved up to the point of disposal. In addition, all material details relating to the discontinuation of operations must be included in the notes to the financial statements. Accounting standards make a distinction between an "activity" (defined as a set of assets that have common physical, operational and reportable characteristics) and individual assets that do not require extensive disclosure (so gains or losses on the sale of individual assets may be just included in the item "other operating income": Monitor FX: https://monitorfx.pl/dzialalnosc-zaniechana/, 30.04.2023.

Source: Own study based on Biznesradar.pl

Due to editorial requirements related to the number of pages of the article, table 1 presents the characteristics of selected organizations. Detailed information can be found on the website: Biznesradar.pl.

3. The Results of Empirical Research

Using empirical amounts of outlays and effects, we search for weights that maximize efficiency for a given object, economic entity, organization (usually called a decision-making unit and usually abbreviated as DMU) scales that maximize efficiency.

As a result, it is about determining the effectivity of decision-making units in relation to their entire group. This is a new approach to evaluate the effectivity (Kozuń-Cieślak, 2011).

The definition of DMU is flexible and general. Decision-making units are understood as e.g. enterprises, public institutions, schools, libraries, hospitals, bank branches, non-profit organizations or construction organizations (Ćwiąkała-Małys, Nowak, 2009).

The measurement of effectivity in the years 2018-2022 according to the DEA method is shown in Tables 2, 3, 4, 5, 6.

Table 2.
The effectivity measure according to the method DEA in 2018

Item (DMU)	THE EFFEECTIVITY MEASURE ACCORDING TO THE METHOD DEA IN 2018			
	outlays (x)	Effects (y)	the efficiency index (y/x)	The relative effectivity index
1.Budimex S.A	7.124.028	7.527.416	1, 056	1,056/1,130 = 0,934 (93,4%)
2.CNT S.A.	1.343.455	1.395.462	1,038	0,918 (91,8%)
3.Dekpol S.A.	819.091	864.308	1,055	0,933 (93,3%)
4.Elektrotim S.A.	321.758	319.151	0,991	0,876 (87,6%)
5. Energoaparatura	43.474	45.291	1,041	0,921 (92,1%)
6. Erbur S.A.	2.362.562	2.340.945	0,990	0,876 (87,6%)
7.Herkules S.A.	138.815	147.742	1,064	0,941 (94,1%)
8.Instal Kraków S.A.	457.956	498.230	1,087	0,961 (96,1%)
9.MDI ENERGIA S.A.	134.451	138.264	1,028	0,909 (90,9%)
10.Mostostal Płock S.A.	107.194	101.973	0,951	0,841 (84,1%)
11.Mostostal Warszawa S.A.	1.066.483	1.029.736	0,965	0,853 (85,3%)
12.Mostostal Zabrze S.A.	614.262	629.826	1,025	0,907 (90,7%)
13.Mirbud S.A.	1.157.636	1.191.047	1,028	0,909 (90,9%)
14.Panova S.A.	170.844	193.130	1,130	1,00 (100,0%)
15.PGE S.A.	1.380.821	1.346.164	0,974	0,861 (86,1%)
16.Polimax-Mostostal S.A.	1.690.512	1.705.748	1,009	0,892 (89,2%)
17. PJP MAKRUM S.A.	254.704	269.648	1,058	0,936 (93,6%)
18.Prochem S.A.	158.369	160.568	1,013	0,896 (89,6%)
19.Tesgaz S.A	75.240	78.326	1,041	0,921 (92,1%)
20.Resbud S.A.	4.175	4.558	1,091	0,965 (96,5%)
21.Torpol S.A.	1.479.678	1.507.805	1,019	0,901 (90,1%)
22.Trakcja S.A.	1.726.077	1.598.673	0,926	0,819 (81,9%)
23.Unibep S.A.	1.632.078	1.669.447	1,022	0,904 (90,4%)
24.Zue S.A.	913.356	836.052	0,915	0,809 (80,9%)
25. Vistal Gdynia S.A.	135.227	85.476	0,632	0,559 (55,9%)

Source: Own study based on Biznesradar.pl.

Table 3.
The effectivity measure according to the method DEA in 2019

Item (DMU)	THE EFFEECTIVITY MEASURE ACCORDING TO THE METHOD DEA IN 2019			
	outlays (x)	Effects (y)	the efficiency index (y/x)	The relative effectivity index
1.Budimex S.A	7.401.671	7.734.028	1,044	1,044/3,191 = 0,327 (32,7%)
2.CNT S.A.	1.076.108	1.117.034	1,038	0,325 (32,5%)
3.Dekpol S.A.	747.297	810.025	1,083	0,339 (33,9%)
4.Elektrotim S.A.	280.289	262.217	0,935	0,293 (29,3%)
5. Energoaparatura	43.375	44.817	1,033	0,323 (32,3%)
6. Erbur S.A.	2.285.842	2.334.728	1,021	0,319 (31,9%)
7.Herkules S.A.	167.956	128.398	0,744	0,233 (23,3%)
8.Instal Kraków S.A.	414.375	447.923	1,080	0,338 (33,8%)
9.MDI ENERGIA S.A.	176.899	181.268	1,024	0,320 (32,0%)
10.Mostostal Płock S.A.	110.239	115.058	1,043	0,326 (32,6%)

Cont. table 3.

11.Mostostal Warszawa S.A.	1.304.245	1.312.301	1,006	0,315 (31,5%)
12.Mostostal Zabrze S.A.	598.203	614.557	1,027	0,321 (32,1%)
13.Mirbud S.A.	943.297	980.292	1,039	0,325 (32,5%)
14.Panova S.A.	258.111	306.396	1,187	0,371 (37,1%)
15.PGE S.A.	1.899.132	-2.974.200	-1,566	-0,490 (-49,0%)
16.Polimax-Mostostal S.A.	1.610.430	1.664.191	1,033	0,323 (32,3%)
17. PJP MAKRUM S.A.	266.164	2.536	0,009	0,002 (0,2%)
18.Prochem S.A.	320.735	330.436	1,030	0,322 (32,2%)
19.Tesgaz S.A	124.107	1.285.77	1,036	0,324 (32,4%)
20.Resbud S.A.	882	1.030	1,167	0,365 (36,5%)
21.Torpol S.A.	1.570.621	1.606.975	1,023	0,320 (32,0%)
22.Trakcja S.A.	1.758.084	1.444.715	0,821	0,257(25,7%)
23.Unibep S.A.	1.626.956	1.665.785	1,023	0,320 (32,0%)
24.Zue S.A.	992.627	999.380	1,006	0,315 (31,5%)
25. Vistal Gdynia S.A.	116.068	370.385	3,191	1 (100%)

Source: Own study based on Biznesradar.pl.

Table 4.

The effectivity measure according to the method DEA in 2020

Item (DMU)	**THE EFFEECTIVITY MEASURE ACCORDING TO THE METHOD DEA IN 2020**			
	outlays (x)	**Effects (y)**	**the efficiency index (y/x)**	**The relative effectivity index**
1.Budimex S.A	7.933.790	8.555.830	1,078	1,078/1,190 = 0,905 (90,5%)
2.CNT S.A.	278.399	331.302	1,190	1,0 (100,0%)
3.Dekpol S.A.	1.010.123	1.077.196	1,066	0,895 (89,5%)
4.Elektrotim S.A.	266.869	288.417	1,080	0,907 (90,7%)
5. Energoaparatura	30.089	28.130	0,934	0,784 (78,4%)
6. Erbur S.A.	2.182.988	2.247.241	1,029	0,864 (86,4%)
7.Herkules S.A.	154.428	160.110	1,036	0,941 (94,1%)
8.Instal Kraków S.A.	396.969	428.453	1,079	0,906 (90,6%)
9.MDI ENERGIA S.A.	256.065	262.247	1,024	0,860 (86,0%)
10.Mostostal Płock S.A.	91.874	97.621	1,062	0,892 (89,2%)
11.Mostostal Warszawa S.A.	1.367.627	1.379.620	1,008	0,847 (84,7%)
12.Mostostal Zabrze S.A.	606.866	623.617	1,027	0,863 (86,3%)
13.Mirbud S.A.	1.218.623	1.288.896	1,057	0,888 (88,8%)
14.Panova S.A.	145.412	165.232	1,136	0,954 (95,4%)
15.PGE S.A.	469129	-141.602	-0,301	-0,252 (-25,2%)
16.Polimex-Mostostal S.A.	1.565.774	1.644.755	1,050	0,882 (88,2%)
17. PJP MAKRUM S.A.	323.396	343.633	1,062	0,892 (89,2%)
18.Prochem S.A.	340.878	358.796	1,052	0,884 (88,4%)
19.Tesgaz S.A	96.813	103.801	1,072	0,900 (90,0%)
20.Resbud S.A.	1.624	23	0,014	0,011 (1,1%)
21.Torpol S.A.	1.337.822	1.396.647	1,043	0,876 (87,6%)
22.Trakcja S.A.	1.431.837	1.311.979	0,916	0,769 (76,9%)
23.Unibep S.A.	1.644.306	1.698.909	1,033	0,868 (86,8%)
24.Zue S.A.	897.354	907.365	1,011	0,849 (84,9%)
25. Vistal Gdynia S.A.	139.923	118.589	0,847	0,711 (71,1%)

Source: Own study based on Biznesradar.pl.

Table 5.
The effectivity measure according to the method DEA in 2021

Item (DMU)	THE EFFEECTIVITY MEASURE ACCORDING TO THE METHOD DEA IN 2021			
	outlays (x)	Effects (y)	the efficiency index (y/x)	The relative effectivity index
1.Budimex S.A	7.455.389	8.530.393	1,144	1,144/1,159 = 0,987 (98,7%)
2.CNT S.A.	336.779	387.255	1,149	0,991 (99,1%)
3.Dekpol S.A.	1.198.982	1.288.620	1,074	0,926 (92,6%)
4.Elektrotim S.A.	271.758	279.368	1,028	0,886 (88,6%)
5. Energoaparatura	524.68	55.335	1,054	0,909 (90,9%)
6. Erbur S.A.	3.024.566	3.109.961	1,028	0,886 (88,6%)
7.Herkules S.A.	168.653	170.575	1,011	0,872 (87,2%)
8.Instal Kraków S.A.	354.770	390.105	1,099	0,948 (94,8%)
9.MDI ENERGIA S.A.	253.353	253.377	1,000	0,862 (86,2%)
10.Mostostal Płock S.A.	157.583	178.866	1,135	0,979 (97,9%)
11.Mostostal Warszawa S.A.	1.279.641	1.315.059	1,027	0,886 (88,6%)
12.Mostostal Zabrze S.A.	755.301	778.361	1,030	0,888 (88,8%)
13.Mirbud S.A.	2.385.374	2.541.431	1,065	0,918 (91,8%)
14.Panova S.A.	175.823	203.822	1,159	1,000 (100,0%)
15.PGE S.A.	41.349	-150.845	-3,648	-3,147 (-314,7%)
16.Polimex-Mostostal S.A.	2.226.614	2.334.052	1,048	0,904 (90,4%)
17. PJP MAKRUM S.A.	312.619	316.165	1,011	0,872 (87,2%)
18.Prochem S.A.	230.174	257.378	1,118	0,964 (96,4%)
19.Tesgaz S.A	109.317	116.324	1,064	0,918 (91,8%)
20.Resbud S.A.	291.717	288.263	0,988	0,852 (85,2%)
21.Torpol S.A.	1.027.633	1.128.886	1,098	0,947 (94,7%)
22.Trakcja S.A.	1.468.765	1.467.140	0,998	0,861 (86,1%)
23.Unibep S.A.	1.683.226	1.747.506	1,038	0,895 (89,5%)
24.Zue S.A.	844.277	859.641	1,018	0,878 (87,8%)
25. Vistal Gdynia S.A.	79.574	62.333	0,783	0,675 (67,5%)
25. Vistal Gdynia S.A.	79.574	62.333	0,783	0,675 (67,5%)

Source: Own study based on Biznesradar.pl.

Table 6.
The effectivity measure according to the method DEA in 2022

Item (DMU)	THE EFFEECTIVITY MEASURE ACCORDING TO THE METHOD DEA IN 2022			
	outlays (x)	Effects (y)	the efficiency index (y/x)	The relative effectivity index
1.Budimex S.A	8.167.451	8.816.385	1,079	1,079/1,262 = 0, 854 (85,4%)
2.CNT S.A.	759.752	807.259	1,062	0,841 (84,1%)
3.Dekpol S.A.	1.322.174	1.420.061	1,074	0,851 (85,1%)
4.Elektrotim S.A.	478.037	508.451	1,063	0,842 (84,2%)
5. Energoaparatura	45.867	48.450	1,056	0,836 (83,6%)
6. Erbur S.A.	3.872.497	3.870.881	0,999	0,791 (79,1%)
7.Herkules S.A.	206.964	183.605	0,887	0,702 (70,2%)
8.Instal Kraków S.A.	375.086	413.845	1,103	0,874 (87,4%)
9.MDI ENERGIA S.A.	210.991	199.978	0,947	0,750 (75,0%)
10.Mostostal Płock S.A.	154.169	157.899	1,024	0,811 (81,1%)
11.Mostostal Warszawa S.A.	1.623.232	1.650.565	1,016	0,805 (80,5%)
12.Mostostal Zabrze S.A.	1.128.654	1.184.273	1,049	0,831 (83,1%)

Cont. table 6.

13.Mirbud S.A.	3.200.642	3.351.803	1,047	0,829 (82,9%)
14.Panova S.A.	182.759	210.544	1,152	0,912 (91,2%)
15.PGE S.A.	41.316	-265.083	-6,415	-5,083 (-508,3%)
16.Polimex-Mostostal S.A.	3.642.874	3.808.693	1,045	0,828 (82,8%)
17. PJP MAKRUM S.A.	504.008	540.193	1,071	0,848 (84,8%)
18.Prochem S.A.	241.650	236.722	0,979	0,775 (77,5%)
19.Tesgaz S.A.	127.075	130.276	1,025	0,812 (81,2%)
20.Resbud S.A.	1.350.283	1.394.673	1,032	0,817 (81,7%)
21.Torpol S.A.	881870	1113372	1,262	1,000 (100,0%)
22.Trakcja S.A.	1.444.344	1.770.776	1,226	0,971 (97,1%)
23.Unibep S.A.	2.237.109	2.279.012	1,018	0,806 (80,6%)
24.Zue S.A.	916.834	938.941	1,024	0,811 (81,1%)
25. Vistal Gdynia S.A.	551.086	76.105	0,138	0,109 (10,9%)

Source: Own study based on Biznesradar.pl.

From the information in Tables 2, 3, 4, 5, 6 you can see that the first column contains the name of the decision unit (DMU). The following columns, on the other hand, contain data on outlays and efects. The fourth column presents the calculation of the efficiency index for individual decision-making units (DMU). The relative effectivity index is presented in the fifth column.

The relative effectivity indicator was calculated as the quotient of the effectiveness of a given decision-making unit and the highest effectiveness achieved by the surveyed organizations. In this way, the share of the effectivity of a given organization in the effectivity of the best possible among the surveyed entities was determined. This share is presented as a percentage.

In such a case, the relative effectiveness indicator for an effective organization, the best in the studied group (the so-called benchmark, pattern) is respectively 100% or simply equal to one, that is:

- year 2018: Panova S.A. = 1.0 (100%),
- year 2019: Vistal Gdynia S.A. = 1.0 (100%),
- year 2020: CNT S.A. = 1.0 (100%),
- year 2021: Panova S.A. = 1.0 (100%),
- year 2022: Torpol S.A. = 1.0 (100%).

For ineffective units it is the reference limit against which theirs leaders can search for directions of changes in order to end up on the border of effectiveness, i.e. to become an effective unit.

4. Discussion

The article reviews the literature on the use of DEA in the literature. Then, the results of empirical research are presented. Empirical research results focus on the use of DEA in the building industry. Based on the conducted empirical research, effective organizations (Panova S.A., Vistal Gdynia S.A., CNT S.A., Torpol S.A.) and ineffective ones (Budimex S.A., Dekpol S.A., Elektrotim S.A., Energoaparatura, Erbur S.A., Herkules S.A., Instal Kraków S.A., MDI ENERGIA S.A., Mostostal Płock S.A., Mostostal Warszawa S.A., Mostostal Zabrze S.A., Mirbud S.A., PGE SA, Polimex-Mostostal S.A., PJP MAKRUM S.A., Prochem S.A., Tesgaz S.A., Resbud S.A., Trakcja S.A., Unibep S.A., Zue S.A.) was recognized. For ineffective leaders it is a reference limit against which they can seek directions of change in order to find themselves an effective unit.

The presented results of empirical research may constitute a kind of signpost to orientate in the direction of identifying the best partner or partners and developing adequate cooperation strategies, single-source sourcing, multi-source sourcing, dual-source sourcing and others in a collaborative stuation (Bozarth, Hanfield, 2007). The need to develop such strategies results not only from the basics of management, but also from the characteristics of the construction process, such as the presence of many participants (direct, indirect).

5. Summary

Over the last few decades, there has been an increase in interest in the DEA method on the world. The article begins with a literature review and shows that there is a deficit of studies focusing on construction companies in the Polish management and economics literature.

Then, the author's own research was presented. The purpose of the research was described and the scope of the research was characterized (subjective, objective, temporal). However, the DEA methodics and research conclusions, discussion were presented. It was emphasized that presented results of empirical research may constitute a kind of signpost to orientate in the direction of identifying the best partner or partners and developing adequate strategies.

In this way, the purpose of the article, which was the implementation of DEA in the building trade and the identification of effective and ineffective entities operating in this industry in the context for strategy of making decisions on cooperation, was achieved.

On the other hand, science is never a completed process. Excellent proposals usually appear long after less perfect proposals, which also contribute to the enrichment of science. Therefore, further research by the author in this domain of interest could be aimed at implementing other methods (e.g. AHP methods, statistical parametric methods).

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AGILE LEADERSHIP PRACTICES IN THE DIGITAL TRANSFORMATION OF HEIS

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Purpose: One of the strategic challenges of many higher education institutions is digital transformation. The success of this process depends not only on the technologies and IT systems being introduced but also on the actions of leaders in the field of digitalisation. This article aims to examine the relationship between agile leadership practices found in HEIs and the level of the progress of digital transformation.
Design/methodology/approach: The article presents the results of quantitative research conducted in 2023 among 515 teaching and administrative staff members in 20 Polish HEIs.
Findings: The results of the study confirm the relationship between the level of progress of an HEI's digital transformation and the selected leadership practices, in particular flexibility, encouraging staff to frequently test, experiment, and seek innovative solutions. At the same time, these practices were less frequent in the surveyed HEIs than the practices with less impact on the progress of digital transformation.
Research limitations/implications: The results of the study may be applicable to the broader HEI population, but caution should be exercised in their generalisation due to certain limitations of the sample. In the course of further investigations, it would be worthwhile to supplement the research approach with mixed methods that provide opportunities for deeper analysis of the described phenomenon.
Practical implications: The results of the study can provide valuable information for higher education institutions regarding the implementation of new digital leadership strategies. They can inform the design of academic leadership development programmes focused on developing an agile approach to management in educational institutions.
Social implications: Implementing effective leadership strategies can lead to increasing innovation within HEIs, optimising educational processes, and improving the quality of education.
Originality/value: Literature review shows research gap in digital academic leadership's role in HEI's digital maturity. The results of the study provide important insights and contribute to developing knowledge on the relationship between agile leadership practices and an HEI's digital transformation process. They provide a basis for further research and development of digitalisation strategies tailored to the specificities of higher education.

Category of the paper: Research paper.

Keywords: Academic Digital Leadership, Agility in Higher Education, HEIs.

1. Introduction

Today's educational landscape, continually shaped by accelerating technological advances, is encouraging higher education institutions (HEIs) to reflect on their own transformation strategies. The digital age is the source of much turbulence and challenges in the environment of organisations (Korzyński, 2018; Romanowska, 2011; Zakrzewska-Bielawska, 2013), including educational ones.

The Covid-19 pandemic was certainly a catalyst for digital transformation in higher education. Many authors highlight its impact on accelerating the digitalisation of higher education institutions and initiating arguably profound and lasting changes (Jorge-Vázquez et al., 2021; Marinoni et al., 2020; Rodríguez-Abitia et al., 2021). The uncertainty caused by the pandemic, the development of distance learning and resulting increased competition from foreign HEIs, and the need to operate using social networks and advanced information technologies required new competencies from academic leaders. On the other hand, changes regarding digitalisation are forced by the expectations of university candidates, especially the youngest generations, often referred to as digital', who are used to acquiring information not only through traditional channels, e.g., physically in the classroom. For this generation, the teacher is not the only source of reliable knowledge. Present-day students use the open resources of so-called MOOCs, learn from online sources and social networks and, increasingly, use artificial intelligence-based solutions, e.g., ChatGPT.

The modern university is changing under the influence of digital technologies that transform the teaching and learning model and increase access to data and allow it to be collected and analysed, effectively influencing management decisions (McCluskey, Winter, 2012). As Mazurek (2019) argues, the digital transformation of higher education is more than just the implementation of technological tools in HEIs. It is a systemic change that includes changing the organisational culture from hierarchical to networked, to decision-making based on centralised, standardised data, developing the digital competencies of all HEI employees, implementing tools that develop teaching innovations, and building relationships with stakeholders through social media (Mazurek, 2019).

As Gudergan et al. (2019) point out, digital transformation is more about people than about digital technology itself. It requires organisational change that is supported by leadership and critical challenges to organisational culture. The authors divide organisations undergoing digital transformation into two categories: digitally developing and digitally mature, each managed differently. It is the differences between leaders that distinguish digitally mature organisations from those that are just developing in this area (Abbu et al., 2022).

Many researchers argue that organisational agility positively influences the course of digital transformation (Li et al., 2020; Porfirio et al., 2021; AlNuaimi, 2022) and that leaders play a key role in building organisational agility (Menon, Suresh, 2020, 2022) and in guiding

organisations through digital transformation (Porfirio et al., 2021; Al-Nuaimi, 2022; Hansen et al., 2011).

The aim of this article is to broaden the understanding of the role that HEI leaders play in the digital transformation process. The posed research question is: Is there a relationship between the agile management practices employed by academic leaders and the level of digital transformation and the degree to which universities use digital technology?

2. Literature review

2.1. Digital maturity in higher education institutions

Digital transformation is a gradual process that ultimately leads to the creation of new business models, more advanced and efficient management practices and business operations, improved service delivery (Morakanyane et al., 2017), the creation of a culture of innovation through the use of advanced technology to act quickly and focus on problem-solving, generate innovative ideas, and meet market needs (Tanniru et al., 2018; Dimitrov, 2018). In the literature relating to the issue of digital transformation, there are attempts to create digital maturity models for organisations (Proença et al., 2016; Remane, 2017; Carvalho, 2019). Digital maturity defines the state of digital transformation of an organisation (Chanias, Hess, 2016). One example of a digital maturity model is the Digital Transformation Toolkit Guide, developed by the South Australian Government in collaboration with KPMG to support organisations in developing digital strategies and help assess their level of digital maturity. The model assumes 5 stages, from minimal to transformed, and is described at the level of 5 spheres: governance and leadership structure, people and culture, capacity and capability, innovation, and technology. Each of these spheres is characterised according to the level of digital maturity. In addition, in each of the mentioned areas, there are actions on different levels: from the reactive through the experimental to the full level — the organisation-wide level, in which digitalisation is part of the organisation's strategy, and mission and vision, and digital technologies are used to increase the efficiency of the organisation's operations, redefine processes and methods of providing services, and even create new products and services based on tools and digital technologies.

There are several digital maturity models developed for educational institutions, although their number is still limited. Rodríguez-Abitia et al. (2020) proposed a framework for assessing the degree of digital maturity of an HEI based on its ability to provide adequate IT infrastructure, to use technology in the teaching and learning process, and to manage the work of teams and the coordination of processes. Two other models can be used as examples: the KPMG and Google models. KPMG calls its model 'a blueprint for digital transformation in

universities'. The blueprint comprises six elements: customers, channels, enterprise strategy, core businesses practices, advanced data and analytics, and enabling business practices. Google has classified seven elements of digital transformation, namely: vision, learning, culture, technology, professional development, funding and sustainability, and community engagement. These two models do not describe the stages in the process of becoming digitally mature, but only show the areas in which this maturity manifests itself.

2.2.Digital leadership in higher education

Digital leadership in higher education is increasingly the focus of academic research, representing an area of great research potential. Many authors believe that digital leadership is an under-researched practice in higher education (Cifuentes-Álvarez, Vanderlinde, 2015; Masrur, 2021). One of the definitions of digital leadership was developed by Ebler & Drews (2021, p. 226): *digital leadership is a complex construct aiming for a customer-centred, digitally enabled, leading-edge business model by (1) transforming the role, skills, and style of the digital leader, (2) realizing a digital organization, including governance, vision, values, structure, culture, and decision processes, and (3) adjusting people management, virtual teams, knowledge, and communication and collaboration on the individual level.*

The notion of digital leadership, particularly in relation to educational institutions, is not well-established. Other terms describing digital leadership appear in the literature: ICT leadership (Cifuentes-Álvarez, Vanderlinde, 2015), e-leadership (Avolio et al., 2001), technology leadership (Yuting et al., 2022), and leadership 4.0 (Mihardjo et al., 2019).

Some of the research focuses on the characteristics of effective digital leaders. Many authors identify similar leadership behaviours, among them readiness for change (Rodríguez-Abitia et al., 2020; Rodríguez-Abitia, Bribiesca-Correa, 2021), the ability to manage change so-called 'transformational leadership' (Antonopoulou et al., 2019, 2020, 2021), team orientation, the ability to involve all stakeholder groups and to delegate leadership — so-called 'distributed leadership' (Laufer et al., 2021; Garrison, Vaughon, 2013; Cifuentes-Álvarez, Vanderlinde, 2015; Avidov-Ungara et al., 2022), the ability to combine management with technology and digital skills (Kotula et al., 2021; Antonopoulou et al., 2020), and an awareness of the need to develop the digital competencies of the HEI's staff (Binh, Le, 2015; Newland, Handley, 2016).

The period of the Covid-19 pandemic encouraged researchers to explore the subject of digital transformation in HEIs and the issue of agility as a characteristic of an HEI that adapts better to operating in a turbulent environment (Dima et al., 2021; Memon, Suresh, 2020, 2022) however, there is still little exploration of this topic.

2.3. Agile leadership and digital transformation

Higher education institutions, like other organisations, operate in an extremely uncertain, dynamically changing environment. In order for them to compete successfully not only in the local but also in the global education market, they must be ready to adapt and redesign their processes quickly, which characterises so-called organisational agility (Menon, Suresh, 2022; Kerrum et al., 2020; Shewchuk, 1998). In the literature, in the context of responding to change, one can find, in addition to the term 'agile organisations', other synonyms such as 'flexible organisations' or 'adaptive organisations' (Sherehiy, 2007; Loiro et al., 2019). The agile project management model, particularly popular in the IT industry, has also emerged among project management methodologies (Hoda et al., 2008). At the same time, agile management is becoming one of the key challenges facing organisations on the road to mature digital transformation (Wiechmann et al., 2022).

In the literature, one can find examples of studies looking for a link between an organisation's leadership style and successful digital transformation. Researchers' interests are particularly focused on the styles that refer to the effective management of organisational change and to adapting to a changing and uncertain environment, which is characteristic of the agile approach. Research by AlNuaimi et al. (2022) has proven that transformational leadership and organisational agility have a positive impact on digital transformation. At the same time, they confirmed a positive relationship between transformational leadership and organisational flexibility. According to the aforementioned researchers, transformational leaders promote organisational agility through the way in which they build relationships with subordinates and encourage them to innovate, take rational risks, and see opportunities in the environment (Wanasida et al., 2020). Porfirio et al. (2021) reached similar conclusions: in their research, they confirmed that more agile and democratic decision-making processes, associated with more democratic leadership styles, constitute characteristics that foster the development of digital transformation in organisations. Furthermore, leaders' openness to innovation may be related to the effectiveness of strategic management processes and the company's ability to maintain a competitive advantage resulting from digital sophistication. As part of their research, Büyükbeşe et al. (2022) created a tool to measure digital leadership (Digital Leadership Scale, DLS), which indicates the strongest relationship between the successful digitalisation of an organisation and two dimensions of leadership: innovation and supporting subordinates, in addition to agility, developing digital skills, and being a so-called 'digital role model'.

Digital transformation is a process that requires leaders to lead an organisation through a series of changes. The Covid-19 pandemic mentioned earlier was certainly a situation that required HEIs to quickly adapt to new conditions — introducing remote learning models, remote or hybrid work models, implementing new IT systems to support learning and the day-to-day running of the HEI, ensuring the health of staff and students, and, at the same time, it became an excellent opportunity to begin or advance the level of digitalisation of the HEI.

Research on the relationship between HEI leadership styles and the digital transformation process is limited; in particular, quantitative and mixed-method research is lacking. Many studies show a positive relationship between agile, flexible and more adaptive management styles and successful digital transformation. A study by Dima et al. (2021), conducted among leaders of 23 European HEIs, found that leadership styles should evolve after the Covid-19 pandemic. New digital and transformational leadership styles may gain an advantage as they are more adaptive and agile. Other researchers also point to the transformational style as more agile and better suited to operating in a changing and dynamic environment. Transformational leaders are better equipped to manage organisational change, especially in a digital environment (Hingins et al., 2018; Santatiagar et al., 2017, Antonopoulou et al., 2019, 2020, 2021).

2. Research methodology

The subject of this study was to examine how the degree of utilisation of digital technologies and the level of progress of a higher education institution's digital transformation relates to the management practices found in the institution and those used by direct supervisors. The study was exploratory in nature; in addition to satisfying the need for a more thorough understanding of the investigated issue, the main idea behind it was to identify the rationale for undertaking broader exploration and to develop methods that will allow further research to be carried out (Sułkowski et al., 2021).

The study posed the following research question:

Is there a link between agile management practices and an HEI's level of digital transformation and the extent to which it utilises digital technology?

The following hypothesis was formed:

Agile management practices found in an HEI correlate to its level of digital transformation and the degree to which it utilises digital technology.

In order to investigate the relationship between leadership practices found in HEIs and the level of their digital transformation, a quantitative study was conducted among 515 teaching and administrative staff members representing 20 Polish HEIs. The sample included 15 public and 5 non-public HEIs. The institutions' authorities did not give permission to publish the names of the HEIs participating in the study. The survey was conducted in May-June 2023 using an anonymous, original online questionnaire, which included questions on the degree to which the HEI is using digital technologies, the level of digital transformation in the HEI, the management practices in the HEI, and the practices of the immediate supervisor in the context of HEI digitalisation.

The main variables used in the survey were expressed in the form of synthetic measures based on specific indicators determined on the basis of theoretical considerations and literature analysis (Sułkowski, 2020). The level of digitalisation was created based on the analysis of the models described in the theoretical part of the article, including the Digital Transformation Toolkit Guide (https://www.dpc.sa.gov.au/) The respondents' level of digital transformation was assessed based on the availability of digital technologies, the degree of digitalisation of processes, and the integration of technology in the daily operations of the HEI. Measures of agile leadership at the HEI level were described by 12 statements, which included an assessment of practices such as flexibility, encouraging staff to experiment and innovate, use of agile project management methodologies, and frequent exploration of the needs of representatives of different stakeholder groups. The Cronbach's Alpha reliability coefficient for this index had a value of 0.943, a result indicative of the high reliability of the tool. The behaviour of the direct supervisor was assessed by the respondents using 9 statements describing the supervisor's practices in the area of digitalisation and consisting of, among other things, the inclusion of subordinates in the decision-making process, supporting them in the process of acquiring digital competencies and assisting them when they encounter difficulties in the area of digitalisation. Once again, satisfactory Cronbach's Alpha coefficient values (0.965) were achieved, demonstrating the high reliability of the index created.

The data collected underwent statistical analysis using the IBM SPSS Statistics software, applying appropriate tools such as correlation analysis and statistical tests. The results of the analysis enabled the identification of relationships between digital academic leadership practices and the degree of digital transformation in an HEI.

3. Research results

The majority of the respondents were women (62.5%). With regard to the age of respondents, the largest group was between 36 and 45 years old (35.1%) and the smallest group was under 25 years old (2.1%). The largest portion of respondents worked in the administration departments of the HEIs (45%); by function, the majority of respondents were categorised as administration and leaders (61.6%). Nearly half of the respondents had been employed at their HEI for more than 10 years (48.2%). A detailed profile of respondents is presented

Table 1.
Respondent characteristics

Respondent profile		**Quantities**	**Percentage (%)**
Gender	woman	322	62.5
	man	193	37.5
Age	below 25 years old	11	2.1
	25-35 years old	79	15.3
	36-45 years old	181	35.1
	46-55 years old	151	29.3
	above 55 years old	93	18.1
Employment category	administration worker	232	45.0
	research and teaching manager	85	16.5
	research and teaching worker	198	38.4
Function	administration and leaders	317	61.6
	teachers	198	38.4
Duration of employment*	less than 2 years	77	15.0
	2-5 years	108	21.0
	5-10 years	80	15.5
	more than 10 years	248	48.2
Total:		**515**	**100.0**

n = 515; * — data not available (2 respondents did not provide duration of employment).

Source: Own survey.

The level of digital technology use in the HEI was rated by the respondents on a scale from 1 to 6, where 1 meant not at all/to a negligible extent and 6 meant to a great extent/fully. Most responses indicated level 5 (46.02); the average level for all HEIs surveyed was 4.61. However, it is worth noting that the level of digital technology use by individual HEIs varied considerably, which was confirmed by the result of the chi-square test. Detailed data is presented in Table 2.

Table 2.
Level of use of digital technologies according to respondent statements

Level of use of digital technologies in their processes by HEIs (scale 1-6)						**M**	**Statistical significance**
1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)		$\chi2 = 118.993$*; V = 0.215
0.58	2.33	7.96	28.16	46.02	14.95	4.61	

n = 515; % — percentage; p — statistical significance; * — $p < 0.05$; $\chi2$ — chi-square test; V — Cramer's V coefficient.

Source: Own survey.

The level of progress of digital transformation in the HEI was assessed by the respondents using a scale from 0 to 4, each level being described as follows:

Table 3.
Description of the levels of progress of digital transformation in the HEI

Level 0	**Digital transformation has not yet begun.**
1 — low level	My institution is at the beginning of its journey in the use of digital technology; we are gaining our first experiences in this area.
2 — medium level	My institution is beginning to experiment with digital technologies that are not yet fully integrated into educational, administrative, and research processes. High level
3 — very high level	My university is beginning to integrate digital technologies into administrative, educational, and research processes in line with its digitalisation strategy.
4 — very high level	My institution is creating new business models and products using digital technologies.

Source: own work.

Table 4 shows the percentage of responses indicating the level of digital transformation at their HEI. Almost half of the respondents (49.51%) rated the level as very high; the average level of progress of the transformation in the surveyed HEIs was 2.61. It is worth noting that the level of digitalisation declared by the respondents depended on the HEI, which was confirmed by statistical analyses (chi-square test). This means that both the level of digitalisation and the level of use of digital technologies among the surveyed HEIs varied greatly; the group of surveyed HEIs included both those that distinguished themselves by their sophistication in the studied area and those characterised by a low level of digital transformation.

Table 4.
Level of progress of digital transformation in the HEI according to respondent statements

Level of progress of digital transformation in the HEI (%)						**Statistical significance**
0	1	2	3	4	M	$\chi2 = 121.795$*; V = 0.243
0.39	6.99	33.20	49.51	9.90	2.61	

n = 515; % — percentage; p — statistical significance; * — $p < 0.05$; $\chi2$ — chi-square test; V — Cramer's V coefficient.

Source: Own survey.

From the perspective of the purpose of the study and the set hypothesis, it was important to test the relationship between the level of digital technology use by HEIs and the level of digitalisation on the one hand, and the leadership practices found in the HEIs and the behaviour of the immediate supervisor on the other. Leadership practices refer to situations that describe a leadership culture, including flexibility as a value, practices occurring not only at a team level but promoted throughout the organisation, e.g., the creation of interdisciplinary teams and the attitude of university authorities towards digitalisation. Supervisor's behaviour only refers to the supervisor's practices within the individual respondent's team. In both the first and second cases, all the statements described refer to an agile approach and are set in the context of digitalisation.

Table 5 shows the results of the Spearman rank correlation coefficient for a summary of the evaluation of agile management practices implemented in an HEI and the level of digital technology use and the level of progress of digital transformation. The results confirmed a statistically significant ($p < 0.05$) correlation in all analysed cases. The strongest relationship (average correlation strength) was observed between the level of digital technology use and the level of progress of digital transformation in an HEI and the practice of supervisors encouraging employees to innovate and seek innovative solutions. Moreover, the level of progress of an HEI's digital transformation correlates positively with the practices of encouraging frequent testing and experimentation by staff, quick decision-making by management, the university authorities' emphasis on the importance of digitalisation and digital transformation in building a competitive advantage in the education market and flexibility as an important organisational value.

Table 5.
Agile management practices and degree of digital technology use and level of digital transformation progress according to respondent statements

Leadership practices	Relationship between the level of digital technology use and the evaluation of management practices	Relationship between the level of progress of an HEI's digital transformation and the evaluation of management practices	M
Staff is encouraged by their superiors to innovate and seek innovative solutions.	**r_s=0.465038;** p=0.000000*	**r_s=0.485343**; p=0.000000*	3.23
Staff is encouraged to test and experiment frequently.	r_s=0.426532; p=0.000000*	**r_s=0.458902**; p=0.000000*	3.02
Failure is treated as a lesson; we believe that creating innovation requires making mistakes.	r_s=0.256795; p=0.000000*	r_s=0.287113; p=0.000000*	3.17
We often form project teams consisting of representatives from different departments of the institution.	r_s=0.277807; p=0.000000*	r_s=0.349024; p=0.000000*	3.13
We are encouraged to work effectively with external stakeholders (partners).	r_s=0.271933; p=0.000000*	r_s=0.340864; p=0.000000*	3.49
We often survey the expectations of our customers, e.g., students, in order to improve the services offered.	r_s=0.250134; p=0.000000*	r_s=0.32798; p=0.000000*	3.46
We create prototypes of our services, which we test/consult with clients/students or other employees.	r_s=0.307913; p=0.000000*	r_s=0.36754; p=0.000000*	3.07
We create new ideas, services, offers, actively collaborating with students (customers), external partners, suppliers, and other stakeholder representatives.	r_s=0.277894; p=0.000000*	r_s=0.344094; p=0.000000*	3.36

Cont. Table 5.

We use agile project management methodologies such as Scrum, Kanban, Agile or others.	r_s=0.307986; p=0.000000*	r_s=0.33079; p=0.000000*	2.82
Decisions are made quickly by managers in my institution.	r_s=0.357525; p=0.000000*	**r_s=0.424853; p=0.000000***	3.13
Flexibility is a valued asset in my institution.	r_s=0.397726; p=0.000000*	**r_s=0.415676; p=0.000000***	3.35
Institution authorities emphasise the importance of digitalisation and digital transformation in building competitive advantage in the education market.	r_s=0.385334; p=0.000000*	**r_s=0.438519; p=0.000000***	3.57

n = 515; M — mean; r_s — Spearman's rank correlation coefficient; p — statistical significance; * — $p < 0.05$.

Source: Own survey.

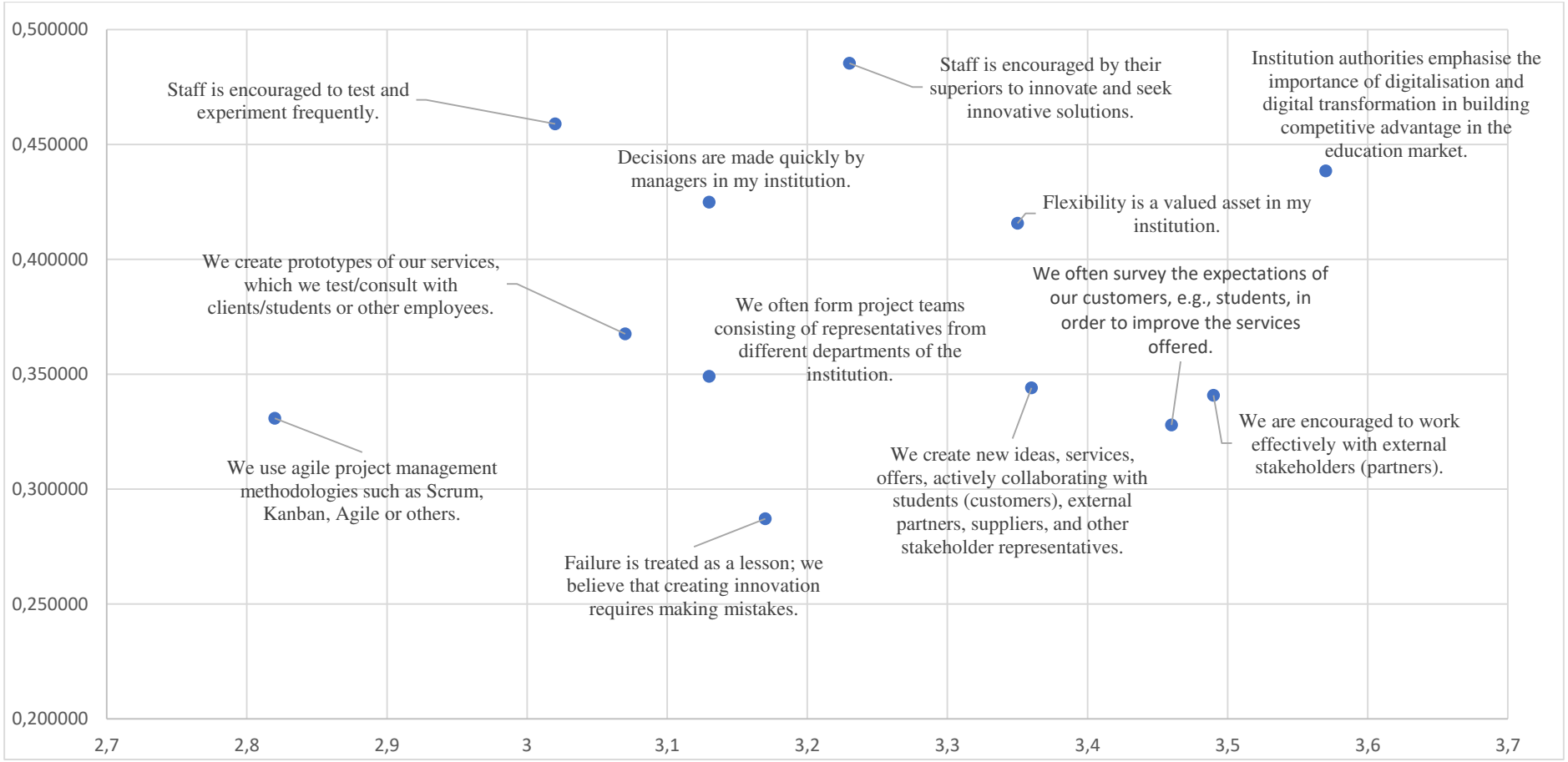
Figure 1 shows the correlation values of the different agile management practices used in HEIs with the level of digital technology use in an HEI. Agile project management methodologies (2.82) and service prototyping (3.07) are used least often in HEIs. Two other practices are also relatively rare: superiors encouraging subordinates to innovate and seek innovative solutions (3.23) and encouraging frequent experimentation and testing (3.02). Both of these practices correlate (at an average level, the highest achieved in this study) with both the respondents' declared level of digital transformation and the level of use of information technology in the HEI (Figure 1 and Figure 2).

Figure 2 visually presents the correlation values of each agile management practice with the level of digital transformation progress. It is worth comparing the management practices that correlate highest with an HEI's level of digital transformation progress to the frequency of their occurrence in HEIs. The data collected shows that respondents are least likely to be encouraged to test frequently (3.02); at the same time, this is a practice that correlates with the level of progress of digital transformation. Analysing the data presented in Tables 4-5 and Figures 1-2, it is worth noting that none of the surveyed management practices achieved a higher frequency score than 3.49 on a scale of 1 to 5, indicating that agile management practices are implemented in HEIs at an average level.

n = 515.

Figure 1. Agile management practices and the level of use of digital technologies according to respondent statements.

Source: Own survey.



n = 515.

Figure 2. Agile management practices and level of progress of digital transformation according to respondent statements.

Source: Own survey.

In the case of the relationship between the level of use of digital technologies and the level of progress of digital transformation and the management practices of direct supervisors in an HEI, the Spearman's rank coefficient results indicated a statistically significant correlation between each of the variables analysed ($p < 0.05$). The three strongest correlations found were between the supervisor's active involvement in the digital transformation process in the institution and the level of digital transformation (average strength), the supervisor's encouragement of digital competence and the level of digital transformation (average strength), and between the supervisor's active involvement in the digital transformation process and the level of digital technology use (average strength) (Table 6).

Table 6.
Management practices of direct supervisors in the HEI vs. the degree of digital technology use and the level of progress of the HEI's digital transformation

Behaviours of direct supervisors	**Relationship between the level of digital technology use and the behaviours of the direct supervisor**	**Relationship between the level of progress of an HEI's digital transformation and the behaviours of the direct supervisor**	**M**
Has an innovative vision, sees value in digitalisation and opportunity for the institution to grow.	r_s=0.292597; p=0.000000*	r_s=0.348408; p=0.000000*	3.72
Has the ability to quickly build and coordinate interdisciplinary teams organised around the implementation of digital solutions in the HEI.	r_s=0.308918; p=0.000000*	r_s=0.341858; p=0.000000*	3.54
Has up-to-date knowledge and skills in digital technologies and their use in our area of operation (e.g., teaching, administration or research).	r_s=0.305053; p=0.000000*	r_s=0.361016; p=0.000000*	3.58
Is actively involved in the digital transformation process in the institution.	**r_s=0.379671; p=0.000000***	**r_s=0.414303; p=0.000000***	3.49
Supports employees when they encounter difficulties in the area of digitalisation, e.g., when implementing new IT solutions and developing their competencies.	r_s=0.333953; p=0.000000*	r_s=0.369379; p=0.000000*	3.53
Invests in the development of their digital competencies; is willing to test them themselves; is a model in this area.	r_s=0.307714; p=0.000000*	r_s=0.360196; p=0.000000*	3.48
Encourages me to develop my digital competencies, e.g., by attending internal or external training courses.	r_s=0.315673; p=0.000000*	r_s=0.380947; p=0.000000*	3.58
Involves me and other employees in decisions that affect our work and my digital working environment.	r_s=0.319774; p=0.000000*	r_s=0.352736; p=0.000000*	3.47
Encourages employees to make greater use of different types of IT solutions.	r_s=0.311134; p=0.000000*	r_s=0.366268; p=0.000000*	3.57

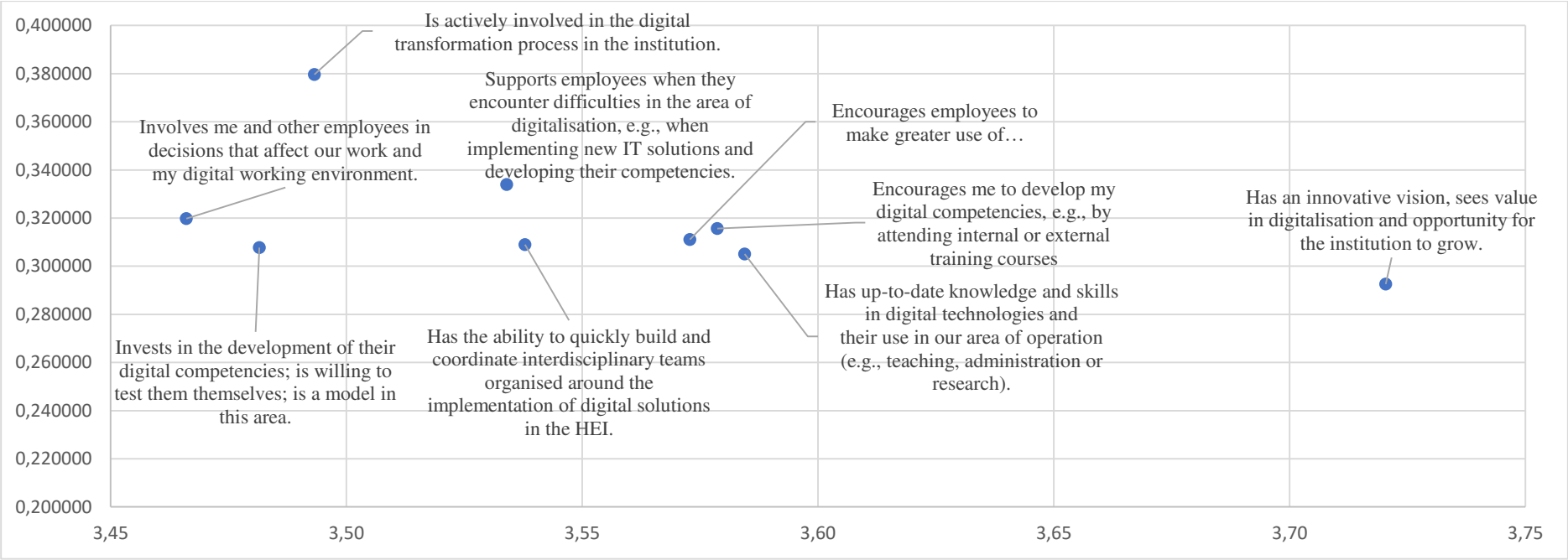
n = 515.

M — mean; r_s — Spearman's rank correlation coefficient; p — statistical significance; * — $p < 0.05$.

Source: Own survey.

Both the data presented in Table 6 and in Figures 3 and 4 show that the activity of the direct supervisor in the area of digitalisation plays a key role in the area of digitalisation development in HEIs; at the same time, it is relatively rare in the surveyed HEIs (3.49) — certainly less frequent than other behaviours assessed in this question. Considering the fact that the frequency of specific behaviours of the supervisor was rated by the respondents on a scale of 1 to 5, it can be said that it is also rare at the surveyed HEIs for the direct supervisor to involve their subordinates in decisions affecting the digital working environment (3.47) and to invest in the development of their digital competencies, and to be a model in this area (3.48).

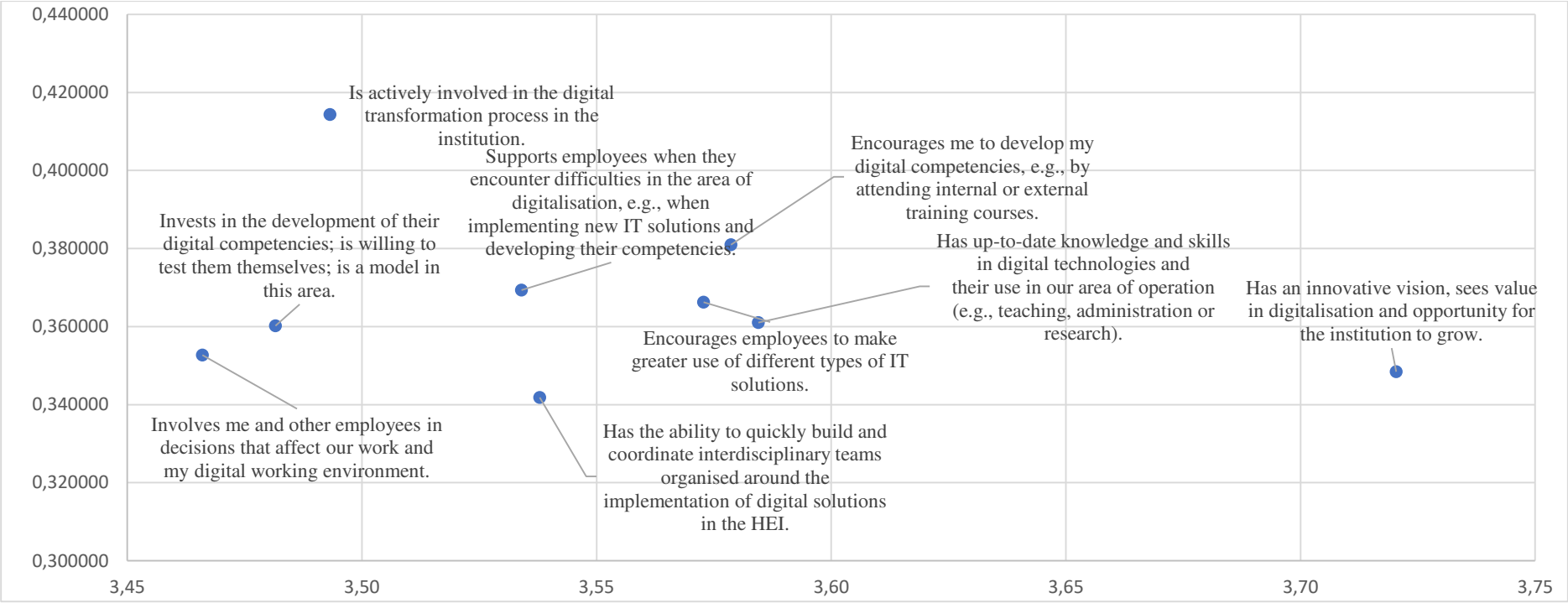
Figures 3 and 4 clearly show that the average frequency of most of the assessed practices of the immediate supervisor assumed values between 3.48 and 3.58. Most common among the assessed practices is the creation of an innovative vision, the supervisor seeing value in digitalisation and the opportunity for growth in the institution.



n = 515.

Figure 3. Management practices of the direct supervisor vs. the level of use of digital technologies according to respondent statements

Source: Own survey.



n = 515.

Figure 4. Management practices of the immediate supervisor and the level of digital transformation of the institution according to respondent statements

Source: Own survey.

Discussion

Digital transformation in higher education institutions is increasingly becoming a subject of interest for researchers. Undoubtedly, the pandemic has been a major catalyst for change in HEIs in this area and has revealed the challenges HEIs have faced, not only in the organisational dimension or in the dimension of infrastructural resources but also in the area of managing the transformation process and the digitalisation of the institution.

The aim of this article was to present the results of a study investigating the relationship between management practices used in the institution and presented by direct supervisors and the level of progress of digital transformation in HEIs. The hypothesis was that there is a relationship between the progress of digital transformation and agile management practices. A survey of 515 employees at 20 Polish HEIs confirmed the link between the level of progress of digital transformation in an institution and its level of use of digital technology and the agile management practices used in the institution and by the direct supervisor. The strongest correlations identified were observed between the declared level of digitalisation of the institution and the management practices of supervisors encouraging their subordinates to innovate and seek innovative solutions and encouraging frequent testing and experimentation. This type of behaviour is characteristic of so-called transformational leaders, who, according to research (Wanasida et al., 2020; Porfirio et al., 2021; Büyükbeşe et al., 2022) encourage innovation and support subordinates and thus promote agility in the organisation, which fosters digital transformation in the organisation.

Correlations were also shown between the level of digital transformation of an HEI and the institution's authorities' emphasis on the importance of digitalisation and digital transformation in building a competitive advantage in the education market, as well as the leader's active efforts towards digital transformation. A positive correlation was also observed between the level of digital transformation of HEIs and the active operation of leaders in the area of digitalisation, which confirms the observations of other researchers. The leader plays a key role in the process of digital transformation (Abbu et al., 2022; Antonopoulou et al., 2021), sets the digital direction (Masrur, 2021; Cifuentes-Álvarez, Vanderlinde, 2015), and should be involved in the digitalisation strategy (Holth, Boe, 2019).

Today, developing the competencies of digital leaders in HEIs is a strategic challenge for the academic world (Sułkowski, 2022; Ehlers, 2020), especially because many institutions are still culturally, mentally, and organisationally in a post-Humboldtian stage (Sułkowski, 2022). Management structures are based on a traditional hierarchical model, the level of academic entrepreneurship is still relatively low, and decisions are more often made centrally rather than according to a participatory model. Higher education institutions lag behind other businesses

and industries in terms of digital progress levels. Due to market pressures, other industries have likely been forced to start the transformation faster than HEIs (Rodríguez-Abitia, Bribiesca-Correa, 2021).

Conclusions

This study expands on previous research on digital leadership, in particular academic digital leadership, which is still under-explored. The literature review indicates a research gap in the area of digital academic leadership and its role in building the digital maturity of an HEI. The results of the study provide important insights and contribute to developing knowledge on the relationship between agile leadership practices and an HEI's digital transformation process. They provide a basis for further research and development of digitalisation strategies tailored to the specificities of higher education.

The results of the study may be applicable to the broader HEI population, but caution should be exercised in their generalisation due to certain limitations of the sample. The HEIs that took part in the survey were not a representative sample of Polish higher education and the population surveyed was also not representative of the institution in question. The typical limitation of a quantitative survey — the subjectivity of respondents' self-assessments — must also be taken into account.

The research certainly needs to be continued. In the course of further exploration, it would be worthwhile to supplement the research approach with mixed methods that offer opportunities for deeper analysis of the described phenomenon, e.g., document analysis or observation and interviews with university representatives, including leaders and people responsible for digitalisation in the institution. For this reason, there are plans to continue the research with a broader and more precisely selected sample and to utilise triangulation of quantitative methods and in-depth qualitative analysis.

The results of the study can provide valuable information for higher education institutions regarding the implementation of new digital leadership strategies. They can inform the design of academic leadership development programmes focused on developing an agile approach to management in educational institutions.

Implementation of effective leadership strategies can lead to increased innovation in higher education institutions, optimisation of educational processes, more effective use and implementation of information technologies and improvement of the quality of education, as well as increasing the competitiveness of Polish higher education in the global education market.

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THE ROLE OF INNOVATION IN THE STRATEGY OF RESIDENTIAL DEVELOPERS IN POLAND

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Purpose: Identification of the role of innovation in the activities of residential developers in Poland in the context of changes caused by the geopolitical crisis and EU legislative initiatives.
Design/methodology/approach: The work will present the innovative activities of residential developers and the changes that are taking place in this area in connection with the outbreak of the war in Ukraine and the introduction of EU regulations regarding broadly understood sustainable development. The above assumption was based on the research conducted using the CATI method, which involves interviewing respondents by telephone using a computer. The study focused on developers implementing residential projects characterized by the construction of multi-story, multi-family buildings and was conducted in August 2020 and November 2022.
Findings: The conducted analysis of the research results allowed for the diagnosis of a low level of innovation implementation by residential developers in Poland, technical and technological innovation as the dominant group in the innovation structure, clear problems with innovation project management, including risk management, and developers' needs in developing innovative activities.
Research limitations/implications: The article points to the need to introduce innovation in the housing market due to EU legislation and thus to develop a national system supporting the process of implementing innovation based primarily on public entities. Thus, the direction of future research on identifying the needs of developers in the development of innovation, especially in the context of the implemented EU legislation, was indicated.
Originality/value: The article identifies the state of innovation development in the primary residential real estate market, showing the state in November 2022, indicating the need to intensify tasks related to the development of innovation in the context of the "Fit for 55" regulation.

Keywords: innovation, residential developer, "Fit for 55" package, RES.

Category of the paper: Research paper.

Introduction

In 2004, following Poland's accession to the European Community (EU), the pace of changes taking place in the global economy became the driving force of economic development. Initially, this development in Poland was driven by the market conditions that were created within the EU, i.e., the free movement of goods, services, employment, business opportunities and cultural wealth, thus creating a single internal market of the EU (The internal market…, 2023).

Further dynamic development of global economies, the European Union and Poland is possible due to the introduction of innovation (Hult et al.,2004; Jin et al., 2004). Within the EU, innovativeness is perceived as a priority for the EU's development and competitiveness on global markets. Article 173 of the Treaty on the Functioning of the European Union (TFEU) (Art. 173, functioning of the EU, Dz.U. 2004) states that "The Union and the Member States shall ensure that the conditions necessary for the competitiveness of the EU's industry are met." The innovation policy is consistent with other EU development strategies and developed consequently in subsequent years. Under the Lisbon Strategy in the years 2000-2020 (Lisbon Strategy, 2000), the Europe 2020 Strategy for smart, sustainable, and inclusive growth in the years 2010-2020, and currently as part of a sustainable Europe by 2030 and initiatives such as the Green Deal, and thus the Fit for 55, the European Union clearly places emphasis on sustainable development, ecological transformation and achieving climate neutrality, which is possible by implementing innovation (Innovation policy, 2023).

The above states that the changes regarding green transformation will largely concern the real estate sector, because this sector is highly energy-intensive and responsible for a large share of greenhouse gas emissions. (Thompson, 2015). Moreover, the changes also apply to the banking sector, which, due to the high capital intensity of real estate, largely funds investments in this sector.

Sustainable finance (European Securities…, 2018; Krukowska, 2021; School of Energy, 2022), which will concern banking activities, including granting mortgage loans, is to redirect the funding stream to activities aimed at achieving the objectives of sustainable development. This will translate into the possibility of financing only sustainable construction with a mortgage loan, i.e., buildings with low or zero emission and energy consumption (Hamilton et al., 2016).

Another factor stimulating the development of innovation in the real estate market is the geopolitical situation, namely the armed conflict in Ukraine. Russia's attack on Ukraine, which took the form of a full-scale war that began on 24 February 2022, had serious consequences throughout the world economy, in the economies of EU countries, and particularly in countries directly adjacent to the conflict, such as Poland. A direct consequence of Russia's invasion of Ukraine was a dynamic and sudden increase in the prices

of raw materials, especially energy resources, such as crude oil, natural gas and coal, of which Russia is a strategic exporter. The situation was even more serious because the main supplier of energy raw materials to the EU was Russia, which, combined with the subsequent restrictions introduced, such as an embargo on imports of individual raw materials from Russia, resulted in a cascading increase in their prices as well as the risk of energy security. The above was another factor in the increasing importance of innovation, in this case especially regarding renewable energy sources ensuring not only climate neutrality but also energy security (Colgan et al., 2023).

The presented circumstances were the incentive to raise the subject of this article relating to the issue of innovative activities carried out in residential development projects. The objective of the article was to identify the role of innovation in the activities of residential developers in Poland in the context of changes caused by the geopolitical crisis and EU legislative initiatives.

The work presents a review of literature covering the issues of innovation in the real estate market, legislative initiatives undertaken by the EU, especially in terms of innovation, climate and energy policies, and the consequences of the conflict in Ukraine in the economy and state policy. Having analyzed the existing state of knowledge, the research method was presented, used to accomplish the objective of the work. The author's own survey was used, conducted among residential developers in Poland in the second half of 2020 and in the second half of 2022. Then, the research results in the analyzed area were presented and a discussion was held in the context of the previously included literature review. At the end of the work, the conclusions were drawn and directions for future research were proposed.

Definition of sustainable construction in the light of the EU

The idea of sustainable development (Sustainable Development Goals, 2015) has accompanied society for many years. In 1987, its concept was presented in the Report of the World Commission on Environment and Development (Brundtland Commission, 2021). Sustainable development assumes intergenerational solidarity, and thus, when satisfying their needs, current generations should take into account the needs of future generations.

The definition of sustainable development is included in the Report of the World Commission on Environment and Development (Brundtland Commission, 2021), where sustainable development is described as "the development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

Initially, in the context of the principle of sustainable development, only the need to limit the negative impact of the economy on the natural environment was discussed. Today, the discussion related to sustainable development is not only about environmental

protection, but also about the issues of social progress and economic growth. These three elements are interconnected and together may lead to the prosperity of current and future generations. The first actions regarding sustainable development in a global context are already being taken. The "2030 Agenda for Sustainable Development" (What is sustainable development-..., 2022), adopted by 193 UN member states, contains 17 goals and 169 tasks to be implemented. The 17 Goals campaign was signed by the leaders of UN member states in the document "Transforming our world: 2030 Agenda for Sustainable Development" at the summit in New York in 2015. Its assumption is to transform the world with respect for the environment, with future generations in mind and taking into account the needs of the least privileged social groups. Declared countries have an obligation to introduce and monitor sustainable development in 5 areas: people, planet, prosperity, peace, partnership (5xP).

In the case of the EU, actions for sustainable development were undertaken much earlier and with greater intensity. The leitmotif of the Europe 2020 Strategy was development which is to be smart, sustainable, and socially inclusive. These goals were to be achieved, among others, by strengthening the position of innovation in the EU and then its implementation. The Innovation Union was established, one of the seven flagship initiatives under the Europe 2020 Strategy, which was intended to improve the conditions for funding research and innovation in the EU and enable the use of innovative ideas for real products and services to increase economic growth and the number of jobs. In 2022, the Commission adopted the new European Innovation Plan, proposing 25 specific actions in five priority areas: funding scale-ups; enabling innovation through experimentation spaces and public procurement; accelerating and strengthening innovation in European Innovation Ecosystems across the EU.

Another extremely important document from the point of view of sustainable development and thus the implementation of innovation in the real estate sector is the Green Deal (Green Deal, 2022). The European Green Deal is a package of policy initiatives which aims at putting the EU on a green transition path and ultimately achieving climate neutrality by 2050. It supports the transformation of the EU into a fair and prosperous society with a modern and competitive economy, stresses the need for a holistic and cross-sectoral approach in which all relevant policy areas contribute to achieving the overarching climate objective. The package includes initiatives in a range of closely interconnected areas, such as climate, environment, energy, transport, industry, agriculture, and sustainable finance. The Fit for 55 package (Fit for 55, 2023) is to translate the climate ambitions of the Green Deal into specific regulations. The European climate law includes a mandatory EU climate goal: reducing emissions in the EU by at least 55% by 2030. EU countries are working on new regulations that will help achieve this goal and make the EU climate neutral by 2050.

Figure 1. How the European Union will reduce its greenhouse emissions by at least 55% by 2030. Source: (Fit for 55, 2023).

As can be seen in Figure 1, the Fit for 55 package covers many aspects of business, including, among others, construction. In EU activities, green construction has the status of a leading industry with key importance for energy savings using energy from renewable sources, minimizing greenhouse gas emissions, reducing the adverse impact on the climate and the natural environment, as well as on the health and condition of building users. Buildings account for 40% of energy consumption in the EU and 36% of energy-related direct and indirect greenhouse gas emissions (Kedir, Hall, 2021).

Until recently, the most important European document on sustainable construction was the 2012/27/UE Directive of 25 October 2012 on energy efficiency. The priority is to rationalize energy consumption, and the directive addresses the issue of auditing buildings in terms of their energy efficiency and specifies in detail the process of inspecting heating and air-conditioning devices and installations, etc. (Grondys et al., 2020). Currently, as part of the Fit for 55 package, an amendment to the EU Energy Efficiency Directive has been proposed, which was accepted on 25 July 2023 (Fit for 55 council agrees on stricter rules, 2023). Its main objective is to reduce final energy consumption at the EU level by 11.7% by 2030 compared to 2020 forecasts. The new regulations on the energy performance of buildings also assume that:

- from 2028 new buildings owned by public authorities will have to be emission-free,
- from 2030 all new buildings will be emission-free,
- from 2030 all new buildings will have to have energy certificates,
- from 2033 all existing residential buildings will have to achieve D energy class (250-344 kWh - single-family buildings and 223-305 kWh per square meter - multi-family buildings),
- by 2050 all existing buildings will be converted into zero-emission buildings.

Obviously, appropriate tools will be launched to achieve these ambitious goals, such as financial assistance, tax reliefs and administrative assistance.

It should be emphasized that the consequence of the adoption of the Energy Efficiency Directive is the introduction of the ban on the sale and rental of apartments that do not meet the requirements for generating a carbon footprint. The idea is to motivate the owners of the existing buildings to make thermal modernization investments (the EU EPBD Directive in Poland will be implemented from January 2024), while the ban on the sale and rental of real estate not meeting energy standards will result in earlier large investments in the thermal modernization of a building or an apartment. This directive will be significant in the case of introducing innovation into residential construction.

Another element that will contribute to the need to implement innovation in residential development projects will be the introduction of legal changes regulating broadly understood sustainable finance. The Green Deal forces taking legislative initiatives aimed at redirecting the funding stream to activities aimed at implementing sustainable development goals. Legislation in the area of sustainable financing covers many issues, including:

- sustainable investments,
- ESG risk management,
- taking into account ESG factors in credit activities,
- taking into account ESG factors in the financial products offered,
- using ESG indicators and ratings,
- disclosing information on the impact of the financial institution's activities on achieving sustainable development goals,
- relationships with customers, business partners and owners,
- ESG due diligence,
- Green bond issuance.

As can be seen, the scope of activities regulated by sustainable finance is wide and includes credit activities and products shared, which will affect the need to implement such investment projects and development projects that meet the conditions for sustainable development, in this case construction (Nykvist, Maltais, 2020). The areas which are particularly important from the point of view of sustainable finance and real estate funding include:

- Taxonomies – criteria determining whether a given economic activity qualifies as contributing to achieving one of the environmental goals - adaptation to and mitigation of climate change.
- ESG risk disclosure – in accordance with the requirements of CRR Pillar III and climate risk management by banks.
- Preparing disclosures based on the CSRD directive - sustainability reporting.

Another important factor that influenced the global market and especially the situation in Poland was the official start of the war in Ukraine on 24 February. Russia, under the pretext of freeing Ukraine from the Nazis, decided to launch an attack which was called a special operation by Russian propaganda. The consequences of the invasion included air and sea

blockades and international responses from the UN, the Council of Europe, the European Union, and NATO. However, the reactions of states include military and cyberwar assistance for Ukraine, as well as the reaction of the international community.

Economic consequences of the war in Ukraine for Poland (Kolany, 2022) are:

- depreciation of the Polish zloty. The Polish currency remains almost record weak, significantly reducing the purchasing power of Poles' earnings and savings; it is an important pro-inflation factor,
- a significant increase in the prices of raw materials: oil, diesel oil, gasoline - i.e., an energy crisis and grain prices (wheat, corn, rapeseed, and coffee),
- higher inflation and higher loan installments,
- costs of supporting a significant increase in the wave of refugees from Ukraine,
- a significant increase in military spending in Poland as a frontline country.

The consequences of the invasion and the reactions of states were dictated by threats to the stability of the European economy (Figure 1). During the study (Fig. 1) carried out by Minds&Roses in 100 bank branches on behalf of the Polish Bank Association in July 2022, the bankers, when asked about the greatest threats to the stability of the European economy, indicated the conflict between Russia and Ukraine (33%), as well as high inflation (26%) (ZBP, 2022). The subsequent positions indicated dependence on energy carriers from Russia, internal problems in EU countries, as well as disintegration processes within the EU.

From the point of view of the topic discussed, the most important consequence of the war in Ukraine is the increase in prices of energy raw materials and, above all, the increase in the risk of supplies of such raw materials. This resulted in an even stronger emphasis on the development of renewable energy sources for the sake of energy self-sufficiency (Martinez-Garcia et al., 2023).

The real estate market is considered one of the most conservative, as shown by the last few decades. The most innovative markets must be those that are characterized by a high risk of losing asset liquidity. However, nowadays also in the real estate market, innovation allows for gaining a competitive advantage and generating higher income (Jiang, Payne, 2019; Maassen, 2017). Innovation is therefore an inherent element of a modern, efficiently functioning and developing real estate market. However, innovation is not uniform, thus its generic structure should be indicated. According to the OECD, we can distinguish four types of innovation: product innovation, process innovation, organizational and marketing innovation.

On the other hand, for the real estate sector, the distinguished groups of innovation depending on the activities conducted by business entities, in accordance with the works, can be characterized as follows:

- technical and technological innovation includes modern solutions used in construction,
- process and organizational innovation related to the implementation of technical innovation, legal changes in relation to the modern real estate market customer,

- marketing innovation as related to the strategy of both sales and distribution of products and services on the real estate market,
- financial innovation enabling real estate market entities to undertake investment activities using modern financial instruments.

All the above-mentioned types of innovation play a very important role, however, in the current reality of enormous changes in the geopolitical situation in the world initiated by the Russian invasion of Ukraine, technical and technological innovation, namely renewable energy sources (RES), are becoming particularly important. Increasing the production of electricity from renewable sources is not only pro-ecological activities, but also activities aimed at ensuring the energy security of countries, in particular those that are forced to import energy raw materials completely or partially.

Every type of activity - also in the real estate market - is burdened with risk and in each type of activity the risk must be taken into account. When innovation is introduced to the real estate market, new uncertainties and innovation risk appear [according to: (Knight, 1964), measurable uncertainties] (Abusalah, Tait, 2018). It must be recognized so that it can be managed, and its negative effects can be reduced. Generally, the risk of innovation activities related to the implementation of innovation is defined as the risk of occurrence of threats and consequences (Sitek, 2013). Therefore, the basis for making investment decisions is the relationship, the proportion between risk and achievable income (Sipa, 2017).

The research by Zhang which indicated that one of the factors driving innovation in the Chinese real estate market is risk, is very interesting. It shows that risk has a positive impact on companies' innovation performance, including investments in research and development, innovation level, and other innovation performance (Zhang, 2020).

In the context of legislative changes implied by the Energy Efficiency Directive, it should be emphasized that in addition to implementing new projects, modernization of the existing resources is becoming more important (Lowe, Chiu, 2020). The modernization market in the light of the new directive will certainly expand significantly. Killip and Owen claim that in order to examine the process of implementation of investments in the real estate market, most often the secondary one, it is necessary to analyze two markets: the first market of repair, maintenance and improvement (RMI) of houses, in which the efficiency energy, and thus introducing innovation, is not the most important issue; and the second market of deep modernization, where the main goal is energy efficiency, and thus the implementation of innovation (Killip, Owen, 2020). The first RMI market is dominated by small and medium-sized enterprises, especially micro-enterprises, operating on local markets. These companies do not maximize profits or focus on the energy efficiency of buildings. In the second market, companies are focused on energy efficiency, and these are usually large enterprises cooperating on the regional and national market. The same situation occurs in the primary residential market.

Developers, including residential ones, carry out various projects, ranging from the construction of apartments on undeveloped land in new locations, reconstruction, and modernization of existing resources, as well as reconstruction, modernization and adaptation of buildings originally intended for a different purpose into residential space, e.g., lofts. Brown distinguishes several elements of a successful modernization management model. He points to value as the guiding principle of innovation management, assuming that value must be based on comfort, well-being, health, and aesthetics. He also notes the very current issue of energy saving guarantee and the integrated supply chains associated with the savings that can provide a "whole-home approach". The above elements distinguished by Brown concern an integrated, low-cost model of funding such projects and a single point of contact with the client. He also pays special attention to the coordination of all the elements he specifies (Brown, 2018).

As can be seen, innovation is an inherent element of a successful project management model. The use of ecological (healthy) building materials, renewable energy sources, providing as many door-to-door services as possible as part of a whole-home approach to residential space, and financial innovation are some examples of value creation in the investment management process on the residential market (Rossiter, Smith, 2018).

Materials and methods

The study of innovation among developers of the primary residential market, the motives for their implementation, and the changes that have occurred in this field in recent years was based on the research conducted using the CATI method, one of the modern research methods used in quantitative research, which involves conducting phone interviews with respondents using a computer. The answers to the questions were also expected about the extent to which entrepreneurs manage investments in activities conducted and whether they include them in their strategies. The study focused on developers implementing residential projects characterized by the construction of multi-story, multi-family buildings. In this case, the criterion that narrowed the general population was the selection of only developers who carry out construction projects of multi-story, multi-family residential real estate. Therefore, the study was not limited to one group of developers, e.g., medium-sized enterprises, but both small, medium-sized, and large enterprises were examined, because the selection criterion was the capital strength of enterprises, i.e., the implementation of large residential projects. Such research was decided on because even developers classified as small enterprises implement large investment projects in Poland, involving subcontractors in their projects. The study was conducted twice at a 2-year interval.

The first study was conducted in August 2020 on a research sample of 130 respondents with a total population of 314 entities identified at that time. Subsequently, at the turn of October and November 2022, another survey was conducted using the same method on a sample of 98 respondents selected from the total population of 280 entities. The conducted research allowed for the identification and analysis of developers' perception of innovation in the period before and after the outbreak of the war in Ukraine. It should be emphasized, however, that the study was conducted before the approval of the EU Energy Efficiency Directive (25 July 2023), which probably increased the importance of innovation for developers.

Results and discussion

The survey concerned the research on innovation in development compamies operating on the primary real estate market. Innovation research among residential construction companies on the primary market was carried out in August 2020 as well as in November 2022. The survey among enterprises was conducted using the CATI—Computer Assisted Telephone Interview method. Research using this technique is often used to develop a company's strategy or marketing activities. The study was conducted on a nationwide sample. The research sample, in 2020, consisted of 130 entities, with the general population constituting (±5%) 324 entities building multi-storey, multi-family houses in Poland (figure 2).

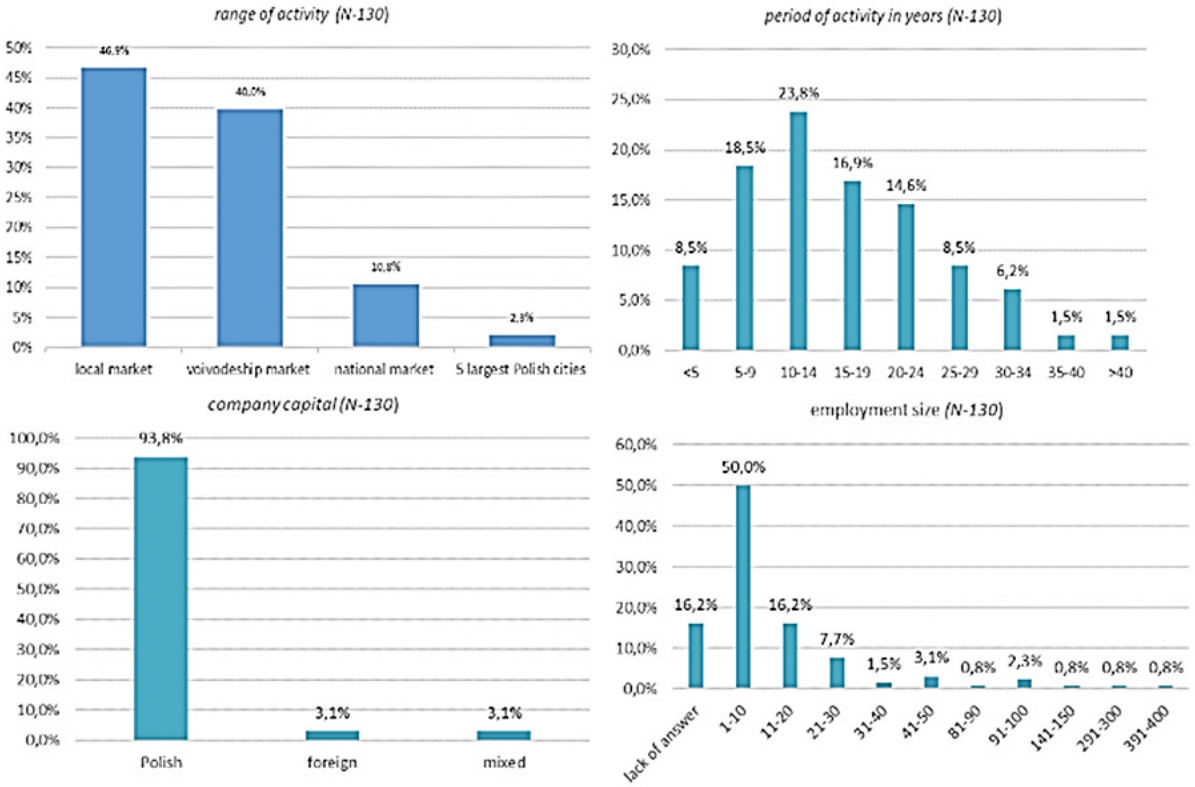


Figure 2. The research sample in 2020.
Source: author`s elaboration.

The research sample, in 2022, consisted of 98 entities, with the general population constituting (±5%) 280 entities building multi-storey, multi-family houses in Poland (figure 3).

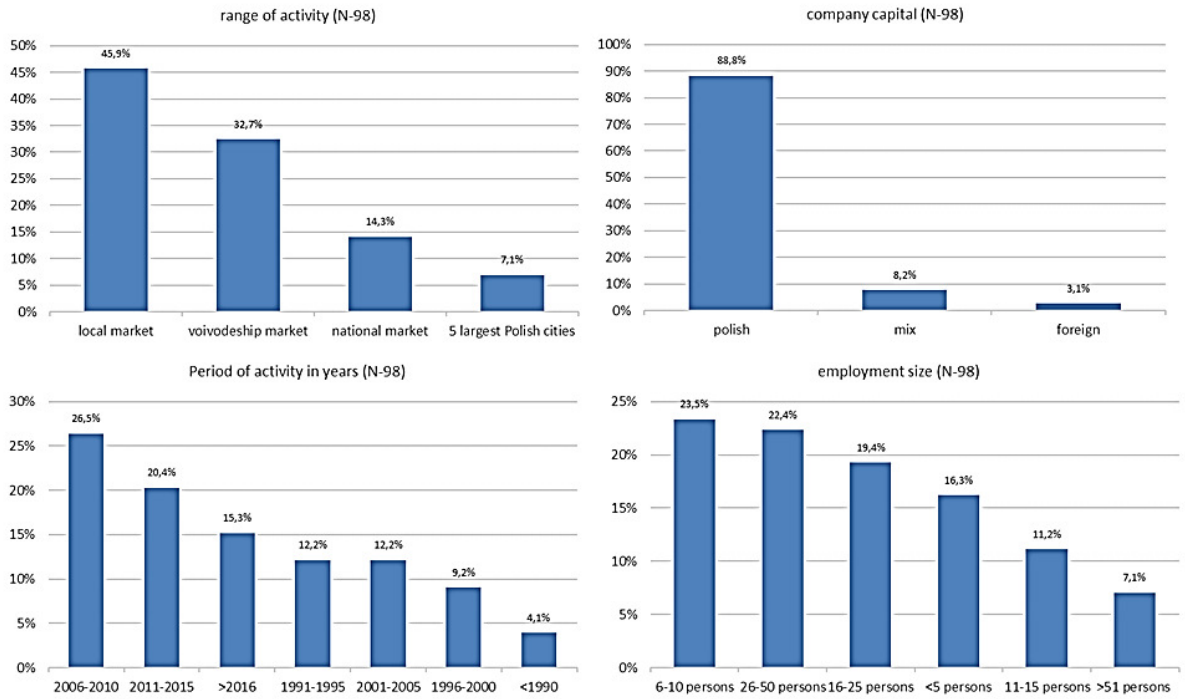
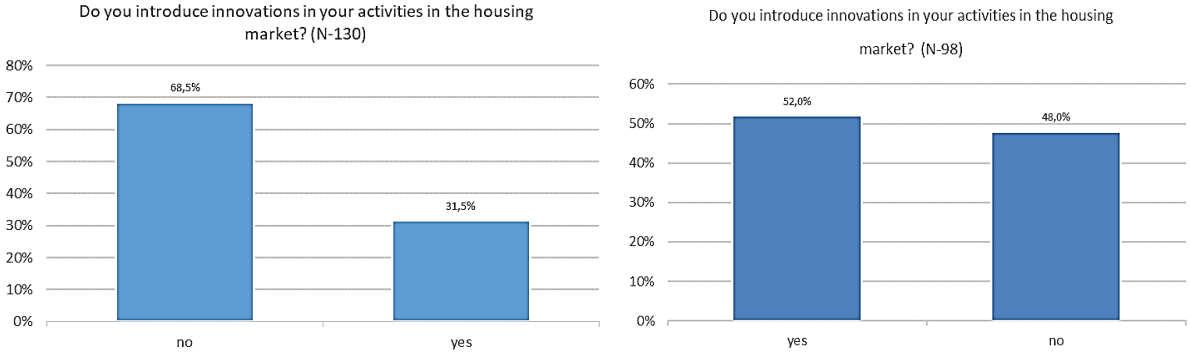


Figure 3. The research sample in 2022.

Source: author`s elaboration.

In terms of the introduction of innovation to the real estate market, in 2020, 31.5% of developers responded positively, while in 2022, 52% of the surveyed developers confirmed the introduction of innovation in their activities. As can be seen, the number of developers declaring the introduction of innovation in their investment projects increased significantly (figure 4).



a) survey 2020 b) survey 2022

Figure 4. Do you introduce innovations in your activities in the housing market?

Source: author`s elaboration.

The low percentage of enterprises declaring the introduction of innovation in 2020 was determined primarily by 3 main factors, namely the fact that customers choose standard construction, i.e., no demand - 23.6%, followed by preference for proven solutions - 22.5% and high costs of innovation 15.7%. On the other hand, as the three main determinants of not implementing innovation in their activities, in 2022, developers considered the lack of such a need - 23.4%, a difficult market situation - 23.4% and the lack of innovative projects. This shows, firstly, that the awareness of the need to introduce innovation by residential developers is high, which results in an increase in the number of enterprises declaring the introduction of innovation and, secondly, that despite the continued importance of the lack of demand/need and the preference for proven solutions, high investment costs were not indicated in 2022 as one of the main determinants of the lack of implementation of innovation. This situation shows that the EU in particular provided decision-makers with tools for funding innovation and that entrepreneurs are looking for information about such tools, increasing their knowledge and experience in this area, and are more willing to use them. Additionally, comparing studies from 2020 and 2022, it can be seen that in the later study, the respondents clearly indicate a difficult market situation. This indication can be explained by the consequences of the war in Ukraine, namely an increase in costs for developers combined with a decline in demand. The decline in demand was caused by high inflation and, consequently, high interest rates and limited access to mortgage loans. On the other hand, the increase in costs was caused by the high price of raw materials, which translated into an increase in the prices of construction materials. Here, it is possible to point out, on the one hand, a huge increase in the price of coking coal and, consequently, steel, but also, on the other hand, the prices of, e.g., wood, which was imported in large quantities in Poland, among others, from Ukraine.

It is impossible not to mention that the most important factor indicated by the respondents in both studies, i.e., the lack of need/demand, changed dramatically in July 2023 in connection with the adoption of the Energy Efficiency Directive. This directive imposes such a need from above, i.e., it determines the demand for sustainable construction, where buildings should be energy self-sufficient and even generate a surplus of energy obtained, obviously, from renewable sources. It can be expected that this will result in a very high increase in enterprises declaring the introduction of innovation.

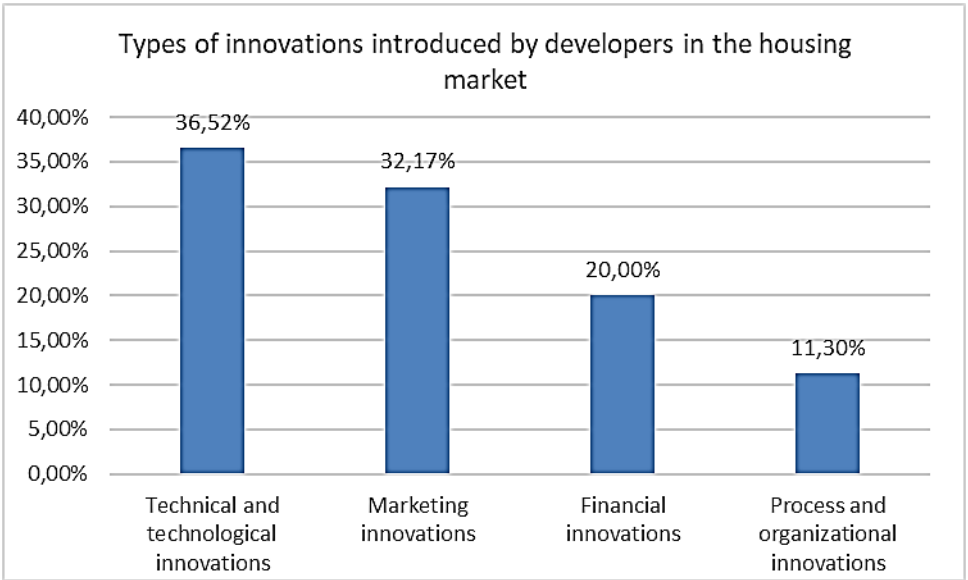


Figure 5. Types of innovations introduced by developers in the housing market.
Source: author`s elaboration.

Another important question answered by developers was the question about the type of innovation introduced by them (figure 5). They agreed that the most frequently introduced innovation belongs to the group of technical and technological innovation (36.52%), marketing (32.17%), financial (20%), and process and organizational innovation (11.3%). In 2020, the types of innovation applied were as follows: technical and technological - 39%, marketing - 25%, financial - 9%, and a surprising indication of process and organizational - 27%. Invariably, the most important and most frequently used innovation is technical and technological. It seems understandable due to the fact that this group includes renewable energy sources, specific materials and construction techniques. This group of innovation allows for a real reduction in the subsequent real estate operating costs, which is why customers pay attention to this. It can be concluded that in the event of the implementation of EU regulations related to the "Fit for 55", the role of technical and technological innovation will increase even further. When comparing the results obtained from the respondents in two studies, it can be seen that the group of marketing innovation is invariably chosen by developers quite often, which may be related to progress in the product presentation by using drones or virtual presentations to achieve a better presentation of the object. Introducing marketing innovation is relatively low-cost and produces measurable effects. There is a clear difference in the implementation of financial, process and organizational innovation presented in both studies. In 2020, process and organizational innovation constituted a large group, obtaining 27% of responses, and financial innovation - 9%, which could be due to the fact that at that time the interest rates on loans were low and, therefore, access to conventional financing was wide and additionally, in 2022, as already mentioned, the respondents emphasized the difficult market situation, which was caused, among others, by the weak demand due to expensive credit. This situation could have been the reason for looking for alternative ways of funding real estate, starting from offering long-term rental with an option of later purchase of an apartment.

The respondents also indicated another aspect of innovative activity, namely whether they adopt innovation created by other entities or create it themselves. Both in 2020 and 2022, the majority of the respondents answered that they adopted innovation already introduced to the market. Despite similar results, it should be noted that in 2022, approximately 22% of the respondents declared that they were working on new innovation themselves, and in 2020, approximately 17%. The increase in 2022 compared to 2020 is very small, which allows for the conclusion that further activities related to the "production" of innovation are necessary not only in the real estate market but also in the entire economy.

The research also showed that developers, by introducing innovation in their projects, are able to obtain a higher sales price for apartments and even sell them faster. From the point of view of the real estate market, this is extremely important due to the low liquidity of real estate.

As indicated by the research results, developers see the advantages of implementing innovation, and what is more, they are aware of the need to implement it and the risk of bankruptcy if they do not implement innovation. Therefore, the vast majority of the respondents admitted that they introduced an aspect of implementing innovation into their strategies, thus emphasizing its importance in their activities (figure 6). In 2020, 85.4% declared including innovation in their strategy and in 2022 - 84.3%. According to the developers, the main factor determining this situation was the desire to achieve a leading position on the market among competitors, the need to adapt apartments to the level offered by competitors, and in 2020, they additionally indicated the desire to be characterized by above-average quality.

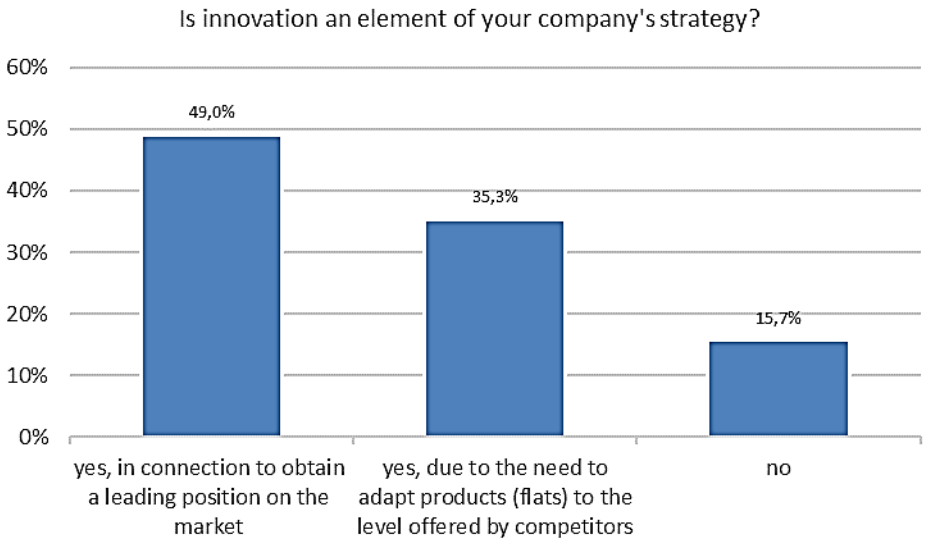


Figure 6. Is innovation an element of your company's strategy?

Source: author`s elaboration.

Residential developers in Poland see the advantages of implementing innovation, they also see the risk of not implementing it, especially in the long term, which is reflected in the strategies. Therefore, why do about half of them admit that they do not implement

innovation? It seems probable that the broadly understood market did not exert adequate pressure on developers, encouraging them to compete more strongly using innovation. Despite the rapid development of the real estate market, we are still talking about a shortage of apartments in Poland, which may cause this situation. Additionally, the process of implementing innovation is not simple and often unknown to developers, making them not reach for new solutions. The respondents in both studies clearly confirmed that implementing innovation results in difficulties in managing such projects (figure 7).

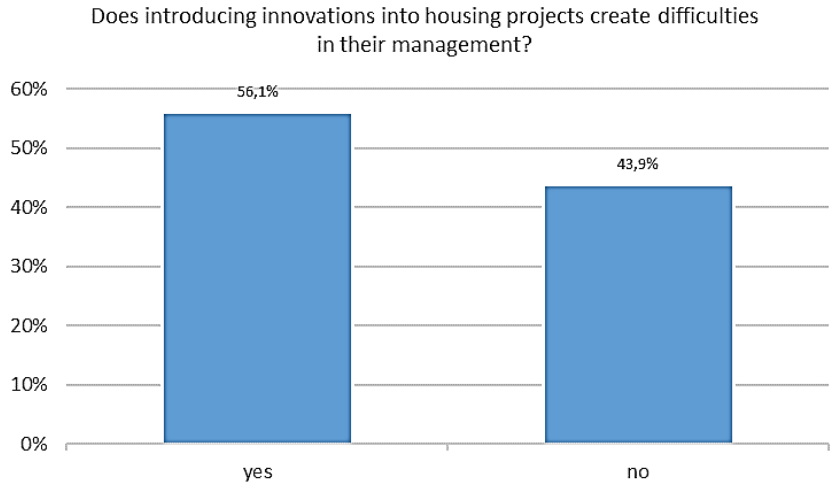


Figure 7. Does introducing innovations into housing projects create difficulties in their management? Source: author`s elaboration.

These difficulties appear both at the stage of managing a single project and a portfolio of projects. Developers confirm that they gradually introduce innovation to their portfolio, much less often they implement all available innovation to all their projects and least often to one project.

More than half of the surveyed developers in 2022 declaring the introduction of innovation do this gradually and as part of various projects (figure 8). In 2020, it was declared respectively: 40.6% gradually introduced innovation as part of implemented projects, 31.2% introduced all possible/available innovation as part of implemented projects and 28.2% introduced all available/possible innovation within one implemented project. This approach to the implementation of innovation confirms that it is not an easy process and managers encounter problems in managing it. These problems often result from inadequate risk management of such innovation or even the lack thereof. The 2020 study showed that about half of the respondents (49%) did not measure risk as part of the implementation of innovation, 41.5% estimate risk intuitively and only about 10% use specialized tools for this purpose. In 2022 developers responded very similarly: 49% measured intuitively, 39% did not measure such risk at all, and only 12% used specialized tools for this purpose.

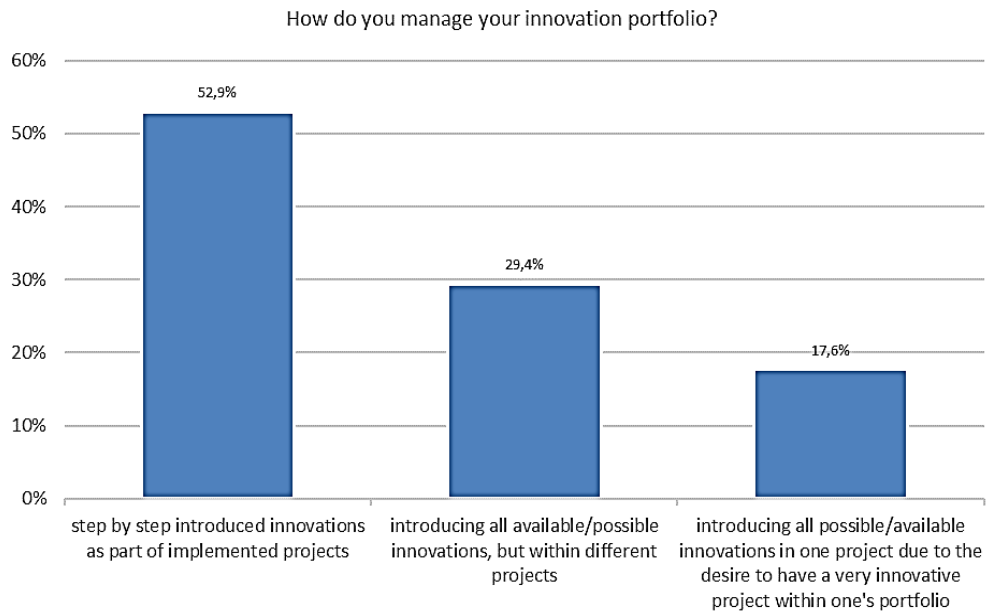


Figure 8. How do you manage your innovation portfolio.
Source: author`s elaboration.

As presented, developers in Poland point to clear problems in managing innovative projects. Over the two years separating both studies, this state of affairs practically did not change. This indicates that the process of achieving appropriate and comprehensive management of innovative projects on the residential market in Poland will be long-lasting. On the other hand, the legal changes initiated by the EU described in the literature review will confront developers with the fact of implementing innovation in their projects. This will not happen immediately, but within the next few years, which is not a long time in the real estate market. Therefore, developers should adapt as quickly as possible to future changes not only in terms of innovation project management but also in terms of the creation and implementation of innovation. Here, an important role can be seen in the assistance from the state and the EU, which develops tools, such as funding such activities. The developers themselves indicated that they need the support of other external entities, especially public ones, to develop innovative activities on the Polish market (figure 9).

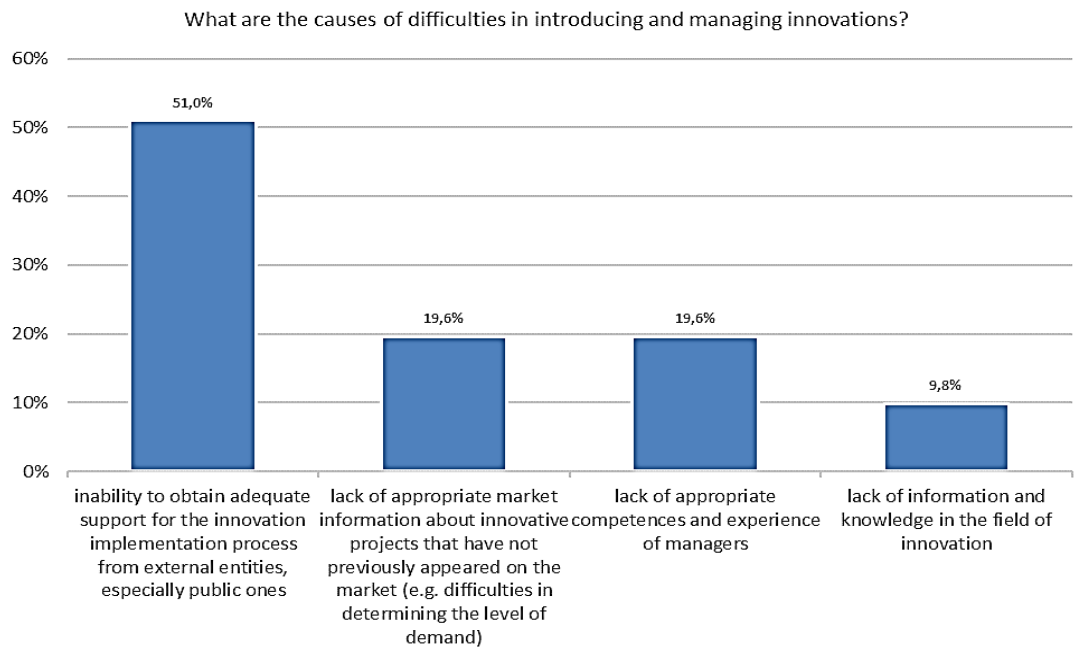


Figure 9. What are the causes of difficulties in introducing and managing innovations?
Source: author`s elaboration.

This suggests that assistance, especially in creating and developing innovation, should be directed to research centers and universities, which, in cooperation with enterprises, would create innovation aimed at business.

Conclusions

The interpretation of the primary research conducted in the work, concerning innovation in the activities of residential developers in Poland in 2020 and 2022 and the literature review presented in the work allowed for the accomplishment of the work's objective, which is to identify the role of innovation in the activities of residential developers in Poland in the context of changes caused by the geopolitical crisis, including RES. The survey described above, conducted before and after the outbreak of the war in Ukraine, allowed for the identification of changes in the perception of innovation. The paper also presents the directions of changes set out by EU directives, which will undoubtedly influence the perception of innovation by residential developers. It should be noted that the second study conducted in November 2022 does not fully capture the impact of EU legislative initiatives because, despite the existence of projects and outlined directions of change, one of the most important directives from the point of view of the real estate market, namely the Energy Efficiency Directive, was adopted in July 2023. The presented research allowed for formulating the following conclusions:

- Identification of the number of residential developers with adequate capital strength to implement projects for the construction of multi-family, multi-story residential properties showed that in 2022 there were fewer of these enterprises than in 2020 (44 entities less), which could be due to difficult market conditions, which was also emphasized by the respondents in the period after the outbreak of the war in Ukraine.
- Despite the decline in the number of selected entities in the general population, an increase in the number of developers declaring the introduction of innovation was observed. This shows the positive direction of development of the Polish housing market and the awareness of importance of innovation among developers. Moreover, the hypothesis can be formulated that due to market difficulties, enterprises that did not introduce innovation disappeared from the market, and therefore in 2022 the research sample was characterized by a higher share of entities introducing innovation.
- The persistently high percentage of developers not introducing innovation in their activities is determined primarily by the lack of demand/need to introduce innovation. In 2022, the respondents also indicated difficult market conditions as a reason for not implementing innovation. In the context of the described changes related to the "Fit for 55" package and the adopted directives, it can be freely stated that the basic determinant, i.e., the lack of need to introduce innovation, has taken a 180-degree turn. In the coming years, it is not even the need, but the necessity to introduce innovation that will drive their development and implementation.
- Invariably (in 2020 and 2022), the most important and most frequently applied innovation is that from the technical and technological group. This seems understandable due to the fact that this group includes renewable energy sources, specific materials and construction techniques. This group of innovation allows for a real reduction in the subsequent operating costs of real estate, which is why customers pay attention to it. It can be concluded that in the event of the implementation of EU regulations related to the “Fit for 55” and the experience of fluctuations in the prices of energy raw materials and the security of their supplies in connection with the conflict in Ukraine, the role of technical and technological innovation will increase even further.
- The respondents also point to the positive effects of involving innovation in their projects, such as higher prices of apartments and faster sales. They also declare that they understand that innovation may give them a competitive advantage and failure to implement it increases the risk of bankruptcy. Therefore, they introduce elements of innovation in their strategies. Obtaining a competitive advantage and thus a leading position on the market was considered the main factor for including innovation in strategies. It can therefore be concluded that stronger competition will increase developers’ interest in innovation. In the current situation of a huge increase in the interest in apartments due to, among others, 2% mortgage loan with state subsidies, an increase in new investments and an increase in entrepreneurs’ interest in development activities should be expected.

- The respondents declare that introducing innovation creates problems in managing development projects. Therefore, the development of knowledge, support, and transfer of know-how in the process of managing innovative projects seems important. Therefore, the respondents declare that they introduce innovation gradually in their projects, which allows them to better monitor the process of its implementation, and thus react in the event of unforeseen events.
- The respondents clearly indicate the need to obtain appropriate support in the process of implementing innovation from external entities, especially public ones. Although the EU is trying to create tools to support innovation, it is clearly visible that a systemic change is needed at the country level, i.e., Poland. This process will certainly be long-term, but properly prepared, involving Polish research units and universities, it would allow for the creation of innovation and not only its adaptation.

The analyzes undertaken also showed a possible direction for future research. It is worth deepening the study in the part regarding the role of renewable energy sources in future development projects and the modernization of the existing resource in the context of the "Fit for 55" package. Moreover, in the current situation, the most important thing is to identify the needs of developers in the process of implementing innovation in the context of providing them with appropriate support and preparation for the implementation of innovative projects that can meet the current and future requirements of sustainable development.

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MIREL CONCEPT-ALIGNED TOOL FOR ANALYSING EMPLOYEE PARTICIPATION IN PROJECTS

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Purpose: The main purpose of the study is to develop and present a spreadsheet-based tool aligned with the MiRel concept to support data processing process in the analysis of employee participation in project implementation by automating the generation of a required report. The process for which the tool is created is an actual process implemented in an organisation operating on the market.
Design/methodology/approach: The process in which a required report is generated has been analysed with particular attention to the data structure typical of the problem in question. The entities it contains along with the associated attributes have been identified. Connections between individual entities have been illustrated using an entity relationship model. The author has proposed methods for both data entry as well as entity representation in the spreadsheet-based tool. Mechanisms employed to transfer data from a form to tables representing individual entities have been discussed. The process in which the required report is created has been divided into a number of steps. For each of them, a target effect has been defined and specific mechanisms enabling the target to be attained have been proposed.
Findings: A spreadsheet provides an utterly sufficient environment to create a tool supporting the process subject to the research. Such a tool can be successfully created in line with the MiRel concept. Despite the fact that the required report in question is strictly defined in terms of its graphical form that does not match the charts and graphic elements available in MS Excel, it is possible to generate it automatically without having to use the VBA code. Its adequate graphical form can be obtained by means of conditional formatting provided that data have been correctly arranged in cells. Where the report is to be generated in a purely graphical form, the tool in question can be expanded with a relatively simple VBA procedure enabling such a report to be generated on the basis of its current form.
Practical implications: The solution proposed in the paper can be successfully applied in practice to support the process analysed.
Social implications: The solution proposed in the paper makes it possible to streamline the performance of the process analysed by relieving employees of the laborious and repeatable obligatory activities as well as reducing the risk of errors appearing in the report created in the process.
Originality/value: The concept described in the paper is the author's original solution.

Keywords: spreadsheet, database, data processing, improvement of information processes, project management.

Category of the paper: Case study and technical paper.

1. Introduction

At this day and age, information is one of the most precious resources of organisations, which is why one can successfully build competitive advantage by using it in a competent manner. With regard to the foregoing, effective implementation of processes in which information is generated, acquired, stored, processed, shared, interpreted, or utilised, or in other words – information processes (Oleński, 2001, 2002), is one of the key factors which determine the success of every business operating in the market.

Given the contemporary level of advancement of information technologies, a decided majority of information processes is implemented with adequate support from more or less sophisticated tools. And even though solutions of this kind are widely accessible, one can still come across processes where all or most of data processing is handled manually. The fact that the aforementioned processes continue to function nowadays may be attributable to the ever changing requirements pertaining to data logging and processing, introducing successive innovative data analysis concepts, the need to focus on a specific fraction of an enterprise in a more detailed manner than before, or the emergence of new and unprecedented issues. The necessity of handling information processes manually undoubtedly represents a serious problem, one which may potentially be solved by developing a dedicated IT tool on an in-house basis.

Needless to say that spreadsheets are definitely very universal and common tools, familiar to nearly all organisations. One can find numerous suggestions in the literature on the subject as to how they can be utilised in diverse operational areas. They prove particularly useful when employed to support information processes in matters such as finance, sales, or marketing management (Jackson, Staunton, 2004; Kusztelak, 2020; Winston, 2019; Próchnicki, 2012), work time organisation (Szczęśniak, 2010; Zasadzień et al., 2017), or quality management (Knight, 2009; Szczęśniak, Molenda, 2013; Szczęśniak, 2021).

The high flexibility of spreadsheets makes them suitable for both ongoing processing of the data sets in disposal and for designing dedicated tools to automate such a processing operation. A solution which supports the creation of such tools is the author's signature concept known as MiRel (Szczęśniak, 2017, 2018a, 2018b, 2020a). Its main pre-assumption is that spreadsheets are used to develop IT tools based on an explicitly defined relational data model. An example of a tool created in line with this concept to support the process of analysis of employee participation in the implementation of individual projects has been discussed further on in this paper. The presented description is a case study for a real problem identified in an organization operating on the market.

2. Characteristics of the process analysed

An information process identified within an organisation whose core operation boils down to performing construction-related project activities consists in generating a report containing a list of employees who participate in the implementation of individual projects. This report is developed into a diagram modelled on the one provided in Figure 1.

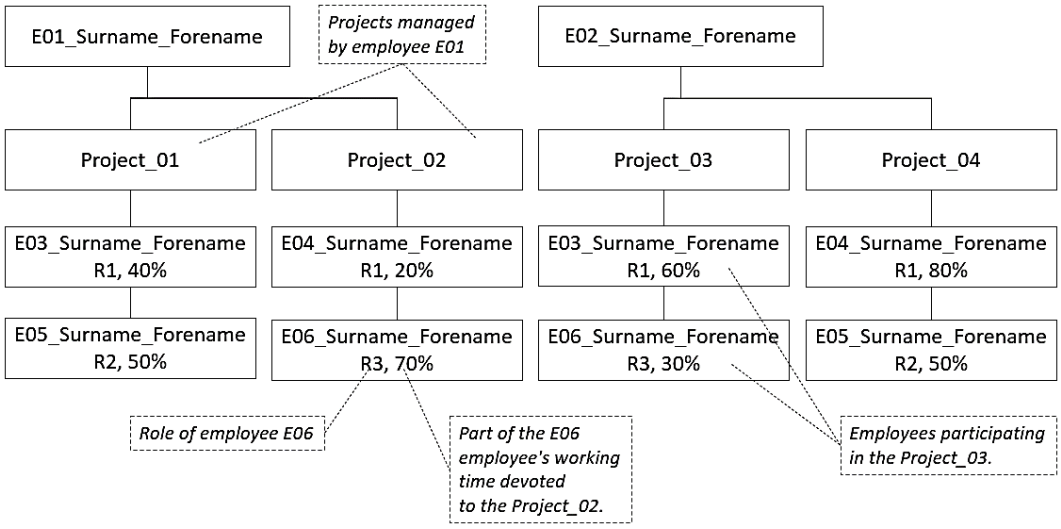


Figure 1. Structure of the report being generated.

It is developed with reference to data stored in a table whose layout has been shown in Figure 2.

Surname	Forname	Role	Projects				
			Project_01	Project_02	Project_03	Project_04	...
E01_Surname	E01_Forname	MN	1	1			...
E02_Surname	E02_Forname	MN			1	1	...
E03_Surname	E03_Forname	R1	0,4		0,6		...
E04_Surname	E04_Forname	R1		0,2		0,8	...
E05_Surname	E05_Forname	R2	0,5			0,5	...
E06_Surname	E06_Forname	R3		0,7	0,3		...
...	...	...	...	...	...	...	...

Figure 2. Structure of the table on which the report is based.

The report is created at the department level of the organization. One of the employees prepares data in the form of a table as shown in Figure 1. In this table, each project and each employee may appear only once. Each employee can play one specific role in the project. If it is a managerial role, this fact is simply marked in the table. If it is a different role, the table includes a number specifying how much of the employee's working time is spent on a given project. Based on the prepared table, the next employee prepares the final form of the report in accordance with Figure 2. In this report, individual roles should appear in a predetermined order. At the moment, the report is created manually. This activity is both

laborious and repeatable. Where this is the case, it seems to be a good solution to make sure that this process becomes fully automated, and to this end, a tool aligned with the MiRel concept and developed in a spreadsheet can prove particularly adequate.

3. Data structure applied in the tool

With regard to the problem in question, the following entities have been identified: role, project, employee, and employee-project. An instance of the *employee* entity represents an employee of a given organisation, while that of the *project* entity – a project implemented by the latter. An instance of the *role* entity refers to the role which an employee can perform under a project. An instance of the *employee-project* entity corresponds to the fact that a specific employee participates in a specific project. The links between individual entities as well as the attributes identified for them have been depicted in Figure 3.

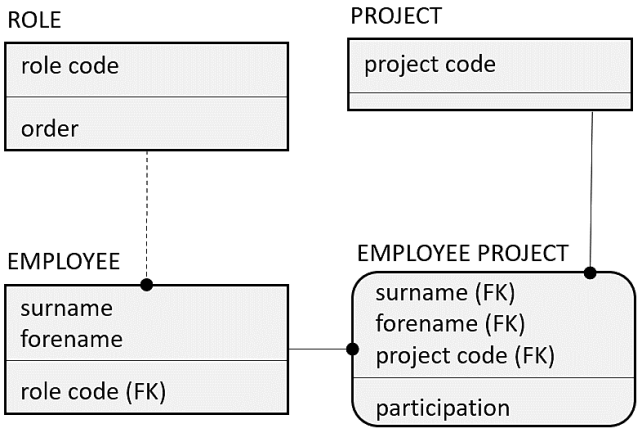


Figure 3. IDEF1x standard-compliant (Allen, 2006) model of inter-entity relations for the tool proposed.

The first of the attributes identified for entity *role* is *role code*. It is a two-letter identification code of the role an employee can perform under a project. The second attribute is *order*. The values it assumes are integers larger than 0. These numbers define the order in which an employee performing a given role will occur in the report being generated. The smaller the value, the sooner one occurs in the report. Exactly one role must take the value of 1 for attribute *order*. This role is considered as the main managerial role. Employees holding this role will occur in the upper section of the report. Other values of attribute *order*, i.e. those larger than 1, can reoccur. Another entity is that of *project*. For this entity, the only attribute which has been identified is a project-identifying code. For another entity, i.e. *employee*, three attributes have been identified. The first two of them are an employee's *surname* and *forename*. It has been assumed that a combination of *surname* and *forename* in the range analysed is unique, and consequently, these attributes form a composite primary key. The third attribute identified for this entity is *role code*, whose value defines the role a given employee performs under

projects. The last entity is *employee-project,* and four attributes have been defined for it. The first three are *surname*, *forename*, and *project code*. These attributes define the links between a given employee and a specific project, representing a composite primary key. The fourth attribute is that of *participation*. It takes numerical values larger than 0 and smaller than or equal to 1. The value of this attribute represents the fraction of a given employee's work which has been allocated to a given project. In the case of an employee assigned a role with the *order* attribute value of 1, the number 1 is entered irrespective of the number of projects which the given employee supervises.

Individual entities in the tool created as proposed are represented in conformity with type I of entity representation, as assumed under the MiRel concept, namely in the form of tables, as in a typical relational database. Each table has been placed in a separate worksheet whose name corresponds to the entity name. Their layout has been shown in Figure 4. One of the premises underlying the solution in question is that it can contain data of no more than 10 roles, 50 employees, and 20 projects. Consequently, it has been further assumed that, in worksheet Roles, data will be contained in rows 2 through 11, in worksheet Projects – in rows 2 through 21, while in worksheet Employees – in rows 2 through 51. What has also been envisaged is that no more than 500 employee assignments to projects can be entered in the tool, and therefore, in worksheet Employees_Projects, data can be contained in rows 2 through 501.

Worksheet: Roles

	A	B
1	RoleCode	Order
2	MN	1
3	R1	4
4	R2	3
5	R3	2
6	R4	5
7		
8		

Projects

	A
1	ProjectCode
2	P01
3	P02
4	P03
5	P04
6	P05
7	P06
8	

Employees

	A	B	C
1	Surname	Forename	Role
2	SN01	FN01	MN
3	SN02	FN02	R1
4	SN03	FN03	MN
5	SN01	FN02	R1
6	SN02	FN03	R2
7	SN03	FN01	MN
8	SN01	FN03	R3

Employees_Projects

	A	B	C	D
1	Surname	Forename	Project	Participation
2	SN01	FN01	P01	1
3	SN01	FN01	P04	1
4	SN01	FN01	P06	1
5	SN02	FN02	P01	0,3
6	SN02	FN02	P03	0,3
7	SN02	FN02	P05	0,4
8	SN03	FN03	P03	1

Figure 4. Representation of entities in the tool in question.

Where the tool in question is used, only the data in worksheet Roles are entered in the layout provided in Figure 4. All other data are entered in the form shown in Figure 5, conforming with the form currently filled while performing the process in question in a routine manner, and then, by way of suitable formulas, they are transferred to corresponding tables.

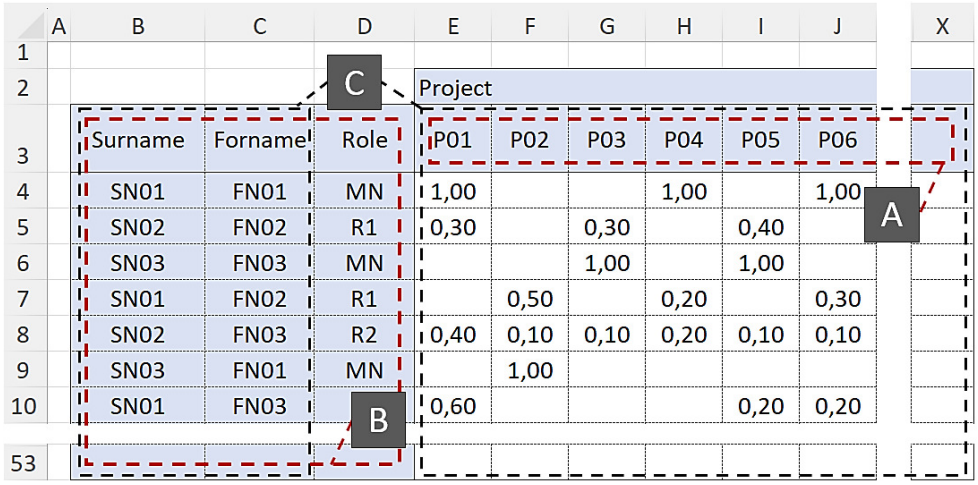


Figure 5. Layout of cells in worksheet Form with the highlighted ranges corresponding to individual tables.

This form is to be found in the worksheet titled Form. It is where one can identify the ranges corresponding to the tables shown in Figure 4. Range A corresponds to table Projects, range B corresponds to table Employees, and range C – to table Employees_Projects. The data layout within ranges A and B matches the data layout in the target tables, and so it suffices to employ simple formulas for data transfer purposes. In the case of range C, the form's data layout is compatible with type II of in-worksheet representation, and therefore, in order to transfer the data to the appropriate table compatible with type I of representation, one of the solutions proposed in the literature has been applied (Szczęśniak, 2018a). Under this solution, auxiliary table T1 has been added to worksheet Form and three auxiliary tables to worksheet Employees_Projects. Both the auxiliary column and its formula have been shown in Figure 6. In terms of how formulas are presented in the paper, it has been assumed that their form, as provided, is to be considered representative of the top left cell of the range in which they occur. For formula FA1 in auxiliary table T1, it is the form to be found in cell AA4.

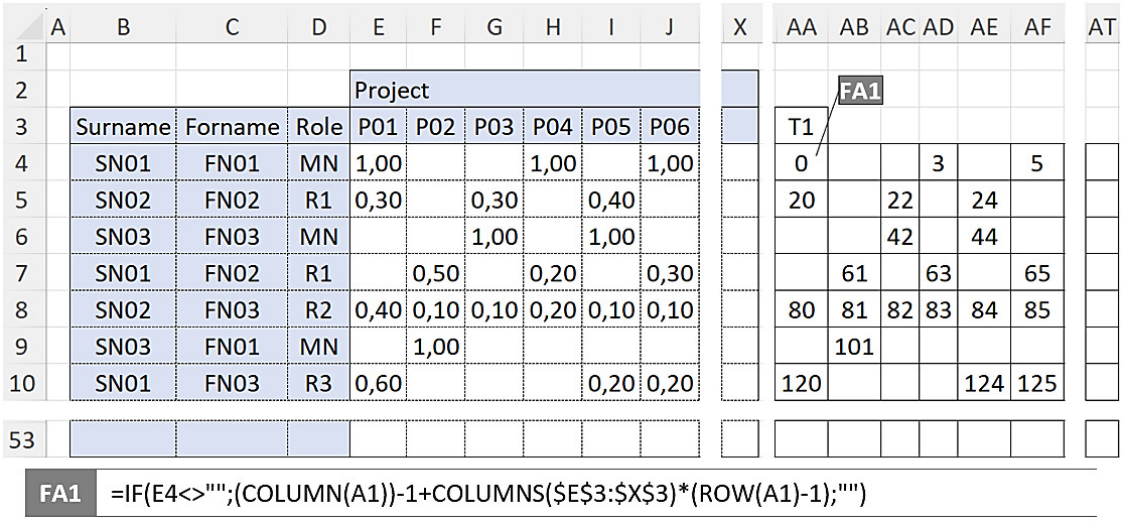


Figure 6. Cell layout and formula in an auxiliary table in worksheet Form.

Individual cells of the auxiliary table correspond to the form cells where the numbers representing the employee participation in the project implementation are entered. The number which conveys information about the row and column in the form where a value previously entered is to be found occurs in each auxiliary table cell if this value exists in the corresponding form cell. This number is entered according to formula 1:

$$n = a - 1 + d(b - 1) \tag{1}$$

where:

n – number entered in auxiliary table T1,

a – number of the current column within range E4:X53 in the form,

b – number of the current row within range E4:X53 in the form,

d – total number of columns in range E3:X3 in the form, representing the maximum number of projects which the tool may comprise.

The auxiliary columns in worksheet Employees_Projects along with their respective formulas have been shown in Figure 7.

	A	B	C	D	F	G	H
	FB4	F54	FB6	FB7	FB1	FB2	FB3
1	Surname	Forename	Project	Participation	C1	C2	C3
2	SN01	FN01	P01	1	0	1	1
3	SN01	FN01	P04	1	3	1	4
4	SN01	FN01	P06	1	5	1	6
5	SN02	FN02	P01	0,3	20	2	1
6	SN02	FN02	P03	0,3	22	2	3
7	SN02	FN02	P05	0,4	24	2	5
8	SN03	FN03	P03	1	42	3	3
501							

FB1	=IFERROR(SMALL(Form!$AA$4:$AT$53;ROW(A1));"")
FB2	=IF(F2<>"";ROUNDDOWN(F2/COLUMNS(Form!$E$3:$X$3);0)+1;"")
FB3	=IF(F2<>"";MOD(F2;COLUMNS(Form!$E$3:$X$3))+1;"")
FB4	=IF(F2<>"";INDEX(Form!$B$4:$B$53;Employees_Projects!G2;1);"")
FB5	=IF(F2<>"";INDEX(Form!$C$4:$C$53;Employees_Projects!G2;1);"")
FB6	=IF(F2<>"";INDEX(Form!$E$3:$X$3;1;Employees_Projects!H2);"")
FB7	=IF(F2<>"";INDEX(Form!$E$4:$X$53;Employees_Projects!G2;Employees_Projects!H2);"")

Figure 7. Layout of columns in worksheet Employees_Projects with the formulas applied.

In consecutive rows, formula FB1 returns consecutive numbers retrieved from auxiliary table T1. Based on these numbers, formula FB2 and formula FB3 identify the numerical designation of the form's row and column, respectively, from which corresponding data should be acquired. The row and column numbers are established according to formulas 2 and 3:

$$r = \left\lfloor \frac{n}{d} \right\rfloor + 1 \tag{2}$$

$$c = mod\left(\frac{n}{d}\right) + 1 \tag{3}$$

where:
r – number of the row in range E4:X53 in the form,
c – number of the column in range E4:X53 in the form,
n – numerical value returned by formula FB1 from auxiliary column C1,
d – total number of columns in range E3:X3 in the form, representing the maximum number of projects which the tool may comprise.

With reference to the row and column numbers previously identified, formulas FB4, FB5, FB6 and FB7 transfer the values of attributes Surname, Forename, Project, and Participation from the form to table Employees_Projects.

4. Generating the report

Based on the data collated in the layout corresponding to the one shown in Figure 4, the report envisaged in the analysed process is generated, as schematically depicted in Figure 1. The report generation process can be divided into a number of steps. The first one consists in identifying the employees who supervise projects as well as the projects assigned to these employees. In this step, auxiliary columns have been added in worksheets Employees and Employees_Projects. These columns, along with their respective formulas, have been shown in Figures 8, 9, and 10, respectively.

	A	B	C	E
				FC1
1	Surname	Forename	Role	C1
2	SN01	FN01	MN	SN01-FN01
3	SN02	FN02	R1	SN02-FN02
4	SN03	FN03	MN	SN03-FN03
5	SN01	FN02	R1	SN01-FN02
6	SN02	FN03	R2	SN02-FN03
7	SN03	FN01	MN	SN03-FN01
8	SN01	FN03	R3	SN01-FN03
51				

FC1 =IF(A2<>"";CONCAT(A2;"-";B2);"")

Figure 8. Auxiliary column in worksheet Employees.

Formula F1 to be found in the auxiliary column in worksheet Employees returns a code which constitutes a combination of the values of the attributes belonging to the primary key of the table. An identical code is generated in the auxiliary column in worksheet Employees_Projects by means of formula FD1. Formula FD2 returns the number of the row in worksheet Employees containing the code from the current row in worksheet Employees_Projects. It is from that row that formula FD3 retrieves the corresponding code of the employee role under a given project. Formula FD4 returns a number which specifies how many times the current code from auxiliary column C21 has occurred in the preceding rows of the worksheet as well as in the current one. Next, formula FD5 returns the value of 1 in the rows where the given code in column C21 occurs for the first time and the code in auxiliary column C23 is the code assigned the order of 1. These values are then totalled by formula FD6, whereby consecutive natural numbers occur in auxiliary column C26 in the rows containing data of the project-supervising employees, and they are the rows in which these data occur for the first time. Additionally, based on the code acquired from column C21, an extended code is generated in auxiliary column C27, containing a number that specifies which consecutive occurrence of the code from column C21 it is.

	A	B	C	D	J	K	L	M	N	O	P
1	Surname	Forename	Project	Participation	FD1 C21	FD2 C22	FD3 C23	FD4 C24	FD5 C25	FD6 C26	FD7 C27
2	SN01	FN01	P01	1	SN01-FN01	1	MN	1	1	1	SN01-FN01-1
3	SN01	FN01	P04	1	SN01-FN01	1	MN	2	0	1	SN01-FN01-2
4	SN01	FN01	P06	1	SN01-FN01	1	MN	3	0	1	SN01-FN01-3
5	SN02	FN02	P01	0,3	SN02-FN02	2	R1	1	0	1	SN02-FN02-1
6	SN02	FN02	P03	0,3	SN02-FN02	2	R1	2	0	1	SN02-FN02-2
7	SN02	FN02	P05	0,4	SN02-FN02	2	R1	3	0	1	SN02-FN02-3
501											

FD1	=IF(A2<>"";CONCAT(A2;"-";B2);"")
FD2	=IF(A2<>"";MATCH(J2;Employees!$E$2:$E$51;0);"")
FD3	=IF(A2<>"";INDEX(Employees!$C$2:$C$51;Employees_Projects!K2;1);"")
FD4	=IF(A2<>"";COUNTIF($J$2:J2;J2);"")
FD5	=IF(A2<>"";IF(AND(L2=INDEX(Roles!$A$2:$A$11;MATCH(1;Roles!$B$2:$B$11;0);1);M2=1);1;0);"")
FD6	=IF(A2<>"";SUM($N$2:N2);"")
DF7	=IF(A2<>"";CONCAT(J2;"-";M2);"")

Figure 9. First group of auxiliary columns of the report generating mechanism in worksheet Employees_Projects.

Using the data to be found in auxiliary columns C21 and C26, formula FE1 creates a list of the codes which identify the project supervisors. For each of the employees thus identified, formula FE2 determines the number of projects they supervise, while formula FE3 calculates a cumulative sum based on this number.

	A	B	C	D	R	S	T	U	V	W	X	Y
1	Surnan	Forena	Projec	Partic	FE1 C28	FE2 C29	FE3 C30	FE4 C31	FE5 C32	FE6 C33	FE7 C34	FE8 C35
2	SN01	FN01	P01	1	SN01-FN01	3	3	1	SN01-FN01	1	SN01-FN01-1	1
3	SN01	FN01	P04	1	SN03-FN03	2	5	1	SN01-FN01	2	SN01-FN01-2	2
4	SN01	FN01	P06	1	SN03-FN01	1	6	1	SN01-FN01	3	SN01-FN01-3	3
5	SN02	FN02	P01	0,3				2	SN03-FN03	1	SN03-FN03-1	7
6	SN02	FN02	P03	0,3				2	SN03-FN03	2	SN03-FN03-2	8
7	SN02	FN02	P05	0,4				3	SN03-FN01	1	SN03-FN01-1	18
21	SN01	FN03	P05	0,2								

FE1	=IFERROR(INDEX($J$2:$J$501;MATCH(ROW(A1);$O$2:$O$501;0));"")
FE2	=IF(R2<>"";COUNTIF($J$2:$J$501;R2);"")
FE3	=IF(R2<>"";SUM($S$2:S2);"")
FE4	=IF(ROW(A1)<=MAX($T$2:$T$21);XMATCH(ROW(A1);$T$2:$T$21;1);"")
FE5	=IF(U2<>"";INDEX($R$2:$R$21;U2;1);"")
FE6	=IF(U2<>"";COUNTIF($V$2:V2;V2);"")
FE7	=IF(U2<>"";CONCAT(V2;"-";W2);"")
FE8	=IF(U2<>"";MATCH(X2;$P$2:$P$501;0);"")

Figure 10. Second group of auxiliary columns of the report generating mechanism in worksheet Employees_Projects.

Formula FE4 enters the subsequent natural number as many times as there are projects supervised by a given employee. For instance, the first employee identified by the code SN01-FN01 supervises three projects, which is why the number 1 occurs in three consecutive rows in auxiliary column C31, while the second employee identified by the code SN03-FN03 supervises two projects, hence the number 2 occurring in two consecutive rows in auxiliary column C31. Based on the numbers to be found in auxiliary column C31, formula FE5 returns a code which identifies a given employee in as many consecutive rows as there are projects supervised by this employee, while formula FE6 calculates how many times the given code occurs. Based on the values in auxiliary columns C32 and C33, formula FE7 generates a code which contains both an employee-identifying code and a number specifying which consecutive occurrence of the given code it is. The structure of the extended code conforms with the structure of the previously generated code to be found in auxiliary column C27. Based on the extended code, formula FE8 specifies the number of the row in table Employees_Projects from which the code of the project supervised by a given employee should be acquired. For instance, in table Employees_Projects, the consecutive codes of the projects supervised by an employee identified by the code SN01-FN01 are to be found in rows 1, 2 and 3, while for an employee identified by the code SN03-FN03, the consecutive codes of the projects they supervise are to be found in rows 7 and 8.

The second step towards generating the report is to prepare and set the order of the contents which the report will contain as information about individual employees. To this end, the third group of nine auxiliary columns have been added in worksheet Employees_Projects, which have been shown in Figure 11 along with their respective formulas.

	A	B	C	D	AA	AB	AC	AD	AE	AF	AG	AH	AI
					FG1	FG2	FG3	FG4	FG5	FG6	FG7	FG8	FG9
1	Surnan	Forena	Projec	Partic	C38	C39	C40	C41	C42	C43	C44	C45	C46
2	SN01	FN01	P01	1	SN01 FN01	1	1	1	1	P01	SN01 FN01	1	P01-1
3	SN01	FN01	P04	1	SN01 FN01	1	1	2	2	P04	SN01 FN01	1	P04-1
4	SN01	FN01	P06	1	SN01 FN01	1	1	3	3	P06	SN01 FN01	1	P06-1
5	SN02	FN02	P01	0,3	SN02 FN02R1: 30%	2	4	16	7	P03	SN03 FN03	1	P03-1
6	SN02	FN02	P03	0,3	SN02 FN02R1: 30%	2	4	17	8	P05	SN03 FN03	1	P05-1
7	SN02	FN02	P05	0,4	SN02 FN02R1: 40%	2	4	18	18	P02	SN03 FN01	1	P02-1
501													

FG1	=IF(A2<>"";CONCAT(A2;" ";B2;IF(L2<>INDEX(Roles!$A$2:$A$11; MATCH(1;Roles!$B$2:$B$11;0);1);CONCAT(CHAR(10);L2;": ";D2*100;"%");""));"")
FG2	=IF(A2<>"";MATCH(L2;Roles!$A$2:$A$11;0);"")
FG3	=IF(A2<>"";INDEX(Roles!$B$2:$B$11;AB2);"")
FG4	=IF(A2<>"";RANK.EQ(AC2;$AC$2:$AC$501;1)+COUNTIF($AC$2:AC2;AC2)-1;"")
FG5	=IF(A2<>"";MATCH(ROW(A1);$AD$2:$AD$501;0);"")
FG6	=IF(A2<>"";INDEX($C$2:$C$501;AE2;1);"")
FG7	=IF(A2<>"";INDEX($AA$2:$AA$501;AE2;1);"")
FG8	=IF(A2<>"";COUNTIF($AF$2:AF2;AF2);"")
FG9	=IF(A2<>""; CONCAT(AF2;"-";AH2);"")

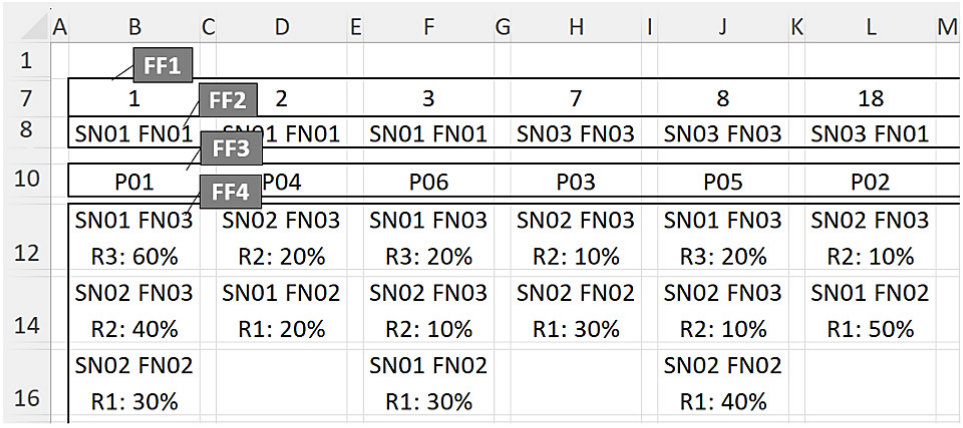
Figure 11. Third group of auxiliary columns of the report generating mechanism in worksheet Employees_Projects.

The values to be found in individual rows in auxiliary columns C38 through C41 correspond to the values to be found in these rows in table Employees_Projects. The values in auxiliary columns C42 through C46 are organised in the order in which they are to occur in the report.

Formula FG1 in auxiliary column C38 creates the actual content which should be contained in the report. For the persons who supervise project implementation, this content is limited to their forename and surname. In the case of all other persons, besides their forename and surname, this content comprises the role performed under a project as well as a number, expressed in per cents, which specifies the employee participation in the project. The role and participation should be displayed in the subsequent row of text. Next, formula FG2 returns a number which designates the row in table Role where the role performed by a given employee is defined, while formula FG3 returns a number which defines the order according to which the person performing this role should appear in the report. According to this number, formula FG4 generates a number which determines the position in the range containing sorted values at which the values from the current row of the unsorted range will be stored. The following is taken into account when establishing this position: the number from auxiliary column C40 and the order

in the unsorted range. Formula FG5 uses that number to return the numerical designation of the row in the unsorted range from which the corresponding values are to be transferred to the given row in the sorted range. In the sorted range, formula FG6 displays the relevant project code, while formula FG7 – the text to appear in the report. Additionally, formula FG8 counts the successive occurrences of the project code in the sorted range. Using that number as well as the project code to be found in auxiliary column C43, formula C46 creates a code according to which the right text is obtained and transferred to the corresponding cell in the report.

The proper report is generated in worksheet Report, in the cells of range B8:AN52. It can comprise up to 20 projects, while besides the supervisor, up to 21 employees can be designated under a single project. There are two sections in the report. One lists the employees who supervise projects as well as the projects they have been assigned. The formulas applied in this section have been entered in individual rows. The other section presents all the persons participating in the implementation of individual projects in the right order. There is a single uniform formula which has been applied in this section. On account of the report formatting, across its entire range, the relevant values occur in every second row and every second column. Both the cell layout and the formulas applied have been shown in Figure 12.



FF1	=IF(ISEVEN(COLUMN(B1));INDEX(Employees_Projects!$Y$2:$Y$21;COLUMN(B1)/2);"")
FF2	=IFERROR(INDEX(Employees_Projects!$AG$2:$AG$501; MATCH(CONCAT(B$10;"-";1);Employees_Projects!$AI$2:$AI$501;0);1);"")
FF3	=IFERROR(INDEX(Employees_Projects!$C$2:$C$501;B7;1);"")
FF4	=IFERROR(INDEX(Employees_Projects!$AG$2:$AG$501;MATCH(CONCAT(B$10;"-";ROW(A4)/2);Employees_Projects!$AI$2:$AI$501;0);1);"")

Figure 12. Layout of cells and formulas in the report.

A single auxiliary row has been added directly above the report. It contains formula FF1 which transfers values from worksheet Employees_Projects, from auxiliary column C35, according to which, formula FF3 retrieves the project code from the corresponding row in table Employees_Projects. Based on the project code, formula FF2 generates the corresponding code, determines its position in auxiliary column C46 in worksheet Employees_Projects, and then retrieves the text to be displayed in the report for the person who supervises the given project from the corresponding row in auxiliary column C44. It is the layout of the formulas applied in the auxiliary columns in worksheet Employees_Projects which guarantees that the

projects supervised by a single employee will be displayed next to one another in the report. Functioning similarly to formula FF2, also with reference to the project code, formula FF4 acquires consecutive texts envisaged to be displayed in the report for all the employees participating in the project implementation.

The right graphical form of the final report has been obtained by way of conditional formatting. In the first place, for the entire report, white has been defined as the fill colour for all cells. For a row which contains information about the supervisors, i.e. for range $B$8:$AN$8, white has been defined as the font colour, followed by the application of three formatting rules:

- rule 1 – top and bottom cell edge is visible, and Blue, Accent 5, Lighter 80% is defined as the cell fill colour for the cells which meet the condition =OR(B8<>"";AND(B8="";A8<>"";C8=A8)),
- rule 2 – right cell edge is visible for the cells which meet the condition =AND(COUNTIF(B8:$AO$8;B8)=1;B8<>""),
- rule 3 – right cell edge is visible and black is defined as the font colour for the cells which meet the condition =AND(COUNTIF($B$8:B8;B8)=1;B8<>"").

For all the remaining cells in the report, i.e. for range $B$9:$AN$52, the following two formatting rules have been applied:

- all cell edges are visible for the cells which meet the condition =B9<>""
- left cell edge is visible for the cells which meet the condition =AND(B9="";B8<>"";B10<>"")

It is for the application of the above formulas that the form demonstrated in Figure 13 has ultimately been obtained.

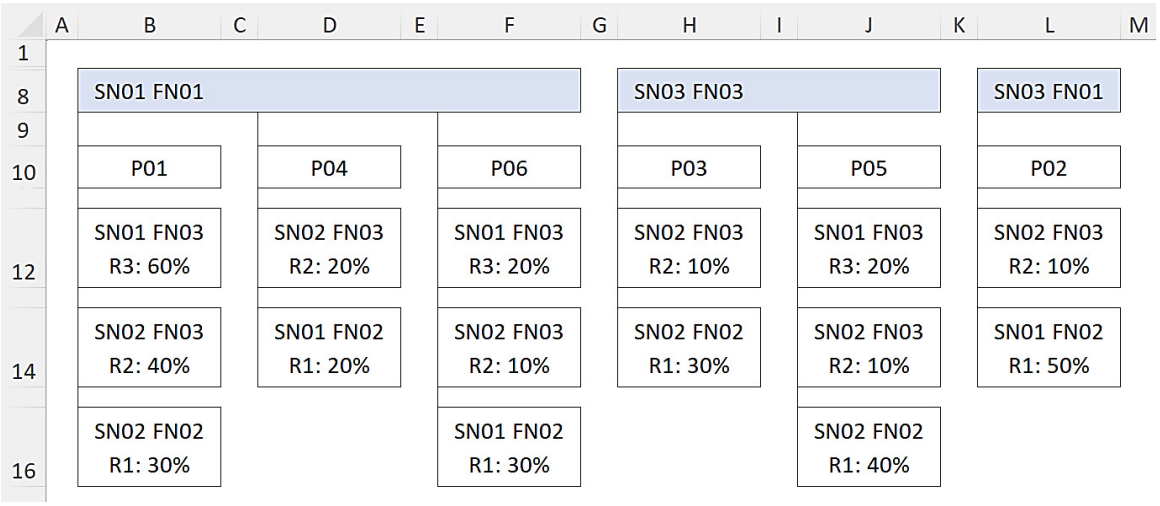


Figure 13. Ultimate form of the report being created.

In the form proposed in this paper, the tool in question uses only built-in spreadsheet functions as well as the conditional formatting mechanism. In cases where the report should be generated in a graphical form, the tool can be expanded with an additional, yet relatively simple, code developed in Visual Basic for Applications, as demonstrated in Figure 14.

```
Public Sub CreateReport()
Dim sL As Single, sT As Single, sW As Single, sH As Single, strP As String
Dim shtI As Worksheet, shtO As Worksheet
Dim rngC As Range, shpC As Shape, shpP As Shape, conC As Shape
sL = 10: sT = 20: sW = 100: sH = 50
Set shtI = Worksheets("Report")
Set shtO = Worksheets("ReportGR")
For Each shpC In shtO.Shapes
    shpC.Delete
Next shpC
For iC = 1 To 20
    For iR = 1 To 23
        Set rngC = shtI.Cells(2 * iR + 6, 2 * iC)
        If rngC = "" Then Exit For
        If iR > 1 Or rngC <> strP Then
            Set shpC = shtO.Shapes.AddShape _
            (msoShapeRectangle, sL + (iC - 1) * (sW + sL), sT + (iR - 1) * (sH + sT), sW, sH)
            shpC.TextFrame2.TextRange.Text = rngC
            If iR = 1 Then
                strP = rngC
                Set shpM = shpC
            End If
        End If
        If iR = 1 Then
            Set shpP = shpM
        Else
            Set conC = shtO.Shapes.AddConnector(msoConnectorElbow, 10, 10, 20, 20)
            conC.ConnectorFormat.BeginConnect shpP, 3
            conC.ConnectorFormat.EndConnect shpC, 1
            Set shpP = shpC
        End If
    Next iR
Next iC
End Sub
```

Figure 14. Code of the procedure to generate the report in a graphical form.

The CreateReport() procedure, as provided in the figure above, generates the report in a graphical form in worksheet ReportGR by making use of the report's current form. This report is composed of rectangles whose width and height is defined by variables sW and sH, respectively, while the horizontal and vertical spaces between them are defined by variables sL and sT, respectively.

5. Conclusions

The solution proposed and discussed in the paper proves that one can successfully use the spreadsheet environment to create tools capable of providing full automation of data processing. Such tools can be created in line with the MiRel concept, assuming that all the tool's data are stored in tables whose structure is compatible with the relational data model. The tool proposed by the author significantly streamlines the process of analysing employee participation in the implementation of projects by eliminating the necessary, yet laborious, manual report generation activity. The required report can therefore be generated automatically once the input data have been entered. In its basic form, the tool does not require using the VBA code, and as such, it raises no doubts as to safety aspects. All of data processing, in terms of both transferring them to appropriate tables and generating the final report, is executed by means of formulas which make use of standard built-in functions available in the MS Excel spreadsheet.

The selection of the functions applied to this end is relatively narrow, comprising AND(), COLUMN(), COLUMNS(), CONCAT(), COUNTIF(), IF(), IFERROR(), INDEX(), ISEVEN(), MATCH(), MAX(), MOD(), OR(), RANK.EQ(), ROUNDDOWN(), ROW(), SMALL(), SUM(), and XMATCH(). The ultimate form of the report has been obtained using the applicable conditional formatting rules. However, in cases where the report is to be generated in a purely graphical form, the tool can be expanded with a relatively uncomplicated VBA procedure capable of generating that report on the basis of its current form.

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QUALITY OF FUEL IN AUTOMOTIVE INDUSTRY

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Purpose: The aim of the article is to determine the quality of aged fuels. It has been shown that laboratory tests of resins formed in fuels are insufficient to determine the quality of gasoline.
Design/methodology/approach: Morphological tests of deposits released in fuels during long-term storage were carried out. The research was qualitative in nature. Morphological tests of deposits released in fuels during long-term storage were carried out. The research was qualitative in nature. Samples of diesel oil, ON95 and ON98 gasoline were tested.
Findings: The novelty of the article is to show that fuels from one manufacturer and stored in the same tank, depending on the fraction, have different properties and significantly differ in quality. In the article different mechanisms of resin release in fuels and their impact on fuel quality were demonstrated.
Research limitations/implications: Glass containers were used in the tests, limiting chemical reactions between the tested fuel and the vessel material. On the other hand, aging processes in glass vessels occur slower than in steel tanks. Due to the roughness of the surface, deposits in glass vessels flow off the walls more easily than in steel and PET vessels.
Practical implications: It is suggested to thoroughly clean fuel tanks intended for transport or storage and to extend the quality testing of liquid fuels such as gasoline by institutions supervising the quality of fuels on the market.
Originality/value: It is to show that fuels from one manufacturer and stored in the same tank, depending on the fraction, have different properties and significantly differ in quality. The article is addressed to institutions dealing with fuel storage.

Keywords: automotive, fuel, quality of gas, quality of oil.

Category of the paper: Research paper.

1. Introduction

The impact of ageing processes of motor fuels on their functional properties is manifested, m.in, by structural changes occurring in fuels (Hirota, Kashima, 2020; Matijošius, Sokolovskij, 2009; He et al., 2021). As a result of chemical oxidation reactions, resin deposits and acids are formed in stored fuels (Vasileiadou, et al., 2021; Correia, et al., 2018; Debe, 2012; Blaabjerg, et al., 2006; Jiang et al., 2024). During the operation of vehicles, these compounds are a source of damage to fuel system components, such as corrosion of seals, blockage of fuel lines, etc. The quality of fuels is therefore extremely important for the functioning of vehicles. Chemical reactions occurring in long-term stored fuel, as well as the deposits formed, cause changes in the density of fuels, which in turn affects the amount of fuel injected into the engine compartment, and the amount of energy released in the combustion process in the piston. The heaviest sediments that are emitted in the fuel (from a collection of several dozen types of hydrocarbons of different molecular weights) combining into larger conglomerates can cause mechanical problems in the propulsion system. The release of dense and heavy fractions that significantly reduce the quality, including the functional properties of fuels, is extremely dangerous. Ageing processes occurring in fuels affect the loss of oxidative stability.

The aim of the article is to examine samples of long-term stored fuels and to determine the level of their quality and suitability for further exploitation in the transport industry.

2. Materials and investigation methods

In order to confirm the decrease in the level of functional properties of the tested fuels, qualitative tests of the structure of the emitted sediments were carried out for them. The fuels (oil and gas) were stored for a period of 4 years in glass vessels. Glass vessels were chosen due to the limitation of possible chemical reactions between the tested fuel and the material of the tank in which the material was stored. According to the literature, this is extremely important in the case of fuels containing biocomponents (Matijošius, Sokolovskij, 2009; He et al., 2021). It should also be noted that glass walls of vessels are less conducive to precipitation of sediments compared to the walls of steel tanks, used, m.in, in non-tank stations. The surface roughness of the materials that are in direct contact with the tested fuel and the tank material itself have an impact on the precipitation processes that take place. According to the literature, the use of polymer tanks of the PET type accelerates the processes of fuel degradation (Jeon, Park, Na, Kim, 2017; Stępień, 2015).

Studies of the structure of sediments emitted in fuels after long-term storage were carried out using an X-ray microscope. The aim of the research was to assess whether the samples of

long-term stored fuel are subject to ageing processes manifested by the formation of deposits on the vessel walls. Observations were made at a magnification of 10 × (10-fold).

3. Results of investigation

Figure 1-3 shows the results of tests of the wall of a laboratory vessel on which sediments were separated when the diesel fuel sample was stored in a vertical position for a period of approx. 4 years. It should be noted that the glass walls of the vessels are less conducive to the precipitation of sediments compared to the walls of steel tanks, used, m.in, at non-tank stations, so it can be assumed that the results of the tests were obtained, indicating a better quality of fuels than it would be in non-laboratory conditions, carried out on a real facility. Figure 1 shows the results of the near-surface fraction, Figure 2 shows the results of the central fraction, and Figure 3 shows the results of the lowest fraction, near the bottom of the tank.

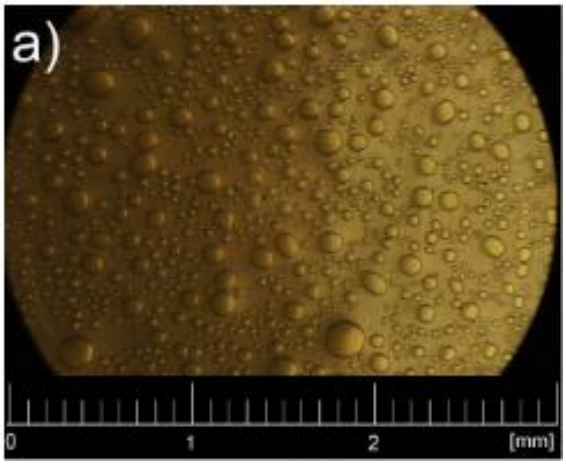


Figure 1. Sediments emitted on the walls of the vessel during long-term storage – in the near-surface fraction

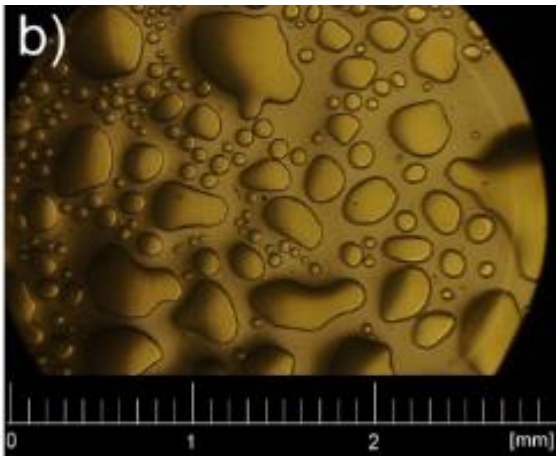
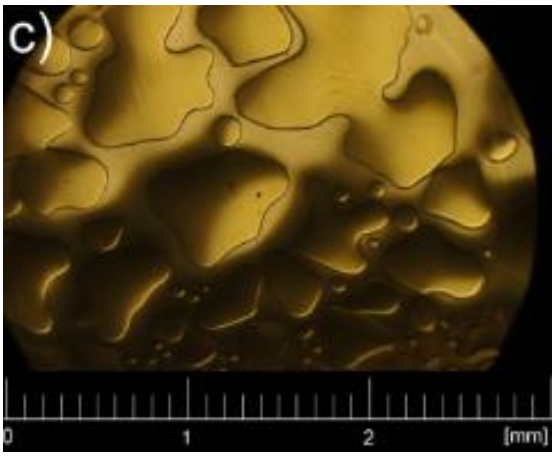


Figure 2. Sediments emitted on the vessel walls during long-term storage – sample taken from the center of the vessel.



A sample taken at the bottom of the tank.

Figure 3. Deposits emitted on the vessel walls during long-term storage.

Comparison of the results of the tests presented in Figure 1-3 allows to find significant differences in the morphological structure of the sediments emitted from different depths of the glass tank. The uppermost layer, located near the surface, is characterized by spherical sediments of the smallest diameter. Single precipitates have a diameter of up to about 0.3 mm. The results of the study, presented in Figure 2, indicate that the forming spherical sediments coagulate, forming clusters of larger sizes and irregular, sometimes elongated shapes. The largest changes were observed in sample 3, taken at the bottom of the vessel. The observed precipitates cover almost the entire surface of the laboratory slide. The observed precipitates are heavier fractions, formed as a result of coagulation of particles that merge together and are emitted during the aging process. The sediments that coagulate become heavier and sink to the bottom of the vessel, according to the action of gravitational forces. Hence the higher concentration of sediments observed in sample 3, in the form of larger, uneven droplets. The results of the study confirm the literature data and clearly indicate that in the case of long-term stored fuel, its physico-chemical properties undergo changes under the influence of ageing processes (Ukhanov et al., 2022; Sacha, 2020). The results of studies conducted in the world indicate that the observed changes are responsible for the decrease in oxidative stability of diesel oils (Silva, 2021).

Therefore, the operational properties of these fuels change adversely. Observation of heavy fractions of sediments (Fig. 3) correspond to very low quality fuels for applications in the automotive industry. In the conducted tests, it was unequivocally confirmed that in the analyzed liquid fuels, non-volatile compounds with a tendency to deposition – called resins – are emitted. The analysis of the results, combined with the literature data, allows us to conclude that the tested fuel is characterized by low quality, as it has lost its original physicochemical properties. The use of fuel of this quality level results in the formation of carbon deposits that reduce the performance of the engine and increases the emission of harmful substances into the atmosphere. Due to the fact that sediments are deposited on the walls of the vessels, it can be concluded that inaccurate cleaning of the tanks during the liquid change may be the cause of

contamination of the next batch of fuel, reducing its functional properties. The conclusion is consistent with the literature data presented by numerous authors (Hirota, Kashima, 2020; Matijošius, Sokolovskij, 2009; He et al., 2021; Silva, 2021; Vasileiadou et al., 2021; Correia et al., 2018; Debe, 2012; Blaabjerg et al., 2006; Jiang et al., 2024; Jeon, Park, Na, Kim, 2017; Stępień, 2015; Ukhanov et al., 2022; Sacha, 2020). In addition, it should be noted that in the case of conventional testing of fuels with sampling only from the upper tank, it may not be sufficient to determine the quality of the stored fuel. Heavy fractions are deposited at the bottom of the tank, so the fuel taken from this area will have worse operating properties compared to the fuel taken only from the top layer (near-surface). Such an observation may explain why fuel from the same manufacturer distributed and delivered to other stations may have different oxidative properties if it were not mixed.

Similar observations were made for long-term storage of ON 95 and ON 98 gasoline. Also in this case, precipitates were observed on the walls of glass vessels in which the liquid was stored for a period of more than 4 years. The vessels were stored in an upright position and filled with gasoline up to 2/3 of their height.

Observations made with the use of an X-ray microscope showed that in the case of gasoline no changes in the form of precipitation of deposits inside the liquid were observed (Figures 4-5). The sediments shown in Figure 4-5 were observed on the walls of the vessel, only above the surface of the stored fuel.

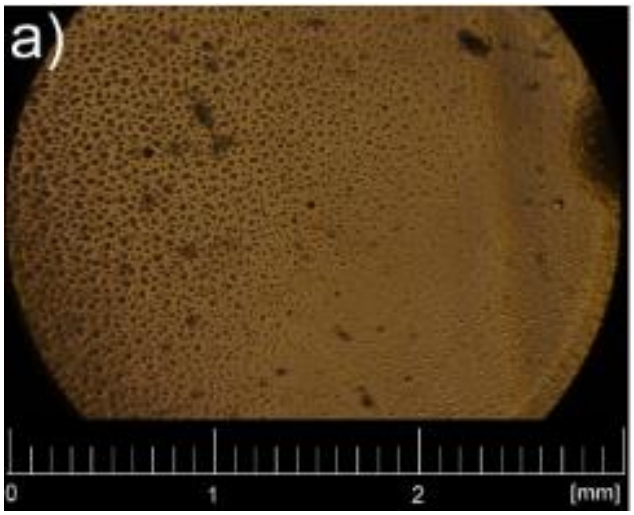


Figure 4. Sediment forming above the Pb98 fuel level.

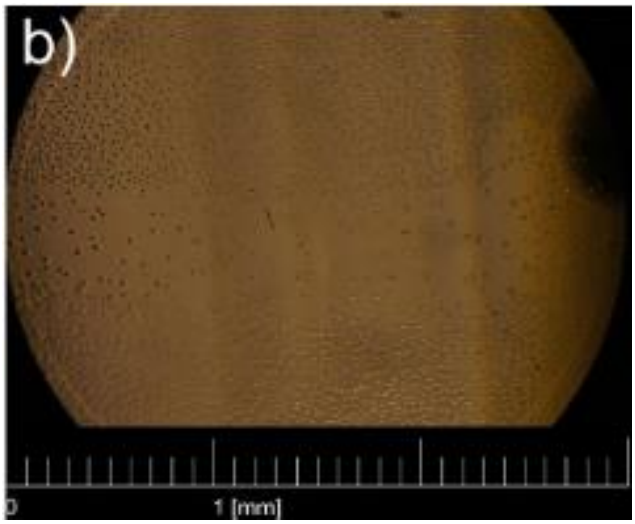


Figure 5. Sediment forming above the Pb95 fuel level.

The analysis of the obtained results allows us to see that the mechanism of deposit formation is therefore different for gasolines and diesel oils. A fuel sample enclosed in a glass vessel filled to approx. 2/3 of its volume with gasoline creates an atmosphere of thermodynamic equilibrium, in which the gasoline vapours mix with the air left in the vessel and carry away all the fractions contained in it. These vapours, as a result of oxidation with the air contained in the vessel, form resins that settle on the walls of the vessels, transforming into condensation centers for the next particles. Resins are released in the form of deposits above the surface of the liquid, while the same compounds in gasoline are dissolved. Due to this mechanism, no precipitation of deposits was observed on the vessel walls within the liquid or in the liquid itself. It can only be assumed that physico-chemical changes occurred in the liquid, related to the aging processes and the mechanism of dissolving deposits in gasoline. It is likely that these changes will be observed at a much later date, as gasoline consists of much lighter molecules than diesel fuels and this process takes much longer. The results of the research presented in the literature indicate, a.o. changes in the clarity of liquids.

The observed phenomenon of fuel ageing and sediment formation is confirmed by the number of fuel samples inspected by the Trade Inspectorate, which during the year detected almost 9% of diesel oil samples that did not meet the specified quality parameters among all tested oil samples and not a single sample that did not meet the resin content parameter in gasolines (UOKIK report, 2023). Since the UOKIK report provides only values that do not meet the standards, on the basis of the research carried out as part of this study, it can be concluded that ageing effects in gasolines also occur, but their intensity is so low that it does not yet exceed the standards in the analyzed time. It should also be considered whether laboratory tests specified in the standards are sufficient to determine the quality of liquid fuels.

4. Summary and conclusions

Chemical reactions occurring in long-term stored fuel are the cause of sediment accumulation, cause changes in the density of fuels and their operational properties. These changes adversely affect motor vehicles by causing mechanical problems in the drive system, premature wear of parts of the structure, as well as changes in the thermodynamics of fuel combustion and the amount of substances emitted unfavorable to the environment. The research carried out as part of the study indicates that fuel stored for a long time adversely changes its properties as a result of spontaneous aging processes. In addition, it has been shown that the same fuel, coming from one manufacturer and stored in one tank, can have different properties within the liquid, depending on whether it comes from the upper or lower fraction of the tank.

A detailed analysis of the study results highlights that:

1. The observed phenomena correspond to ageing changes occurring in fuels (both in the case of the analyzed gasolines and diesel oil) As a result of long-term storage, the functional properties of the fuels have been significantly reduced.
2. The tested fuel – diesel should be withdrawn from circulation due to its inadequate functional quality, resulting from progressive ageing processes, manifested by the formation of deposits. According to the literature, the identified deposits in fuels may be the cause of a decrease in the efficiency of vehicles powered by these fuels, result in the formation of carbon deposits that reduce engine performance and contribute to the increasing emission of harmful substances into the atmosphere.
3. Different fractions of fuel from the same tank may have different performance characteristics. In the case of diesel fuels, fractions taken from the bottom of the tank showed a significant progress in degradation processes compared to near-surface fractions. In the case of long-term storage of fuels, it is necessary to blend them and carry out qualitative tests before placing them on the market.
4. Taking samples of fuels for laboratory tests only from the near-surface fraction may result in an erroneous estimation of fuel quality. Fuel of inadequate quality may be approved for use.
5. When testing gasoline-type fuels, estimating the amount of deposits formed in the liquid is insufficient to determine the quality of the fuel and its service life. Deposits usually form above the surface of the liquid, and in the gasoline itself they are unobservable with the help of an X-ray microscope.
6. Comparing the test results for gasolines and oil, it can be stated that the amount of sediments precipitated in diesel fuels is many times higher than in gasolines.
7. The results of the study show that despite the fact that the mechanisms of deposit formation are different for gasolines and diesel oils, the results clearly indicate that the quality of liquid fuels results from the ageing processes taking place in them.

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PAVING THE WAY FOR TOMORROW: THE EVOLUTION OF ERP AND BPMS SYSTEMS

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Purpose: This paper aims to assess the contemporary relevance of Enterprise Resource Planning (ERP) systems and Business Process Management Systems (BPMS) in the context of Industry 4.0 and Industry 5.0. The purpose is to investigate whether BPMS remains pertinent in the face of increasingly complex and diverse business processes, considering the overlapping functionalities with ERP systems.
Design/methodology/approach: This discussion paper employs a systematic theoretical literature review approach. The methodology integrates insights from existing research, conducting comprehensive searches across reputable academic databases, including Web of Science, Scopus, IEEE Xplore, ScienceDirect, and Google Scholar. Keyword searches yielded over 500 results, which were refined to 203 relevant articles through prioritizing peer-reviewed sources. The synthesis of literature includes an analysis of historical evolution and a comparative study of critical success factors, forming the basis for deriving potential future trajectories for these interconnected system classes, and emphasizing their strategic alignment.
Findings: This discussion paper presents an overview of the current state and future development trajectory of the two critical information systems (IS) classes for modern organizational management—ERP and BPMS—and compares the critical success factors (CSFs) associated with each system class. Based on this comparison, the paper determines the development direction of both system classes concerning business requirements.
Originality/value: Unlike prior literature which has examined ERP and BPMS systems individually, this study provides original perspectives by conducting a direct comparative analysis of the critical success factors for each system class. The comparative CSF analysis approach enables this study to contribute unique insights into the status and future trajectory of ERP and BPMS systems.

Keywords: Enterprise Resource Planning System (ERP), Business Process Management System (BPMS), Business Process Management Suite, Industry 4.0, Industry 5.0.

Category of the paper: Literature Review.

1. Introduction

Enterprise Resource Planning (ERP) and Business Process Management Systems (BPMS) enable organizations to operate efficiently (Davenport, 2018; Klaus et al., 2000). However, as these systems evolve, critical decisions arise regarding the implementation approach, integration architecture, and future trajectory (Esteves, Pastor, 2006; Shang, Seddon, 2002; Teltumbde, 2000).

ERP vendors must choose between building process capabilities natively or integrating with separate BPMS tools (Gartner, 2021a; Gartner, 2021b; Haddara, Elragal, 2015). Adopters must decide between process-centric ERP or flexible ERP-BPMS integration (Soh et al., 2000; Weske, 2012). These strategic decisions have long-term implications, necessitating substantial investments (Gable et al., 2003).

While frameworks like Enterprise Architecture (EA) and Digital Twin (DT) model technical integration, this paper uniquely analyzes ERP and BPMS systems from a business strategy lens. It asks, "Is the future better served by unified process-ERP systems or flexible ERP-BPMS integration?" (Dubey et al., 2019; Perboli et al., 2018; van der Aalst et al., 2016).

Rather than a technical focus, this study examines the alignment of ERP and BPMS's business objectives and critical success factors (CSFs) for implementation. By identifying CSFs from literature and comparative analysis, novel perspectives emerge on ERP and BPMS trajectories grounded in strategic requirements versus purely technical considerations (Asante et al., 2021; Szelągowski et al., 2022).

Critical Success Factors (CSFs) represent the key areas and activities that must be focused on to ensure the successful implementation and adoption of a technology or system. In the context of ERP and BPMS, CSFs reflect the vital organizational, managerial, strategic, and technological factors that determine the effective deployment of these systems. Clearly defining and understanding the CSFs enables organizations to allocate resources proactively and plan toward high-priority domains essential for successful implementation. Common CSFs include top management commitment, effective project management, user training and engagement, business-IT strategic alignment, and organizational cultural readiness. Operationalizing the CSFs with metrics and key performance indicators (KPIs) can further help organizations track progress on these fronts tangibly. For instance, KPIs like employee adoption rates, user satisfaction scores, process cycle time reduction, and system uptime and performance can quantify outcomes related to user engagement, change management, and technical robustness CSFs. The following sections will delve deeper into analyzing and comparing the specific CSFs for ERP and BPMS systems highlighted in scholarly literature.

ERP systems: The paper outlines the research methodology, reviews ERP and BPMS system evolution, compares CSFs, and concludes with recommendations based on the business-focused analysis. While technical integration frameworks exist, this strategic CSF approach provides unique insights into the current status and future direction of ERP and BPMS.

2. Methods

This discussion paper employs a systematic theoretical literature review approach to examine the evolution, current status, and future directions of ERP and BPMS systems. This methodology synthesizes findings from existing research to identify concepts, relationships, and patterns that can inform theoretical development (Pare et al., 2015; Webster, Watson, 2002).

The literature search utilized the following academic databases: Web of Science, Scopus, IEEE Xplore, ScienceDirect, and Google Scholar. Initial keyword searches were conducted using the terms "ERP system", "BPMS system", "BPM system", "workflow system", "critical success factors," and "system evolution". These searches yielded over 500 results published over the past 20 years.

The results were further refined by limiting to peer-reviewed conference proceedings and journal articles published in relevant disciplines, including information systems, business process management, operations management, and supply chain management. Priority was given to studies published in highly cited journals. In total, 203 relevant articles were identified for inclusion in the analysis.

Literature was synthesized to develop an understanding of the evolution of ERP and BPMS systems over time. Additionally, scholarly research on critical success factors (CSFs) for ERP and BPMS implementation was compiled and systematically compared. This comparison provides the basis for deducing the potential future trajectories of these interconnected system classes based on their strategic alignment.

The following sections outline the historical development progression of ERP and BPMS, followed by a comparative CSF analysis. Finally, conclusions are presented on the likely future direction and integration possibilities for ERP and BPMS centered on meeting business objectives. The CSF analysis provides a unique perspective grounded in strategic business factors rather than technical considerations alone.

While contemporary technical paradigms like Enterprise Architecture (EA) and Digital Twin (DT) model the integration of ERP and BPMS from an architectural perspective, this research maintains a focus on comparative analysis of the critical success factors (CSFs). The study acknowledges that frameworks like EA and DT provide valuable insights into the technical dynamics and integration considerations for ERP and BPMS systems. However, a strategic evaluation of the alignment in ERP and BPMS's business objectives, as represented through their shared CSFs, can offer complementary perspectives to guide integration decisions. The CSF lens illuminates core areas organizations must focus on for implementation success, irrespective of technical approach. Thus, this research puts forth the CSF analysis as a novel, business-strategy-oriented perspective, while acknowledging the technical insights offered by integration frameworks like EA and DT.

3. Enterprise Resources Planning Systems

The evolution of ERP systems started in the 1960s and 1970s and can be presented in five stages (Figure 1).

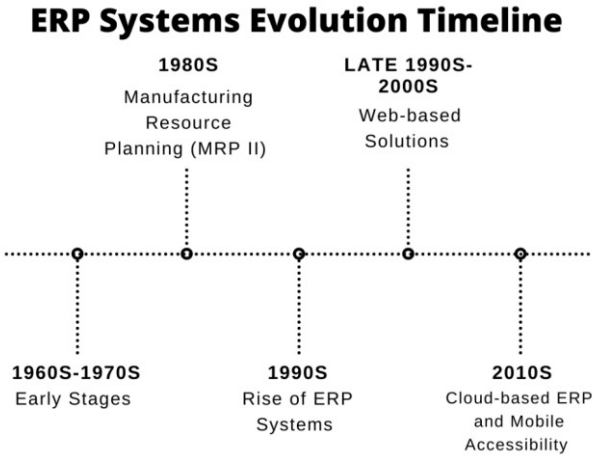

Figure 1. The evolution of ERP systems.

The evolution diagrams drawn in Figures 1 and 2 aim to provide a high-level historical overview of the development progression of ERP and BPMS systems over time. However, it is acknowledged that these simple linear diagrams have limitations in capturing the nuances and architectural details underpinning each phase. The diagrams serve as a starting point to orient the reader on the eras and driving forces that shaped the advancement of ERP and BPMS systems. However, they do not delineate the specific technological shifts or integration architectures that characterized each era. As such, while providing a historical context, the diagrams necessarily simplify the technical complexities and modular capabilities added during each period of evolution. The narrative in the following sections will dive deeper into the technical factors and integration possibilities shaping ERP and BPMS systems' ongoing advancement.

- 1960s-1970s: Early Stages - The foundations of ERP systems were laid during this period with the emergence of inventory management and control systems. These early systems focused on tracking inventory and managing material requirements.
- 1980s: Manufacturing Resource Planning (MRP II) - MRP systems advanced into MRP II, expanding their functionalities to include shop floor control, capacity planning, and master production scheduling. This allowed for more comprehensive manufacturing resource planning.
- The 1990s: Rise of ERP systems - ERP systems gained prominence during the 1990s by integrating multiple business functions, such as finance, human resources, and manufacturing, into a unified system. Notable ERP systems like SAP R/3 and Oracle Applications emerged and became widely adopted.

- The late 1990s-2000s: Web-based Solutions - With the advent of the internet, ERP systems embraced web-based interfaces and began integrating with e-commerce platforms. This enabled organizations to conduct online transactions and streamline their operations.
- The 2010s: Cloud-based ERP and Mobile Accessibility - The 2010s witnessed the rise of cloud-based ERP systems, offering benefits such as lower costs, more straightforward implementation, and improved scalability. Additionally, mobile accessibility became a key feature, allowing users to access and interact with ERP systems through smartphones and tablets, enhancing flexibility and productivity.
- Late 2010s-Present: Integration of Big Data, IoT, and AI - In recent years, ERP systems have been integrating emerging technologies such as Big Data analytics, the Internet of Things (IoT), and Artificial Intelligence (AI). These integrations enable organizations to harness the power of data analytics, optimize processes, and make more informed decisions.

The use of IS in business initially involved simple programs primarily focused on maintaining databases for record-keeping purposes. However, it quickly became evident that these systems could effectively handle material records and other types of resources. Subsequently, efforts were made to expand these systems by incorporating modules capable of recording operations specific to different resources. These operations encompassed receipts, issues, purchases, sales, employment, and dismissals. This expansion enabled IS to support and monitor various functional areas within an enterprise, employing independent programs tailored to each respective area, such as warehouse management, human resources, payroll, or financial accounting.

As the IS progressed, the logical next step was to enhance its functionality to encompass material requirements planning (MRP) and, subsequently, material resources planning (MRP II) (Katuu, 2020). During this phase, the need for internal integration of the diverse areas of IS operation emerged as a fundamental characteristic of the subsequent generation of IS – Enterprise Resource Planning (ERP) systems. ERP systems facilitated the comprehensive management not only of production resources but also the resources spanning the entire organization, representing a significant advancement in IS capabilities.

Initially, ERP systems were similar to their predecessors, functioning as monolithic systems with tightly integrated mechanisms for different areas within the system's architecture and IS database (Katuu, 2020). During the 1990s and early 2000s, ERP software became the standard and formed the foundation of organizational systems architecture. However, by the mid-2000s, the limitations of this approach became increasingly evident, including lack of flexibility, dependency on a single supplier, high costs of acquisition and usage, and challenges in adapting to the user's specific business processes (Haddara, Elragal, 2015; Haddara et al., 2015). Pressures from the business environment and emerging technological opportunities prompted the evolution of ERP systems toward a modular structure, where

a distinct module was responsible for seamless integration and data flow between individual modules (Lupeikiene et al., 2014). This shift allowed organizations to incorporate modules from different vendors, reducing their reliance on a single provider. Recognizing this transformation, Gartner introduced a new class of information systems called "postmodern ERP" (Gartner, 2019a; Hardcastle, 2014). These systems departed from the monolithic structure, favouring a "loosely coupled decentralization" of administrative and operational modules (Gartner IT Glossary, nd). A postmodern ERP strategy aims to leverage the best applications in each specific area while ensuring effective integration when needed. This approach enables users to select the most suitable traditional ERP modules such as finance, production, or human resources and incorporate various hyper-automation technologies not provided by ERP vendors. Examples of such technologies include integration with IoT sensors, OCR for text recognition, QR code scanning, speech recognition, software robotics, and AI-driven decision support offered by leading companies in this rapidly evolving IT sector (Gartner, 2019b).

While ERP systems are conceptually designed to integrate business processes within an organization (Nazemi et al., 2012), even postmodern ERP systems primarily function as transactional systems focused on recording and monitoring transactions rather than facilitating the design and execution of end-to-end business processes (Gartner, 2019a). In acknowledgement of this limitation, ERP system providers are making efforts to integrate with business process management by incorporating internal business process modellers (e.g., Microsoft Dynamics AX) or enabling the loading and operationalization of business process models using the Business Process Model and Notation (BPMN) from version 2.0 (e.g., SAP). The main envisioned paths for the evolution of ERP systems involve improved integration of AI, increased focus on cybersecurity, blockchain integration, virtual and augmented reality, and greater emphasis on sustainability, and circular economy.

3.1. Improved Integration of AI

The future of ERP systems lies in their increased integration with advanced AI, machine learning algorithms in particular. This integration will bring automation to allow tasks to be more complex, optimize processes, and provide more accurate predictions and recommendations. By harnessing the power of AI and machine learning, ERP systems can significantly enhance various aspects of enterprise resource planning. Potential areas where AI can be utilized to improve ERP are (Arunachalam et al., 2018; Dumas et al., 2023; Eid, Addas, 2017; Merenda et al., 2020; Ribeiro et al., 2021; van der Aa et al., 2018; Wang et al., 2016; Yathiraju, 2022; Yu et al., 2021):

- Intelligent Automation: AI can automate repetitive and rule-based tasks within ERP systems, such as data entry, reconciliation, and report generation. Machine learning algorithms can learn from historical data and make predictions or decisions, reducing manual effort and improving efficiency.

- Predictive Analytics: By analyzing historical data and patterns, machine learning algorithms can provide predictive insights to optimize inventory management, demand forecasting, and supply chain planning in ERP systems. This helps make more accurate forecasts, reduce costs, and improve decision-making.
- Anomaly Detection: AI algorithms can monitor ERP data in real-time to identify anomalies or unusual patterns that may indicate fraud, errors, or system failures. This proactive approach helps detect and mitigate risks early, improve data integrity, and ensure compliance.
- Natural Language Processing (NLP): NLP techniques enable ERP systems to understand and interpret unstructured data, such as customer feedback, emails, and support tickets. This improves customer service, sentiment analysis, and more effective organizational communication.
- Personalized experience: AI algorithms can learn from user behaviour and preferences to personalize the ERP user interface, making it more intuitive and tailored to individual users. This improves user adoption and productivity.

3.2. Increased Focus on Cybersecurity

ERP systems have played a vital role in increasing focus on cybersecurity by implementing various measures to protect sensitive data and mitigate cyber threats. This will cover, among others, the following areas (Knowles et al., 2015; Shang, Seddon, 2002; Wolden et al., 2015):

- Access Control and User Management: ERP systems incorporate robust access control mechanisms and user management features to ensure that only authorized individuals can access critical data and functionalities. Role-based access control (RBAC) is commonly used to assign specific privileges to users based on their roles and responsibilities.
- Data Encryption and Secure Communication: ERP systems employ encryption techniques to safeguard data during transmission and storage. Encryption protocols such as Secure Sockets Layer (SSL) or Transport Layer Security (TLS) are utilized to protect data integrity and confidentiality.
- Security Monitoring and Incident Response: ERP systems integrate security monitoring capabilities, including intrusion detection systems (IDS) and security information and event management (SIEM) tools, to detect and respond to potential security incidents. These systems provide real-time alerts and notifications, enabling timely incident response.
- Regular System Updates and Patches: ERP vendors release regular updates and patches to address security vulnerabilities and software flaws. Timely installation of these updates is crucial to protect ERP systems from known vulnerabilities.

- Employee Training and Awareness: ERP systems are supported by comprehensive training programs and security awareness initiatives to educate employees about best cybersecurity practices. This includes training on data handling, password management, and recognizing and reporting potential security threats.

3.3. Blockchain Integration

Integrating blockchain technology in ERP systems holds significant potential for enhancing various aspects of ERP functionality. This will cover, among others, the following areas (Asante et al., 2021; Batwa, Norrman, 2021; Min, 2019; Perboli et al., 2018; Queiroz et al., 2020):

- Enhanced Data Security and Integrity: The blockchain provides a decentralized and immutable ledger that ensures the integrity and transparency of data. By integrating the blockchain with ERP systems, organizations can enhance data security, reduce the risk of data tampering, and enable secure and auditable transactions.
- Improved Supply Chain Traceability: Blockchain integration in ERP systems can enable end-to-end traceability and transparency in supply chain operations. It allows tracking the movement of goods, verifying authenticity, and ensuring compliance with regulations. This can help organizations in product recalls, counterfeit prevention, and ethical sourcing.
- Streamlined Inter-organizational Processes: The blockchain enables secure and automated smart contracts that facilitate trust and transparency in inter-organizational collaborations. Organizations can automate procurement, invoicing, and payment processes by integrating the blockchain with ERP systems, reducing manual errors and improving efficiency.
- Efficient Data Sharing and Collaboration: Blockchain integration can enable secure and decentralized data sharing among stakeholders within an ERP ecosystem. It eliminates the need for intermediaries and allows real-time data access, leading to improved collaboration, streamlined workflows, and faster decision-making.
- Enhanced Auditing and Compliance: The transparent and immutable nature of the blockchain can facilitate auditing and compliance processes within ERP systems. It provides an auditable trail of transactions and ensures compliance with regulations such as data privacy (e.g., GDPR) and financial reporting standards.

3.4. Virtual and Augmented Reality

Virtual and Augmented Reality (VR/AR) technologies offer promising possibilities for enhancing ERP systems development and user experience. These include, among others (Gonzalez et al., 2022; Marino et al., 2021):

- Training and Simulation: VR/AR can provide immersive training environments for ERP system users. Employees can learn and practice ERP processes and workflows in a virtual setting, enabling them to gain hands-on experience without impacting live systems. This helps reduce training costs, improve user proficiency, and minimize errors.
- Data Visualization and Analytics: VR/AR interfaces can present complex ERP data visually and interactively. Users can navigate through virtual dashboards, charts, and graphs, allowing for better real-time data analysis, decision-making, and spotting patterns or anomalies.
- Remote Collaboration and Support: AR technologies enable remote collaboration by overlaying virtual information onto the physical world. In ERP systems, employees can receive real-time expert guidance and support through AR overlays, assisting them in troubleshooting, maintenance, or complex tasks.
- Enhanced User Interfaces: VR/AR interfaces can provide intuitive and immersive user experiences in ERP systems. Users can interact with ERP functionalities using gestures, voice commands, or spatial mapping, enhancing usability and reducing the learning curve associated with traditional interfaces.
- Data Integration and Visualization in the Field: AR can overlay ERP data onto physical objects or environments in real time. For instance, field service technicians can visualize equipment maintenance history, repair instructions, or IoT sensor data overlaid onto physical equipment, enabling them to perform tasks efficiently and accurately.

3.5. Greater Focus on Sustainability and Circular Economy

In the future, ERP systems can be crucial in promoting sustainability and supporting circular economy practices. Supply Chain Visibility: ERP systems can incorporate features to provide comprehensive visibility into the supply chain, allowing organizations to track and trace products throughout their lifecycle. This visibility enables better monitoring of the environmental impact of raw material sourcing, production processes, transportation, and end-of-life management. These include, among others (Manavalan, Jayakrishna, 2019; Queiroz et al., 2020; Wichaisri, Sopadang, 2018; Wynn, Jones, 2022):

- Eco-design and Product Lifecycle Management: ERP systems can integrate modules for eco-design and product lifecycle management (PLM). These modules can enable organizations to assess the environmental impact of products, facilitate the use of sustainable materials, optimize product life cycles, and support circular product design principles such as recycling, remanufacturing, and refurbishment.
- Waste Management and Recycling: ERP systems can incorporate functionalities to manage waste and recycling processes efficiently. This can include tracking waste generation, managing recycling workflows, monitoring compliance with waste

management regulations, and facilitating the circular flow of materials within the organization.

- Energy and Resource Management: ERP systems can integrate energy and resource management modules to monitor and optimize resource consumption across the organization. These modules can enable organizations to track energy usage, identify energy-saving opportunities, manage water consumption, and promote resource-efficient practices.
- Reporting and Analytics: ERP systems can enhance sustainability reporting capabilities by incorporating features that capture and analyze sustainability-related data. This can enable organizations to generate comprehensive sustainability reports, measure key performance indicators, and make data-driven decisions to improve their sustainability and circular economy practices.

4. Business Process Management Systems

When discussing the development of BPMS, it is worth starting with the evolution of data-driven workflow systems in the 1970s and 1980s. However, the evolution of BPMS began in the 1990s (Figure 2).

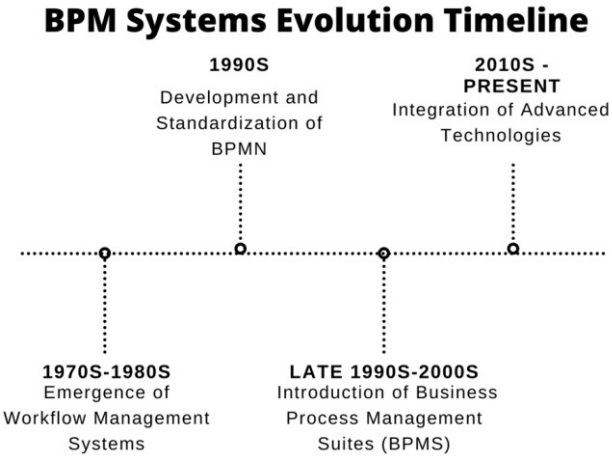

Figure 2. The evolution of ERP systems.

In the 1990s, there was a widespread belief that workflow management systems would be the logical progression in supporting office work, following other tools like database management systems, spreadsheets, and email systems (van der Aalst et al., 1994). This prediction turned out to be accurate, as workflow management (WFM) and document management (DM) systems proved effective in organizing people and documents and automating specific stages of processes, particularly in small and medium-sized companies and administration. However, these systems primarily focused on automating predefined, repetitive workflows and offered limited support for process analysis, optimization, and end-to-end

process management. To address the need for comprehensive management and greater flexibility in supporting implemented processes, Business BPMS emerged. BPMS combined information technology with knowledge from management sciences and applied them to operational business processes (Bitkowska et al., 2022; Gartner IT Glossary, nd; van der Aalst 2022). BPMS can be defined as an application infrastructure that supports BPM projects and programs, encompassing the entire execution and improvement lifecycle, from process identification and modelling to design, implementation, analysis, and continuous improvement (Dumas et al., 2018; Szelągowski, 2019).

BPMS is being embraced by organizations to enhance business process agility within a diverse application landscape (Koopman, Seymour, 2020). These suites offer several advantages, including increased visibility and transparency of processes, streamlined organizational rules and principles enforcement, and reduced workload through process automation. BPMS also enables flexible integration with numerous IT systems to support organizational work (Dumas et al., 2018). According to Capgemini (Capgemini, 2012), 96% of enterprises that implemented business process optimization systems experienced a significant return on investment, with at least 200% ROI achieved by 55% of them. However, according to the BPTrends report (Harmon, Garcia, 2020), while 93% of companies are engaged in various activities to improve their processes, only 52% of companies using BPM software expressed satisfaction with their specific tool.

BPMS has encountered limitations in handling the increasing volume of data and the complexity of real-time decision-making processes. The emergence of Industry 4.0 has led to replacing traditional business processes with dynamic processes, including partially structured processes with predefined fragments and unstructured processes, for which precise steps cannot be defined (Kemsley, 2011; Szelągowski, 2019; Wysokińska-Senkus et al., 2016). In this context, organizations must implement comprehensive company strategies, coordinate interactions across departments and external systems, and integrate various platforms such as CRM and ECM to facilitate management across departments, processes, and individuals. Managing business processes in the digital transformation era and Industry 4.0 requires a new approach, which is where Business Process Management Systems, also known as Business Process Management Suites or Business Process Management Software, prove valuable.

The development of BPM support software systems originated from two contrasting assumptions:

- Case Management Systems (CMS) - These systems were designed to handle processes characterized by unpredictable flows and a high level of knowledge intensity, even though the exact knowledge required for execution might not be fully known. CMS focuses on supporting such processes.

- Traditional BPMS - In contrast, traditional Business Process Management Systems (BPMS) were developed to support processes with a known and strictly repeated nature. These systems assume that all the necessary knowledge for process execution is available beforehand. Traditional BPMS aims to provide support for process groups regardless of their nature, unpredictability, or knowledge intensity (Di Ciccio et al., 2015).

A comprehensive analysis of intelligent Business Process Management Systems (iBPMS) and Dynamic Case Management Systems (CMS) revealed a notable trend of increasing convergence in their capabilities. Over the examined period, both types of systems demonstrated the following shared features:

- Dynamic Process Execution: Both iBPMS and dynamic CMS enabled the execution of processes flexibly and adaptively, accommodating changes in the operational context.
- Contextual Adaptation: These systems demonstrated the ability to adapt to the specific operational context in which processes are being executed, considering factors such as user roles, organizational rules, and environmental conditions.
- Rules Processing Integration: iBPMS and dynamic CMS incorporated rules processing capabilities, allowing for enforcing organizational rules and automating decision-making processes.
- Real-Time Data Access: These systems provided access to diverse data sources, empowering them to derive informed decisions in real-time, thereby enhancing the agility and responsiveness of processes.
- Process Redesign Support: Both iBPMS and dynamic CMS emphasized the importance of process automation and digitization, facilitating process redesign efforts to streamline operations and leverage technological advancements (Szelągowski, Lupeikiene, 2020; Szelągowski et al., 2022).

Intelligent BPMS (iBPMS) has emerged as a solution to address these challenges (Gartner, 2012). An iBPMS is a high-productivity application development platform that empowers organizations to change their operating models, processes, and procedures dynamically. These changes are documented as models and directly drive the execution of business operations, allowing business users to make frequent or ad hoc process modifications independently of IT-managed technical assets, such as integration with external systems and security administration (Gartner, 2015).

iBPMS solutions typically encompass advanced capabilities, including enterprise document management, business rules, case management, advanced integration features based on Service-Oriented Architecture (SOA), cloud computing, social collaboration features, and responsive mobile user interfaces (Cheng, 2012). According to Gartner (2015), the iBPMS market comprises vendors offering an integrated set of technologies that coordinate people, machines, and things. These systems enable collaboration between "citizen developers" (usually business

analysts and end users) and professional developers to enhance and transform business processes. iBPMS products provide real-time optimization capabilities for specific work tasks, allowing emergent practices to quickly scale across functions or the entire enterprise.

The essential capabilities of iBPMS platforms are built around six primary use cases, as identified by Gartner (2019):

- Composition of Intelligent Process-Centered Applications: iBPMS platforms enable the development of process-centered applications that leverage intelligence, automation, and integration capabilities to streamline and optimize business processes.
- Continuous Process Improvement: These platforms support ongoing process improvement initiatives by providing tools and features for process monitoring, analysis, and optimization. They facilitate the identification of bottlenecks, inefficiencies, and opportunities for enhancing process performance.
- Business Transformation: iBPMS platforms are crucial in enabling business transformation initiatives. They provide the necessary tools and technologies to model, design, and implement new processes that align with the organization's strategic objectives and help drive significant changes across the business.
- Digitized Processes: iBPMS platforms enable the digitization of processes by leveraging technologies such as robotic process automation (RPA), artificial intelligence (AI), and machine learning (ML). This allows organizations to automate manual tasks, improve data accuracy, and enhance process efficiency.
- Citizen Developer Application Composition: These platforms empower non-technical business users, often called citizen developers, to create and compose process-centric applications without extensive coding knowledge. They provide intuitive interfaces, low-code or no-code development capabilities, and pre-built components for rapid application development.
- Adaptive Case Management: iBPMS platforms support managing complex and unstructured processes through adaptive case management capabilities. These features enable knowledge workers to handle cases that require flexibility, collaboration, and decision-making based on contextual information.

BPMS systems are continuously developing to meet the evolving demands of the business environment. While intelligent business process management platforms consider aspects of business transformation and digitization, advancements in technology and the drive for digital transformation push the evolution of BPM software even further (Belev, 2018). These changes aim to provide a tool that enables effective competition in the present and establishes a competitive position for the future.

In practice, the emergence of Industry 4.0 and the upcoming Industry 5.0 emphasize the close integration of BPM with various ICTs (Information and Communication Technologies). These technologies are implemented as standalone applications but increasingly as components of comprehensive BPMS packages (van der Aalst et al., 2016). The diverse requirements of users based on the nature and context of their business processes necessitate the flexibility of BPMS systems to integrate different technologies and devices. This integration ensures the organization's ability to achieve its business objectives. The main forecasted directions of BPMS development are Pervasive Artificial Intelligence, Improved Human-Machine Collaboration, Blockchain-based Process Management, Adaptive and Context-Aware BPMS, Greater Focus on Sustainability and Circular Economy, and Industry-Specific and Customizable Solutions.

4.1. Pervasive Artificial Intelligence

BPMS will increasingly integrate artificial intelligence (AI) and machine learning algorithms, facilitating greater automation, advanced analytics, and more accurate predictions. These technologies have a wide range of applications across various industries. The main directions of development are (Davenport, 2018; Merenda et al., 2020; Ribeiro et al., 2021; van der Aa et al., 2018; Wang et al., 2016; Yathiraju, 2022; Yu et al., 2021):

- Intelligent Process Automation: Pervasive AI in BPMS can automate routine and repetitive tasks, allowing organizations to streamline processes, improve efficiency, and reduce manual errors.
- Predictive Analytics: AI-powered BPMS can leverage historical data to make accurate predictions about future trends, customer behaviour, and process outcomes. This helps organizations make data-driven decisions and optimize their processes.
- Natural Language Processing (NLP): AI-driven NLP capabilities in BPMS enable better understanding and interpretation of unstructured data, such as customer feedback, emails, and social media interactions. This helps organizations gain insights and take appropriate actions based on the analyzed text.
- Intelligent Decision Support: Pervasive AI in BPMS can support decisions by analyzing data, identifying patterns, and recommending optimal actions. This assists users in making informed decisions and improving overall performance.
- Real-time Process Monitoring: AI integrated into BPMS enables real-time monitoring of processes, allowing organizations to track process performance, identify deviations, and take timely corrective actions. This enhances process visibility and control.

According to existing research, Pervasive AI and Machine Learning Business Process Management Systems (BPMS) exhibit various applications in diverse domains such as the Internet of Things (IoT), smart homes, intelligent buildings, and Industry 4.0. The challenges associated with achieving resource efficiency in distributed artificial intelligence within

pervasive systems have been acknowledged. Various architectures and platforms have been put forth to facilitate the implementation of machine learning-driven applications in intelligent buildings. The significance of smart resource scheduling in Internet of Things (IoT) devices and infrastructure is underscored to mitigate communication and computation overheads and guarantee optimal performance.

Artificial intelligence (AI) is widely acknowledged as highly compatible with business process management (BPM). It can be effectively utilized across various subtopics within BPM, including Reference Model Mining, Predictive Process Monitoring, and Process Discovery. Nevertheless, the market encounters multiple obstacles that must be addressed, including surmounting limitations on organizational structure, personnel capabilities, social dynamics, and technological constraints. Additionally, challenges related to model scalability and distributed computing further compound the complexities faced by the market. Considering internal and external challenges in the extensive implementation of AI technologies is underscored. In general, although the Pervasive AI and Machine Learning BPMS market exhibits promising opportunities, it also presents particular challenges that necessitate attention to fully actualize its potential (Merenda et al., 2020; Ribeiro et al., 2021; van der Aa et al., 2018; Wang et al., 2016; Yathiraju, 2022; Yu et al., 2021).

4.2. Improved Human-Machine Collaboration

BPMS can promote more effective human-machine collaboration by leveraging AI and automation capabilities in several ways (Khan et al., 2010; Koopman, Seymour, 2020; Marino et al., 2021; Merenda et al., 2020; Ribeiro et al., 2021; Ubaid, Dweiri, 2020; Van de Meerendonk et al., 2010; van der Aa et al., 2018; Venerella, 2019):

- Intelligent Task Allocation: BPM systems powered by AI can analyze task requirements, employee skills, and availability to assign tasks to the most suitable individuals intelligently. This improves task allocation efficiency and ensures the right people are given assignments.
- Automated Routine Tasks: AI and automation capabilities in BPM systems can handle repetitive and rule-based tasks, freeing up human employees to focus on higher-value activities that require creativity, problem-solving, and critical thinking. This leads to more effective collaboration between humans and machines.
- Intelligent Decision Support: AI algorithms integrated into BPM systems can analyze data and provide real-time insights and recommendations to human employees. This assists them in making informed decisions, accelerating decision-making processes, and promoting collaboration between humans and intelligent systems.
- Natural Language Processing (NLP): NLP capabilities in BPM systems enable seamless communication between humans and machines. Users can interact with the system using natural language, making it easier for employees to collaborate with the system, retrieve information, and give instructions.

- Process Optimization and Recommendation: AI-powered analytics in BPM systems can analyze process data, identify bottlenecks, and recommend process improvements. This collaborative approach allows human employees and the system to work together in optimizing processes and achieving better outcomes.

4.3. Blockchain-based Process Management

BPMS will incorporate blockchain technology, providing secure, transparent, decentralized process management. This will improve stakeholder trust and collaboration and enable more efficient auditing and compliance. The use of blockchain technology in BPM will specifically focus on process mining and auditing capabilities (Asante et al., 2021; Batwa, Norrman, 2021; Perboli et al., 2018; Queiroz et al., 2020).

4.4. Adaptive and Context-Aware BPMS

Future BPMS (Business Process Management Systems) are expected to become more adaptive and context-aware, enabling dynamic process adjustments based on real-time data and changing circumstances. This enhanced capability will contribute to the agility and resilience of organizations, allowing them to respond effectively to disruptions and market changes (Bhattacharya et al., 2023; Helbin, Van Looy, 2019; Szelągowski, Lupeikiene, 2020; Szelągowski et al., 2022).

4.5. Greater Focus on Sustainability and Circular Economy

BPMS will increasingly emphasize sustainability and circular economy principles, helping organizations optimize resource utilization, reduce waste, and make data-driven decisions to minimize their environmental impact, in particular through (Garcia-Muiña et al., 2019; Manavalan, Jayakrishna, 2019; Queiroz et al., 2020; Wichaisri, Sopadang, 2018; Wynn, Jones, 2022):

- Resource Optimization: BPMS can contribute to sustainability efforts by optimizing resource utilization within business processes. Organizations can identify inefficiencies and implement measures to reduce resource consumption by analyzing and monitoring resource usage.
- Waste Reduction: BPMS can help organizations adopt circular economy principles by minimizing waste generation and facilitating waste recovery and recycling. Through process analysis and optimization, BPMS can identify opportunities to reduce waste and promote circularity.
- Data-Driven Decision Making: BPMS can enable data-driven decision-making considering sustainability factors. By integrating environmental data and performance indicators into process management, organizations can make informed decisions prioritizing sustainable practices.

- Environmental Impact Assessment: BPMS can incorporate ecological impact assessment tools to evaluate the sustainability of processes. By considering factors such as carbon footprint, energy consumption, and material waste, organizations can identify areas for improvement and implement sustainable practices.
- Stakeholder Engagement: BPMS can facilitate stakeholder engagement in sustainability initiatives. Organizations can promote awareness, collaboration, and shared responsibility for sustainability goals by involving employees, customers, and partners in process management.

4.6. Industry-Specific and Customizable Solutions

BPMS will continue to evolve and cater to the unique requirements of various industries, offering customizable features and modules that address specific business needs and challenges (Bjelland, Haddara, 2018; Cieciora et al., 2020; Gavali, Halder, 2020; Haddara et al., 2015; Hardcastle, 2014; Kralijc, Kralijc, 2017; Rashid et al., 2002; Teltumbde, 2000; van der Aalst et al., 1994). Especially:

- Industry-Specific Optimization: BPMS can be tailored to meet the unique requirements of different industries, enabling organizations to optimize processes specific to their sector. Customizable features and modules allow industry-specific workflows, regulations, and best practices to be incorporated into the BPMS.
- Flexibility for Diverse Business Needs: BPMS provides flexibility to address diverse business needs within different industries. Customizable features enable organizations to adapt the system to specific processes, organizational structures, and integration requirements.
- Compliance and Regulatory Support: Industry-specific BPMS solutions can incorporate compliance and regulatory frameworks relevant to particular sectors. Customizable modules can ensure adherence to industry-specific standards, regulations, and governance requirements.
- Addressing Sector Challenges: Industry-specific BPMS solutions can help organizations tackle unique challenges within their sectors. Customizable features and modules can assist in overcoming industry-specific complexities, improving efficiency, and achieving competitive advantage.
- Best Practice Incorporation: BPMS can integrate industry-specific best practices and guidelines into process models. Customizable solutions allow organizations to align their processes with industry standards and leverage proven approaches for improved performance.

5. ERP and BPMS integration

Organizations in Industry 4.0 and Industry 5.0, employ ERP and BPMS systems. However, these two system classes' purposes have changed in the last 10-15 years. Previously, ERP systems were primarily utilized for resource management, while BPMS (or its predecessor, WFM) supported the implementation of business processes. The requirements and drivers for developing and architecting these system classes also varied (Nazemi et al., 2012).

A decade ago, the success of implementing BPM was assessed based on the simplicity, quality, and flexibility of business processes within the organization (Dabaghkashani et al., 2012). Industry 5.0 has shifted the focus away from technology, recognizing that true development potential lies in the collaboration between humans and machines. During the era of digital transformation, an organization's success is measured by its current efficiency, the development potential of its products and services, and the ability to leverage and cultivate its intellectual capital. This approach requires continuous BPM ambidexterity, impossible in Industry 4.0/5.0 without ensuring effective cooperation between machines (including AI elements) and well-trained and innovative employees (Helbin, Van Looy, 2019; Nahavandi, 2019).

The strategic objectives of implementing and utilizing ERP and BPMS systems are undoubtedly similar. However, during the 90s and 2000s, the specific applications, goals, requirements, and critical success factors differed between these system classes. Technological limitations, particularly internal system integration flexibility, also contributed to differentiation. The advent of digital transformation and changes like value-generating business processes, including the rise of dynamically managed processes, have altered both system classes' requirements and critical success factors. Management perspectives consider a successful ERP implementation as one that reduces workload, costs, and time while improving the quality and flexibility of value-generating business processes (Leyh, Sander, 2015). Simultaneously, managers expect BPMS implementations, with its embedded hyper-automation technologies, to ensure seamless and flexible information exchange, efficient execution of production or service-oriented processes, workload reduction through robotization and automation, and timely provision of detailed analytical reporting data (Karimi et al., 2007). Analyzing the critical success factors (CSFs) for both system classes brings similar findings:

1. Strategic coherence,
    a. Strategic alignment (Bosilj et al., 2018; Castro et al., 2020; Gabryelczvk, 2018; Koopman, Seymour, 2020; Syed et al., 2018; Ubaid, Dweiri, 2020; Zendehdel Nobari et al., 2022).
    b. Business vision and mission (Gavali, Halder, 2020; Koopman, Seymour, 2020; Kralijc, Kralijc, 2017; Syed et al., 2018).

   c. Business process effectiveness (Bosilj et al., 2018; Cieciora et al., 2020; Gabryelczyk, Roztocki, 2018; Hasan et al., 2019; Ubaid, Dweiri, 2020).
2. Governance,
   a. Top management support (Bosilj et al., 2018; Castro et al., 2020; Esteves, Pastor, 2001; 2006; Ganesh et al., 2014; Gavali, Halder, 2020; Kapur et al., 2014; Nagpal et al., 2017; Vargas, Comuzzi, 2020).
   b. Effective change management (Ganesh et al., 2014; Kapur et al., 2014; Kralijc, Kralijc, 2017; Magpal et al., 2017; Syed et al., 2018; Ubaid, Dweiri, 2020; Vargas, Comuzzi, 2020; Zendehdel Nobari et al., 2022).
   c. Business process improvements implementation (Brkic et al., 2020; Ganesh et al., 2014; Kapur et al., 2014; Kralijc, Kralijc, 2017; Nagpal et al., 2017; Zhu et al., 2020).
   d. Continuous monitoring and improvement system Castro et al., 2020; Hasan et al., 2019; Ubaid, Dweiri, 2020).
3. Methods,
   a. Awareness and understanding of BPM (Brkic et al., 2020; Gavali, Halder, 2020; Kapur et al., 2014; Syed et al., 2018; Vargas, Comuzzi, 2020).
   b. Implementation strategy (Bosilj et al., 2018; Castro et al., 2020).
   c. Effective Project management (Esteves, Pastor, 2001; Ganesh et al., 2014; Gavali, Holder, 2020; Hasan et al., 2019; Nagpal et al., 2017; Syed et al., 2018; Vargas, Comuzzi, 2020; Zendehdel Nobari et al., 2022).
4. Technology,
   a. Evaluation of technology potential and limitations (Ganesh et al., 2014; Syed et al., 2018; Zendehdel Nobari et al., 2022).
   b. Architecture: flexibility and integration opportunities (Gavali, Holder, 2020; Kapur et al., 2014; Kralijc, Kralijc, 2017).
   c. Data analysis and conversion (Cieciora et al., 2020; Ganesh et al., 2014; Koopman, Seymour, 2020; Kralijc, Kralijc, 2017; Nagpal et al., 2017; Vargas, Comuzzi, 2020).
   d. Careful module selection Cieciora et al., 2020; Ganesh et al., 2014; Koopman, Seymour, 2020; Nagpal et al., 2017; Vargas, Comuzzi, 2020).
5. People,
      a. Empowerment (Syed et al., 2018; Ubaid, Dweiri, 2020).
      b. Expertise level (Castro et al., 2020; Ganesh et al., 2014; Koopman, Seymour, 2020; Vargas, Comuzzi, 2020).
      c. User engagement (Esteves and Pastor, 2001; Ganesh et al., 2014; Ubaid, Dweiri, 2020; Vargas, Comuzzi, 2020).

6. Culture,
    a. Corporate culture (Bosilj et al., 2018; Ganesh et al., 2014; Ubaid, Dweiri, 2020; Vargas, Comuzzi, 2020).
    b. Communication and collaboration (Gabryelczyk, Roztocki, 2018; Ganesh et al., 2014; Hasan et al., 2019; Kapur et al., 2014; Koopman, Seymour, 2020; Nagpal et al., 2017; Syed et al., 2018; Vargas, Comuzzi, 2020).

From a business standpoint, the requirements for both system classes are essentially the same. At the level of IT architecture, both classes of systems differ in how they use hyper-automation elements. While iBPMS includes them as an integral component, postmodern ERPs usually require external integration. Therefore, these two system classes' artificial division and separate development are increasingly losing significance. However, it is unlikely that one integrated system will soon encompass all the critical success factors, as it is a complex design problem with multiple criteria to consider.

Consequently, an organization's information system configuration will depend on its underlying business philosophy (Lupeikiene et al., 2014). For instance, a unified process ERP system would indicate that it is the dominant component for time-critical, product/service-oriented businesses. Such an ERP system should encompass advanced planning and supply chain management to achieve the desired outcomes. In this scenario, the BPM system should focus on the "behavioural" aspect to ensure the attainment of established goals and act as a subordinate to the ERP system. Nevertheless, to make the system more transparent and more straightforward for the user and to better support the business, we can expect the following possible directions of integration:

- API-Based Integration: Application Programming Interfaces (APIs) are crucial in system integration. In the future, ERP and BPMS vendors may provide standardized APIs that allow seamless data exchange and process integration between the two systems. This would enable organizations to connect and coordinate data and workflows between ERP and BPMS systems more efficiently.
- Middleware Solutions: Middleware software acts as a bridge between different systems, facilitating communication and data transfer. In the future, specialized middleware solutions (improved data or service buses) may emerge to facilitate integration between ERP and BPMS systems. These solutions could handle data transformation, coordination, and business process orchestration between the two systems.
- Unified Platform Solutions: Some vendors may develop unified platforms combining ERP and BPMS functionalities into one integrated solution. This approach would provide a cohesive user experience and enable seamless data and process integration between ERP and BPMS. Organizations would benefit from a comprehensive system that caters to resource management and business process execution.

- Data Integration and Analytics: Integrating data from ERP and BPMS systems can provide organizations valuable insights. In the future, integration may focus on combining data from both systems to drive advanced analytics and reporting capabilities. By correlating data from ERP's resource management with BPMS's process execution data, organizations can gain deeper insights into operational efficiency, cost optimization, and process improvement.

The research findings hold significant practical implications for organizations navigating Industry 4.0 and Industry 5.0, employing both ERP and BPMS systems. The strategic objectives for implementing ERP and BPMS systems remain similar, but the specific applications, goals, and critical success factors have evolved. Technological limitations that once differentiated them are diminishing. From a practical standpoint, organizations should focus on strategic alignment, top management support, effective change management, awareness and understanding of BPM, evaluation of technology potential, empowerment, and corporate culture. As organizations transition from the historical separation of ERP and BPMS systems to a more integrated approach, these findings guide practical decision-making. Whether through standardized APIs, middleware solutions, unified platforms, or advanced analytics, organizations can strategically align their systems to meet evolving business objectives in the dynamic landscape of Industry 4.0 and Industry 5.0.

6. Conclusions

This study demonstrates that from a strategic perspective, businesses pursue identical objectives for ERP and BPMS systems, as evidenced by the overlap in their critical success factors (CSFs) (Ganesh et al., 2014; Kapur et al., 2014; Syed et al., 2018). While traditionally the choice between these systems was determined by organizational size (Cieciora et al., 2020; Rashid et al., 2002), digital transformation has changed requirements, necessitating capabilities like dynamic process management regardless of a company's scale (Helbin, Van Looy, 2019; Szelągowski, 2019).

Although ERP and BPMS have technically evolved separately, from a business standpoint their CSFs align, spanning factors like top management commitment, effective change management, business-IT alignment, and user training (Esteves, Pastor, 2001; Nagpal et al., 2017; Zendehdel Nobari et al., 2022). This indicates that differentiating between ERP and BPMS may become less relevant in the future.

Technically, ERP and BPMS remain distinct in their native handling of technologies like AI and RPA (Hofmann et al., 2020; van der Aalst, 2022). However, postmodern ERP employs APIs and microservices to enable flexible integration of these innovations (Gartner, 2019b; López-Muñoz, Escribá-Esteve, 2019; Weske, 2012). With appropriate enterprise architecture,

ERP's transactional capabilities can be combined with BPMS's dynamic process support (Lupeikiene et al., 2014; Teltumbde, 2000).

Therefore, while historically seen as disparate systems, the analysis in this research suggests ERP and BPMS's business objectives and CSFs are converging. This supports integrating their strengths into a unified platform, providing organizations with the needed transaction support, flexibility, and innovation (Dubey et al., 2019; van der Aalst et al., 2016). Further studies validating this integrated approach via case studies or prototype development would offer additional empirical evidence.

Overall, by reviewing ERP and BPMS's evolution and critically comparing their CSFs, this study provides valuable and novel insights into their current status and future trajectory (Asante et al., 2021; Szelągowski et al., 2022). The findings can guide organizations in leveraging these systems effectively amid ongoing digital transformation.

The comparative CSF analysis in this study provides insights that organizations and ERP consultants can leverage to inform their integration strategies and improve implementation outcomes. The identified CSFs highlight key areas that organizations should focus on when adopting ERP, BPMS, or pursuing integration between these systems. For instance, factors like top management commitment, change management, business-IT alignment, and user training emerge as vital for implementation success regardless of the system. Organizations should devote appropriate resources and planning to address these high-priority areas. The findings help consultants guide clients to factor in these critical areas when formulating implementation plans and system integration roadmaps. Thus, the research provides a strategic lens for organizations and consultants to evaluate integration options and optimize ERP and BPMS deployments based on business objectives.

Unlike prior literature which has examined ERP and BPMS systems individually, this study provides original perspectives by conducting a direct comparative analysis of the critical success factors for each system class. The side-by-side comparison of the CSFs necessary for ERP and BPMS implementation success represents a novel framework for investigating the alignment of their strategic objectives. By comprehensively reviewing and contrasting the factors vital for the adoption of each system, this research offers new insights into the convergence of ERP and BPMS from a business-focused lens. The findings lead to informed conclusions about potentially integrating their capabilities into a unified platform that meets modern organizations' needs. Thus, the comparative CSF analysis approach enables this study to contribute unique insights into the current status and future trajectory of ERP and BPMS systems.

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PARADOXES IN THE ENGINEERING CHANGE MANAGEMENT PROCESS

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Purpose: The main purpose of this paper is to conceptualize and operationalize paradoxes that are significant in the engineering change management (ECM) process. The following research question was stated: What are the paradoxes that influence the ECM process, and how can they be measured?
Design/methodology/approach: The study is divided into two parts: conceptualization and operationalization. Conceptualization involved a literature review, which allowed for identifying initial categories of paradoxes that were later verified during in-depth personal interviews with the study participants. The subsequent operationalization involved developing a measurement tool which is a semantic differential scale that allows for assessing the perceived current and desired approach to solving paradoxes affecting ECM. The tool was revised based on in-depth personal interviews with participants of the ECM process. For the study, a manufacturing company which implemented a change management process was selected.
Findings: Four general groups of paradoxes previously identified in the paradox theory literature (i.e. learning, belonging, performing, and organizing) were used to develop a list of paradoxes specific to the ECM process. In-depth interviews allowed to obtain data from experienced participants of the process, which was used to verify the preliminary list. The result of this verification was the list of 12 paradoxes that was included in the final measurement tool.
Research limitations: Even though the study involved well-informed participants who are experienced in the ECM process, they represented a single company. Additionally, the proposed research tool may require further verification in subsequent studies.
Practical implications: The knowledge regarding paradoxes specific to the ECM process and the created tool can be helpful for change administrators, project managers, and other stakeholders. They allow to define the areas of most significant tensions in the ECM process that require attention and effort.
Originality/value: This paper's main value pertains to two different domains- cognitive and methodic. The undertaken attempt to include paradoxes and their significance in the analysis of the ECM process broadens the current understanding of process determinants. The proposed research tool, which is based on a well-grounded theoretical approach to paradoxes and adapted to fit the ECM process, can be used in further research.

Keywords: Paradox Theory, Paradox Management, Tension, Engineering Change Management, Engineering Change.

Category of the paper: Research paper, Case study.

1. Introduction

The engineering change management (ECM) process is a process of information distribution that deserves in-depth studies because of its newness and importance for production companies. ECM is among the most important processes in companies with an Engineering-to-Order production environment. ECM involves the implementation of changes, modification of structures and alterations of functionality elements that are already utilized in the production process (Reddi, Moon, 2013; Hamraz et al., 2013). The ECM process can be considered in two ways: as a planned engineering change implementation (Tavčar, Duhovnik, 2005; Jarratt et al., 2011) and as an emergent engineering change implementation (Sjögren et al., 2019; Eckert et al., 2017). In both these approaches the importance of tensions that are present in the ECM process, should be considered and validated.

The contingency theory offers only one answer to the organizational tensions pertaining to management (Lawrence, Lorsch, 1967). Paradox theory adopts an alternative approach to organizational tensions, exploring how organizations can treat different tensions simultaneously (Smith, Lewis, 2011). The effect of selecting a one-sided answer when addressing competing tensions can be quick, but function only in a short-term. According to the paradox theory, it is possible to achieve a more long-term, sustainable solutions (Lewis, 2000). Paradoxes that are present in literature focus mainly the organizational aspects of management. According to the decision-making process perspective in management, paradoxes are present in every aspect of management.

There is a gap in the literature that the present paper intends to fill. In our paper, we aim to conceptualize and operationalize paradoxes that are relevant to the engineering change management (ECM) process. The end result of our efforts is a measurement tool that can help identify and analyze the ECM process.

The paper is divided into five parts. The first part includes the literature review which includes paradox theory and the ECM process. The second part concerns methodology employed in the conducted study which is followed by results shown in the third part. In part four, the authors describe the subsequent steps of conceptualizing and operationalizing paradoxes in ECM and propose a tool for measuring and analyzing paradoxes. Finally, fifth part includes theoretical and practical implications, research limitations and proposed further directions of research and inquiries.

2. Literature review

In organizations managers continuously have to decide between conflicting tensions; flexibility and stability, exploration and exploitation, global and local values etc. (Clegg et al., 2002; Smith, Lewis, 2011). Contrary to contingency theory, paradox theory proposes to change the question from 'Under what conditions should managers emphasize either A or B?' to the question 'How we can engage in both A and B simultaneously?' (Tabesh, Vera, 2020). It is stressed in the literature that it is essential for managers to accept 'paradoxical thinking' not only accept the contradictory tensions but to embrace them in order to obtain the long-term sustainable effects (Ingram et al., 2014). This type of thinking promotes 'acceptance and engagement' over paradox elimination and changing the perspective on tensions from 'either/or' to 'both/and' (Smith, Lewis, 2011).

In the literature few definitions of paradoxes (tensions) can be found. It is considered 'a persistent contradiction between interdependent elements' (Schad et al., 2016). Paradox is contradictory and includes interrelated elements, which seem logical when they are isolated but their simultaneous occurrence seems to be irrational (Lewis, 2000). According to another definition, paradox 'consists of two contrary or even contradictory propositions to which we are led by apparently sound arguments' (Poole, Van de Ven, 1989). A contradiction which exists in a paradox is compared to the tug-of-war experience (Schad et al., 2016). Interdependence in Schad et al. (2016) definition refers to the inextricable connection between opposing elements. According to scholars, it is possible to separate those elements, but their simultaneous existence creates a paradoxical wholeness (Poole, Van de Ven, 1989). In the literature the most popular example of such a connection is yin-yang (Schad et al., 2016; Lewis, 2000; Smith, Lewis, 2011). In the literature there are several different categorizations of paradoxes. The two most popular approaches include three groups of paradoxes proposed by Lewis (2000): learning, organizing and belonging and the later extension including four groups proposed by Smith and Lewis (2011): learning, organizing, belonging and performing (Table 1).

Table 1.
Groups of the organizational paradoxes

No.	Type of paradox	Meaning for organization
1	Organizing	Organizing paradoxes are the tensions which describe differences between behaviors in organization.
2	Learning	Differences between types of learning.
3	Belonging	This paradox describes differences in the approach to identity.
4	Performing	Differences between interests and strategies.

Source: Own elaboration based on Jarząbkowski, 2013; Smith, Lewis, 2011.

Four groups of paradoxes describe different approaches to managing different situation in organizations. These different approaches foster collaboration and competition or control and flexibility behaviors (organizing tensions). Learning paradoxes pertain to tensions between

building new reality and disassociating from the past in order to build up new types technologies, behaviors, etc. The third group – belonging tensions – foster tensions between individual and collective or between competing values, roles and memberships. The last group includes performing tensions which focus on different goals represented by different groups of stakeholders in organizations (Smith, Lewis, 2011).

Multiple examples of organizational tensions which are subject of research can be found in literature. In Table 2 we present examples of frequently studied organizational paradoxes (Smith, Lewis, 2011; Clegg et al., 2002; Schad et al., 2016; Lawrence, Lorsch, 1967). Presented examples of the organizational paradoxes include each of the four groups (Table 1). Because tensions can also exist between group of paradoxes, according to Smith and Lewis (2011) some of the paradoxes can be divided even more precisely.

Table 2.
Management paradoxes in the literature

No.	Type of paradox	Example of tension	Author
1	Organizing	Cooperation vs competition	Runge et al. (2022), Munten et al. (2022), Best et al. (2021), van Duijn et al. (2021), Rey-Garcia et al. (2021), Dooley, Gubbins (2019), Tóth et al. (2018), Chou, Zolkiewski (2018), Pressey, Vanharanta (2016), Stadtler, Van Wassenhove (2016), Fernandez, Chiambaretto (2016)
2	Learning vs Organizing	Rigidity vs flexibility	Schmidt (2019), Tóth et al. (2018), Chou, Zolkiewski (2018), Vangen (2017), Pressey, Vanharanta (2016), Pajunen, Fang (2013)
3	Learning	Exploration vs exploitation	Rey-Garcia et al. (2021), Lannon, Walsh (2020), Remneland, Wikhamn (2020), Dooley, Gubbins (2019), Brown, Head (2019)
4	Organizing	Short-term vs long-term orientation	Tóth et al. (2018), Chou, Zolkiewski (2018), Pressey, Vanharanta (2016), Pajunen, Fang (2013)
5	Organizing	Unity vs diversity	Rey-Garcia et al. (2021), DeFillippi, Sydow (2016)
6	Performing	Autonomy vs accountability	Rey-Garcia et al. (2021), Dooley, Gubbins (2019), Vangen (2017)
7	Learning vs Belonging	Knowledge sharing vs knowledge protection	Huang, Chiu (2020), Rouyre, Fernandez (2019), Stadtler, Van Wassenhove (2016)
8	Performing vs Belonging	Value creation vs value appropriation	Best et al. (2021), Stefan et al. (2021), Remneland Wikhamn (2020), Niesten, Stefan (2019), Gillett et al. (2019), DeFillippi, Sydow (2016)
9	Performing vs organizing	Economic vs social logic	Best et al. (2021), Ahmadsimab, Chowdhury (2021), Gillett et al. (2019)
10	Organizing	Trust vs distrust	Pressey, Vanharanta (2016), Pajunen, Fang (2013)
11	Belonging	Centralization vs decentralization	van Duijn et al. (2021), Schmidt (2019)
12	Belonging vs Organizing	Goal congruence vs goal diversity	Rey-Garcia et al. (2021), Vangen (2017)
13	Performing	Information sharing vs information protection	Fernandez, Chiambaretto (2016)
14	Learning vs Performing	Temporary vs permanent	DeFillippi, Sydow (2016), Stjerne, Svejenova (2016)
15	Learning vs Organizing	Standard vs standard flexibility	DeFillippi, Sydow (2016)

16	Performing vs Belonging	Proximity vs distance	Zaheer, Hernandez (2011)
17	Organizing	Power vs trust	Horak, Long (2018)
18	Performing vs Organizing	Individualistic vs collective social structure	Dooley, Gubbins (2019)
19	Learning vs Belonging	External R&D vs internal R&D	Wang et al. (2017)
20	Learning vs Organizing	Complexity vs simplification	Vangen (2017)

Source: Own elaboration based on: Fortes et al., 2023; Smith, Lewis, 2011.

Presented groups and paradoxes describe tensions that managers have to deal with in their daily work. Paradox theory as opposed to the contingency theory doesn't propose one good solution for the tensions (Lawrence, Lorsch, 1967) but tries to organize work and treat tensions simultaneously (Smith, Lewis, 2011). The most frequently appearing paradoxes in the literature are the cooperation vs competition (Runge et al., 2022; Munten et al., 2022; Best et al., 2021; van Duijn et al., 2021; Rey-Garcia et al., 2021; Dooley, Gubbins, 2019; Tóth et al., 2018; Chou, Zolkiewski, 2018; Pressey, Vanharanta, 2016; Stadtler, Van Wassenhove, 2016; Fernandez, Chiambaretto, 2016), exploration vs exploitation (Rey-Garcia et al., 2021; Lannon, Walsh, 2020; Remneland, Wikhamn, 2020; Dooley, Gubbins, 2019; Brown, Head, 2019) and rigidity vs flexibility (Schmidt, 2019; Tóth et al., 2018; Chou, Zolkiewski, 2018; Vangen, 2017; Pressey, Vanharanta, 2016; Pajunen, Fang, 2013). Those three paradoxes are the most frequently typed paradoxes in organizational management literature. This 'popularity' can stem from the difficulties which they pose to managers.

In organizations in general and production organizations particularly, changes are caused by multiple factors, e.g. the change of the shareholders' vision, the fact that the material did not arrive or a customer changed the order. In this type of organizations the ECM process involves many departments, such as design, engineering and production. The purpose of this process is the implementation of changes that were provided in technical documentation and making it available to other departments. It is important to make the information available not only after the implementation of changes, but also during the process (Iakymenko et al., 2020). Each process has its owner (Dumas et al., 2013) and in the case of ECM, the role of the process owner is assigned to the project manager who in the case of the ECM process is called an engineering changes coordinator (Iakymenko et al., 2020). The engineering changes coordinator as a process owner is responsible for the shape of the process, its inputs and outputs. Engineering changes coordinators, just as all leaders in a company involved in the ECM process, are required to take decisions pertaining to the process for which they are responsible.

Groups of paradoxes defined in organizational management are also present in the ECM process. Table 3 includes paradoxes grouped into the four previously described categories that are specific to the ECM process.

Table 3.
Groups of the ECM paradoxes meaning

No.	Type of paradox	Meaning for ECM
1	Organizing	This type of tensions describes difference in change order approach and in the analysis of change order.
2	Learning	Change performance and searching for the answer about the origin of the change order.
3	Belonging	ECM deals with the different departments in the organization.
4	Performing	Performing tensions concerns different effects of the implemented changes

Source: Own elaboration.

As per the ECM process, the organizing type of paradox does not concern behaviors in an organization, but requires the analysis of approaching different types of engineering change orders. Learning paradoxes would pertain to analyzing the origins of each change order. As the ECM process involves multiple departments, belonging paradoxes are an essential issue. Those paradoxes pertain to tensions that exist between departments and tensions between a department and processes. The last described group are the performing paradoxes. This type pertains to different final effects of change implementation. It is about the speed of change implementation or about range of the informed group of stakeholders. Organizational tensions shown in Table 2 are also present in case of the ECM process. The difference between organizational paradoxes and ECM paradoxes will concern the main actors of the process. For example temporary vs permanent tension describes that temporary arising company emerges separately and then coordinates its action within a permanent organization (Braun, Lampel, 2020). In the case of the ECM process this paradox will involve the durability of a technical solution which is related with the speed of change implementation.

3. Material and methods

In our paper, we describe an exploratory study aimed at addressing the following research question: How can we identify, define, operationalize, and measure paradoxes in engineering change management (ECM)? Our objective is to compile a list of the most common tensions that arise in a manufacturing company and develop a tool for analyzing paradoxes within the ECM process.

To answer this research question, we conducted an exploratory qualitative study rooted in the interpretative-symbolic paradigm (Sułkowski, 2012) and employing an abductive approach (Peirce, 1931; 1958). We employed purposive sampling, selecting a Polish manufacturing company for our study. This company specializes in low-volume, high-mix production and has been a prominent player in the automotive market for over 30 years. With over 800 employees, approximately 95% of whom are either directly involved in production or closely linked to it, the company was an ideal candidate for our research. Furthermore, the company was actively

implementing the ECM process at the time of the study, making it a suitable choice for our investigation.

The research unfolded in three stages. The initial stage involved an exhaustive literature review aimed at conceptualizing paradoxes within the ECM process. We scoured Polish and English-language publications indexed in global databases, including the Web of Science, Scopus, and ProQuest. Based on this review, we compiled an initial list of paradoxes relevant to the ECM process.

The second stage sought to validate and expand upon the initial set of paradoxes through empirical research. To accomplish this, we conducted a pilot study that relied on in-depth, semi-structured personal interviews. The interviews explored four key themes: 1) Knowledge about ECM, 2) Previous experience with ECM, 3) Impact on the process implementation, and 4) Organizational and personal challenges encountered during ECM implementation at the analyzed company. During this phase, we chose not to directly address the paradoxes but rather to derive them abductively from the statements made by the respondents. The study encompassed a total of 31 employees from the selected company, representing various positions, including 2 specialists, 19 heads of divisions, 8 heads of departments, and 2 project managers. These respondents were all directly or indirectly involved in ECM. Interviews, lasting an average of 105 minutes each, guaranteed the confidentiality and anonymity of the participants. Conventional qualitative content analysis (Hsieh, Shannon, 2005) was the primary technique used for data analysis and interpretation.

The culmination of the first two stages resulted in the operationalization of paradoxes within the ECM process and the development of a measurement tool—an empirical differential scale. This scale was designed to assess perceived current and desired approaches to resolving paradoxes affecting ECM. Validation of this tool took place during the third stage of our research, involving in-depth personal interviews that directly addressed the developed set of paradoxes. Respondents were asked to share their experiences related to each presented paradox and provide their opinions on the occurrence of these paradoxes within the ECM process. In total, 15 employees from the selected company participated in this stage, representing various positions, including 2 specialists, 8 heads of divisions, 4 heads of departments, and 1 project manager.

The stages of research are summarized in Table 4.

Table 4.
Research stages.

Stage no.	Method	Purpose	Effect
Stage 1	Literature review	Identifying paradoxes that can be important in the ECM process.	A list of paradoxes that can be important in the ECM process.
Stage 2	In-depth, semi-structured personal interviews with 31 participants directly and indirectly involved in the ECM process (a pilot study)	Verifying and supplementing the identified set of paradoxes with additional paradoxes reported by the participants.	An enhanced and specific list of paradoxes which were the basis of creating a tool for measuring paradoxes in ECM.
Stage 3	In-depth, structured interviews involving 15 participants directly involved in the ECM process	Validating the measurement tool.	Information about the paradoxes that are the most prevalent in the ECM process.

Source: own elaboration.

4. Results

This section of the article includes the description of results obtained in the consecutive research stages presented before in the article. In Stage 1 (the literature review), the list of paradoxes and their types described in the management literature and summarized earlier in the article (Table 2) served as a basis for identifying paradoxes that can be important in the ECM process. The paradoxes identified by the authors during this process are included in Table 5. Tensions belonging to each of the four types of paradoxes (i.e. organizing, performing, learning, and belonging) were included. They were still general at this stage, but their identification facilitated the interpretation of the data obtained in the second stage.

Table 5.
Types of paradoxes in Engineering Changes Management

No.	Type of paradox	Example of tension in ECM process
1	Organizing	Formal information flow vs informal information flow
2		Efficiency of process vs flexibility of process
3	Organizing	Standard solution vs flexible solution
4		Planned change implementation vs emergent change implementation
5		Piecemeal view of change vs holistic view of change
6		Macro scale of change vs micro scale of change
7	Performing	Temporary solution vs permanent solution
8		Short-term solution vs long-term solution
9		Wide group of informed vs narrow group of informed
10	Learning	External searching of solution vs internal searching of solution
11		Problem solving vs cause searching
12	Belonging	Cooperation with all departments in company vs cooperation inside department
13		Personal good vs common good

Source: Own elaboration.

In the second stage of the research the further verification of the paradoxes took place. As has already been mentioned, at this stage, which was still exploratory, respondents were asked about their experiences related to the ECM process, but they were not directly asked about the previously identified paradoxes. This procedure was purposeful and was intended to enable exploring potential other paradoxes as they are perceived by those who participate in ECM processes on daily basis without limiting or biasing their answers. Rather, they were abductively derived from the obtained information. This allowed for the creation of a more specific list of paradoxes that is presented in Table 6. It includes the list of paradoxes considered by the authors as the most relevant in the ECM process. The letter "I" is used to mark those paradoxes that were identified during the interviews whereas the letter "L" refers to those that were identified in the literature analysis.

Table 6.
Final questions in the study

No.	Type of paradox	Example of paradox	Source: Literature (L), Interviews (I)	Given question
1	Learning	Exploration vs exploitation	L / I	Focusing on the existing products development vs Focusing on the searching new, convertible solutions.
2	Organizing	Macro vs micro	I	Changes implementation comprehensively, after coexisting elements analysis vs Changes implementation only in the chosen part after its identification.
3	Organizing	Trust vs distrust	L / I	Autonomy and self-solving the problem by employees vs Searching way to solve the problem with supervisor of department.
4	Learning and Organizing	Rigidity vs flexibility	L	Focusing on the flexible form of information transfer vs Focusing on the procedures of information transfer.
5	Organizing	Emergent vs planned	L / I	Changes implementation one by one vs Batching changes and implementation a few changes at the same time.
6	Learning and Organizing	Standard vs standard flexibility	L / I	Changes implementation whenever the engineering change request is register vs Consideration and analysis of each change request.
	Organizing	Emergent vs planned		
7	Performing	Autonomy vs accountability	L	Additional tasks avoidance and focusing on the basic responsibilities vs Additional tasks acceptance keeping in mind the common good.
8	Learning and Belonging	Knowledge sharing vs knowledge protection	L / I	Widely discussing results of changes vs Informing about results of changes only the most interested people.
9	Belonging	Centralization vs decentralization	L	Emphasis putting (in case of serial product) on the solution searching inside the company vs Emphasis putting (in case of serial product) on the solution searching outside the company.
10	Organizing	Short-term vs long-term orientation	L / I	Problems identifying with problem cause identification vs Problems identifying without problem cause identification.

Cont. table 6.

11	Performing and Belonging	Value creation vs value appropriation	L	New specialist hiring vs Looking for the specialist in existing staff.
12	Performing and Organizing	Individualistic vs collective social structure	L	Investing in the trainings to build the human potential vs Investing in new technologies to build market advantage.
13	Learning and Belonging	Knowledge sharing vs knowledge protection	L	Cooperation, due to product creation, with similar product portfolio companies vs New product creation independently.
	Performing	Autonomy vs accountability	L	

Source: Own elaboration.

The paradoxes presented in Table 5 were used to develop the measurement tool, which we consider an important outcome of the described process and our study. It was inspired by the semantic differential method (Osgood, 1957), which originated in psychology and is considered reliable and valid in social sciences. Typically, when this method is applied, respondents need to provide an answer on a scale anchored with bipolar adjectives (e.g. good – bad; strong–weak) indicating their attitude or the way they perceive a designated object. Since the introduction of the method, it has been widely used in the context of, for example, intercultural studies (e.g. Skrandies, Chiu, 2003), investigating the content of stereotypes (Kervyn et al., 2013), marketing research (e.g. Kriyantono, 2017) or possible future scenarios using horizon scanning (Hideg et al., 2021).

The original semantic differential technique involves bipolar adjectives belonging to three dimensions identified through factor analysis in Osgood's intercultural research (i.e. evaluation, potency, and activity). More recent studies used measures belonging to different underlying categories that were adjusted to specific study objectives. For example, Kim and Jung (2023) found a complex (six-factor) structure of people's attitudes towards Artificial Intelligence agents in their study that used the semantic differential. Following this general logic, we created our own tool to fit the needs of the current study.

In the process of developing the tool, we utilized the idea of presenting to respondents stimulus based on two bipolar options, which in this case were contradictory approaches to resolving problems that emerge when dealing with ECM (i.e. paradoxical tensions). They are included in the last column of Table 5. Each option presented as a scale's pole represents a rational and plausible action that cannot be followed simultaneously with its opposite. Such conflicting and rational approaches are at the heart of the emergence of organizational paradoxes (Jarzabkowski et al., 2013). Respondents were asked to indicate the perceived current state in the organization (how the tension is presently resolved) and the perceived desired state (how the tension should, in their opinion, be resolved). An example of the used questions is provided below and pertains to the paradox number 5 as listed in Table 5. Other paradoxes listed in this table have been included in the measurement tool in the same manner.

It is better to implement single changes one by one vs. It is better to batch changes and implement several at once.

What is the current state?

Single changes Batching changes

-5 0 5

What is the desired state?

Single changes Batching changes

-5 0 5

What should be done to obtain the desired state?

……
……
……

We decided to further verify the measurement tool with people with first-hand experience with the ECM process. During semi-structured interviews that had a broader focus and content, the participants were asked to indicate whether they encountered each of the identified paradoxes in their general professional activities and in the ECM process. Table 6 includes the percentages of participants who indicated that each of the 13 paradoxes was present in their professional activities.

The research has shown that 6 out of 13 defined paradoxes were indicated by at least half of the participants as experienced by them in the ECM process. They include paradoxes number 1, 2, 3, 5, 6, and 8 presented previously in Table 5. These paradoxes can be considered particularly important in ECM and thus should be given the most attention by people who manage or guide that process. Additional three paradoxes were identified by at least half of participants belonging to one of the study groups (but were not indicated by 50% of the total number of participant) – number 4, 10, and 12. Four other paradoxes were indicated as occurring in the ECM process less often. Even though each of the previously identified paradoxes was considered to be present in the process by at least one of the participants, some of them can be considered less prevalent. As the number of participants involved in the validation that took place in the last stage of the research was limited, the obtained results should be approached cautiously. Nevertheless, they can be considered valuable guidelines for verifying and further developing the designed measurement tool.

Table 7.
Questions in the study accuracy

Number of paradox	Overall score		Senior management		Specialists	
	General	ECM	General	ECM	General	ECM
1	53%	**73%**	63%	**75%**	43%	**71%**
2	67%	**80%**	75%	**75%**	57%	**86%**
3	80%	**53%**	75%	38%	86%	**71%**
4	60%	47%	63%	38%	57%	**57%**
5	53%	**67%**	63%	**63%**	43%	**71%**
6	60%	**80%**	63%	**75%**	57%	**86%**
7	33%	20%	38%	13%	29%	29%
8	53%	**60%**	75%	**63%**	29%	**57%**
9	47%	13%	75%	13%	14%	14%
10	53%	33%	75%	**50%**	29%	14%
11	60%	20%	63%	13%	57%	29%
12	60%	47%	75%	38%	43%	**57%**
13	33%	20%	50%	25%	14%	14%

Source: own elaboration.

5. Conclusions

Our paper contributes to the existing state of knowledge about ECM by conceptualizing and operationalizing paradoxes in this process. Although the theory of paradoxes is quite well described in the literature, it is used mostly in the context of organizational change management. Its potential in the context of ECM seems to be not sufficiently utilized. In fact, we are not aware of publications that directly linked the issues of paradoxes to the management and development of the ECM process.

Our study also provides practical implications, since – based on the conceptualization and operationalization performed – we have proposed a useful tool for measuring paradoxes in the ECM process. This is particularly useful for manufacturing companies, which can recognize areas for improvement on its basis. The proposed measurement tool can be particularly useful for human resources (HR) managers and chief operating officers (COOs), especially when describing the role of the change coordinator. Using the tool within a company can indicate areas in which need development or need special attention of the management team. It can also provide a useful basis for further discussions and informed decisions within a company because results have a potential to show different approaches to the same case represented by a management team, specialists and other co-workers.

There are also a few limitations to the study. The first was the small research sample. Actual shape of the tool was proposed based on the experience of a single company. This narrows the research perspective. The second, related limitation pertains to the particular organizational culture and structure of the selected company. These aspects may influence the

shape of the ECM process – number of stakeholders, involved departments, etc. It can also affect the nature of the paradoxes itself. Therefore, the created measurement tool containing a set of identified paradoxes should be treated as a starting point for further in-depth research, taking into account the participation of additional companies. It will be of value to verify the tool in companies with different models of production: mass, single-piece, or low-volume.

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CORPORATE SOCIAL RESPONSIBILITY IN BUSINESS MANAGEMENT IN POLAND AND THE COVID-19 PANDEMIC

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Purpose: The article aims to review and systematize knowledge about CSR in Poland in an attempt to find an answer to the question about the place of this concept in enterprise management, in particular in the context of the crisis caused by the CoViD-19 pandemic.
Design, methodology and approach: The article is based mainly on the method of analysis of the literature on the subject, legal acts and reports on "CSR in practice" from 2016-2022 (results of surveys carried out among enterprises by the French-Polish Chamber of Commerce). Other methods include synthesis, description, graphic presentation of data, comparison and deductive inference.
Findings: The analysis of the literature on the subject clearly indicates that the CoViD-19 pandemic has changed the life of business around the world. It highlighted the need for cooperation between all actors of the socio-economic system, and increased the need and pressure on organizations to be more responsible towards the environment and society. There are also claims that the pandemic has become a catalyst for the development of CSR. On the other hand, based on the data presented in the article (from questionnaires completed by selected entrepreneurs), one can only to some extent agree with the statements presented in the literature. The pandemic has changed the visage of Polish CSR, but not enough to make a definite claim about a development leap or professionalization of CSR and, above all, about solidification of positive trends. The brand image is still the most important motive for engaging in socially responsible activities, which are often taken ad hoc. Also the financing of such activities is often interim. What should be particularly appreciated is a larger percentage of companies with long-term CSR strategies, more managerial commitment and more entities with CSR departments (while about 20% had no such units). It also seems important that there are less and less organizations that are unable to estimate their CSR costs and, at the same time, the number and percentage of those with CSR budgets exceeding PLN 1M have increased. Today, it is difficult to claim (based on the data presented in the article) that the CSR concept is an important element of enterprise management in Poland, or that the CoViD-19 pandemic has made it flourish. However, the research results presented in the article (for the years 2016-2022) are characterized by a fairly high degree of generalization, so further analysis was definitely needed. Another reason was that, according to numerous publications, society is becoming increasingly aware of both responsible and irresponsible behaviors of business and wishes for the former ones, especially in the face of emerging crises.
Originality and value: The article is part of the reflection on the importance of CSR in the management of enterprises in Poland, in particular in the face of the challenges posed to economies, societies and enterprises by the CoViD-19 pandemic. Admittedly, the subject of

CSR is often raised in the literature, but the effect of the disease is a more recent aspect which requires a more in-depth analysis. Therefore, the article attempts to fill this cognitive gap. The value of the article lies primarily in the analysis and synthesis of the content presented in the latest literature on the subject and the attempt to answer the question: "Has the pandemic changed the visage of CSR and, if so, how?".

Keywords: CSR, CoViD-19 pandemic.

Category of the paper: General review.

1. Introduction

The events of recent years (including in particular the CoViD-19 pandemic, Russia's aggression in Ukraine and the energy crisis) have highlighted links between people, economies, the planet's resources and the matters of health, poverty, climate and stability of supplies. It is not surprising that broadly defined environmental, social and corporate governance issues have attracted heightened interest, given their obvious importance in many different areas, from sustainable economy to politics (Rojo-Suárez, Alonso-Conde 2023). Faced with the problems mentioned above, modern economies and businesses have been forced to look for an ethically responsible and sustainable way of doing business. Thus, the concept of social responsibility (which is opposed by many due to the apparent lack of economic rationale) has gained in importance and relevance. This is despite the fact that the practice of economic life repeatedly shows the skepticism of entrepreneurs in this matter, who even perceive CSR as a kind of coercion (resulting, for example, from the non-financial reporting obligation) or a kind of façade for veiling the company's problems (Tylec, 2016; 2017).

Bearing in mind the above, the article discusses the issue of CSR in the context of enterprise management in Poland. The article is an extension of earlier considerations contained in the publication entitled "Social responsibility – an element of enterprise management in Poland?" (Tylec, 2021). The incentive was the CoViD-19 pandemic and the question that arose in connection with it: "Has the pandemic changed the visage of CSR and, if so, how?". The question was considered from the point of view of the literature on the subject, which deals with the issue of the impact of the pandemic on the social involvement of enterprises in Poland and elsewhere, as well as from the perspective of the research by the Polish-French Chamber of Commerce which since 2016 has been annually examining the social involvement of enterprises operating in Poland.

2. CSR and the CoViD-19 pandemic – theoretical background

Increasingly frequent adverse social and environmental phenomena force companies to change the way they do business. An emanation of this change is the inclusion of the concept of CSR in management processes. This concept is not new but it has gained particular importance in the face of the recent crises, including the pandemic that broke out at the end of 2021. The first cases of infection with the new SARS-CoV-2 coronavirus were detected in China in November 2019 (in Wuhan), and the virus quickly spread around the world. The WHO declared a "public health emergency of international concern" on January 30, 2020, and recognized the situation as a "pandemic" on March 11, 2020. On May 5, 2023, the WHO declared the end of the emergency but continues to claim that it is still a pandemic. According to the WHO, CoViD-19 is now a permanent and ongoing health problem. More than 275.7 million people have contracted coronavirus and more than 2.2 million have died in Europe alone since the beginning of the pandemic (until August 2, 2023) (WHO, 2023a; 2023b; Krukowska-Miler, 2021). The first case of infection in Poland was recorded on March 4, 2020. Due to the spread of disease, the government imposed further and further restrictions on economic and social activity.[1] The state of epidemic was in force in Poland from March 20, 2020, to May 15, 2022 (Regulation of the Minister of Health of March 20, 2020). On May 16, 2022, the "state of epidemic" was changed to the "state of epidemic emergency" and then canceled on July 1, 2023 (Regulation of the Council of Ministers of May 13, 2022; Regulation of the Minister of Health of June 14, 2023). According to the Ministry of Health (as of August 4, 2023), there were 6,518,209 cases of infection and 119,635 fatalities (Ministry of Health, 2023). The restrictions have significantly affected most sectors and members of the economy and society: businesses, workers, consumers, students and many more. According to A.B. Caroll, the restrictions put CSR to the test, in the face of which many companies were trying to reset their CSR thinking and initiatives in order to adapt to the crisis and meet expectations of society. The author also believes that at no other time in recent history businesses had an opportunity, or a strong mandate, to accelerate, rethink and possibly change their CSR strategies, policies and activities. In a next few years, companies and their managers will have an undeniable opportunity (or will be simply compelled) to change their

[1] Inter alia: classes in schools, kindergartens and nurseries were suspended; the operation of shopping malls was restricted; a ban on gatherings was introduced (first on more than 50 people, then total); restaurants were restricted to delivering takeaway food; gyms, swimming pools, dance clubs, fitness clubs, museums, libraries, cinemas were closed; restrictions on movement outside of living, health or professional purposes have been introduced; the number of available seats in public transport was limited; the number of customers in stores was limited (first to 3 people per cash register, later depending on the surface of the store); activity of large-format hardware stores was limited; "senior hours" were introduced in stores; hotels and short-term rentals, hairdressers, beauty salons, tattoo and piercing parlors were closed; there was a ban on staying on beaches and green areas; the operation of sanatoriums was suspended; an order to wear face masks was introduced. The restrictions depending on the number of infections and mortality were gradually tightened or eased. (Union of Entrepreneurs and Employers, 2021; Czech et al., 2020).

CSR performance and impact because they will no longer be able to avoid meeting various public expectations (Carroll, 2021).

Also A. and M. García-Sánchez, who examined activities of large Spanish companies in the context of the pandemic, agreed that the pandemic had caused a global health, economic and social crisis, which required cooperation and commitment of all actors, especially those from the private sector. The authors pointed out that only a few large companies had shown a strong commitment to social issues by developing actions to mitigate the effects of CoViD-19, while others had developed several strategies with different goals. At the same time, they identified three clusters of responsibility: (1) protecting only the interests of shareholders and investors; (2) promoting the well-being of Spanish society in general and vulnerable groups in particular; (3) combining previous altruistic actions with commercial interests. In the authors' opinion, the research shows that the changes that the pandemic has caused in society will affect the business world, giving rise to enterprises that will be more oriented towards common good, developing practices better adapted to entrenched social problems, such as poverty and inequality, which the epidemic has exacerbated (García-Sánchez, I.M., García-Sánchez, A. 2021).

The theses presented above are consistent with those contained in articles on the course of the pandemic in Poland. Based on the analysis of national publications, one can put forward a thesis about the positive impact of the pandemic crisis on the development of CSR and increasing its role in the management of companies. The authors of selected publications (which address the issue of social involvement during the CoViD-19 pandemic), mainly based on the analysis of initiatives taken by enterprises in the face of the crisis caused by the pandemic, present the following statements:

- Long-term and onerous restrictions on the movement of people, the closure of economies, the decline in profits from sales and the frequent bankruptcies have forced business owners to look for new solutions to maintain stability in their companies. That also applied to CSR, and the issues of trust in employees became the key factors in building CSR (Kobos, Patejczyk, 2022);
- The extremely difficult situation in which business and society found themselves in spring 2020 raises questions about the role of CSR in the CoViD-19 era, as well as in the post-pandemic period. The pandemic has forced organizations to redefine many aspects of their operations, including their social involvement. Thus, the current crisis will accelerate the development of post-pandemic CSR in the long term, as more and more companies realize that their long-term survival and growth depend on achieving some kind of balance between profitability and harmony with various stakeholders (Babińska, 2020);
- CSR activities of companies can act as a catalyst for change and be a beginning of diversifying services with offers based on CSR foundations (Machnik, 2022);

- Based on research carried out on the tourism market during the CoViD-19 pandemic, it can be concluded that, in most cases, CSR practices followed during the pandemic are well perceived by stakeholders, and providing a sense of security for employees and travelers strengthens ties with the company. So, developing CSR strategies during crises is advisable due to the possibilities of building relational capital and implementing new programs, solutions and tools, which offers long-term benefits (Johann, 2023);
- When analyzing activities undertaken by brands during the pandemic, it should be noted that, although they operated in different sectors, they jointly pursued the common goal: reduce the number of infections and combat the pandemic. Enterprises involved in CSR activities recognized their importance and the need to support society, and so distinguished themselves from other organizations. The changes resulting from the pandemic contributed to the development of CSR, drove specific activities, built positive image and supported society (Tchaikovsky, 2020);
- Actions taken by business in response to the epidemiological situation can be broadly divided into two categories: philanthropic (involving the transfer of money) and business-oriented (involving the use of in-house infrastructure and know-how). In addition to local communities and customers, important addressees of such activities are employees towards whom companies undertake protective, informative, supportive and human resource-allocative activities. The analysis of good CoViD practices of the partners of the Responsible Business Forum leads to the conclusion that activities aimed at alleviating adverse socio-economic effects of the pandemic are carried out primarily by large companies that try to help by providing support, making in-kind and financial donations. However, the actions taken are primarily an ad hoc and direct response to the pandemic, focused on the groups most affected by it (Jastrzębska, 2021);
- The CoViD-19 pandemic had significant impacts and implications for most spheres or sectors of economic life, and its optimistic accent is that that at no other time in recent history businesses had an opportunity, or a strong mandate, to accelerate, rethink and possibly change their strategies, policies and activities within the framework of responsible management. The pandemic has put responsible management to the test, and there is evidence to support the view that many companies are trying to reset their mindset and responsible management initiatives in the face of it (Zajkowska, Sołek-Borowska, 2022).

The claims quoted above are consistent with the theses presented in the foreign literature about the positive impact of the CoViD-19 pandemic on the social involvement of enterprises, with a single indication that it is difficult to determine whether these changes will be long-term.

3. CSR in business management in Poland – analysis of data from the "CSR in practice" reports

The analysis of selected publications on the role of CSR, mostly presenting the increase in social involvement of enterprises during the pandemic, as well as almost unambiguously indicating the increase in the importance of CSR in management processes and palpable optimism indicating a new era and development of CSR, only partially corresponds to the results of research presented in the "CSR in practice" reports, which are the basis for the considerations in this part of the article.

The presented data and charts were prepared based on surveys from the years 2016-2022 (presented in the annual "CSR in practice" reports) carried out among enterprises by the French-Polish Chamber of Commerce. The number of companies surveyed ranged from 56 in 2019 to 113 in 2022. In each of the survey years (except for 2022), large enterprises (employing more than 250 persons) slightly dominated among the respondents – their share increased from 51% in 2020 to 58% in 2021. The year 2022 was exceptional in this respect: there were the largest number of surveyed organizations and SMEs prevailed (58%).

The motives for the involvement of enterprises in socially responsible activities were taken as the first of the analyzed aspects (Figure 1). In each of the survey years, image considerations prevailed. When asked about the motives for engaging in socially responsible activities, the answer "strengthening the image" was given by 64%, 83%, 72% and 76% of the respondents in the years 2017, 2020, 2021 and 2022, respectively. The second dominant motive since 2019 was the "need to run the business in a sustainable way" (50%). Of great importance were also the "top-down policy of the company" (30-60%), "gaining trust and commitment of employees" (29-44%) and "… of customers" (17-47%). Comparing the answers from the two extreme years, it should be noted that the rank of each of the motives increased, except for one: "improving relations with the local community". While in 2016 it was an important motive for 37% of the respondents, in 2022 only for 23%. Comparing the averaged data from the period before the pandemic (until 2019) and from the years 2020-2022, it should be noted that the percentage of companies indicating each of the motives increased. However, the image considerations continued to dominate (in the absence of a clear increase in the importance of this motive), but the rank of three responses increased significantly: "external pressures and/or requirements", "winning customers and their trust" and "gaining a competitive advantage".

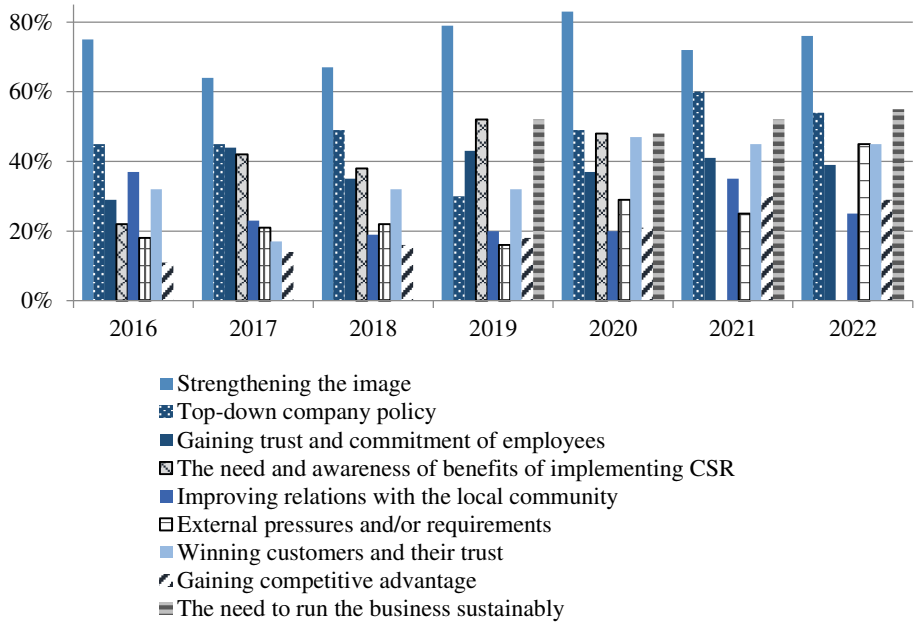

Figure 1. Motives for companies to engage in CSR activities.

Source: Own study based on the "CSR in practice – barometer of the French-Polish Chamber of Commerce" reports from 2016-2022.

The importance of CSR in business management is evidenced, among others, by the inclusion (or not) of socially responsible activities in the strategy, as well as the level of management at which they are planned and implemented (Figures 2 and 3). When analyzing the first of these factors, it should be noted that the dominant answer was: "there is a long-term CSR strategy" (36% in 2019, 45% in 2021-2022). At the same time, in the case of a slightly smaller number of entities, the answer was opposite: "There is no CSR strategy, the actions are ad hoc" (33% in 2020, 46% in 2019). On average, 16% of the respondents reported that their companies had a one- or two-year CSR action plan. As a positive change related to the years of the pandemic crisis, it should be pointed out that after 2019 not only the dominant "strategic" rank of CSR, expressed by the existence of a long-term CSR strategy, was maintained but, above all, the number and percentage of entities with strategic approaches to the issue increased, with an obvious (slight) reduction in the number and percentage of companies in which there were no such strategies, or the actions taken were planned for a maximum period of two years (without attributing strategic importance to them). Based on the data presented in Figure 2, it may be justified to accept the claims about a gradual, albeit slow, growth of importance of social involvement during the pandemic years.

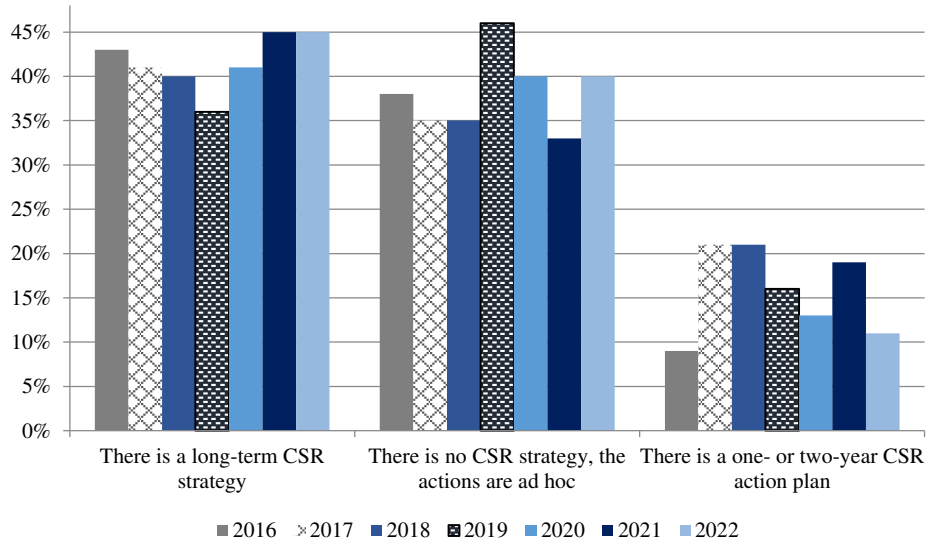

Figure 2. Does your company have a CSR strategy?

Source: Own study based on the "CSR in practice – barometer of the French-Polish Chamber of Commerce" reports from 2016-2022.

In each of the survey years, the corporate units most frequently engaging in CSR activities were management boards (46% in 2019, 64% in 2022) and HR departments (11% in 2016, 33% in 2021) followed by marketing and CSR departments. What is worth emphasizing, while the existence of a separate CSR department was confirmed by only 13% of the respondents in 2016, in 2022 it was 23%, and 30% in 2019.

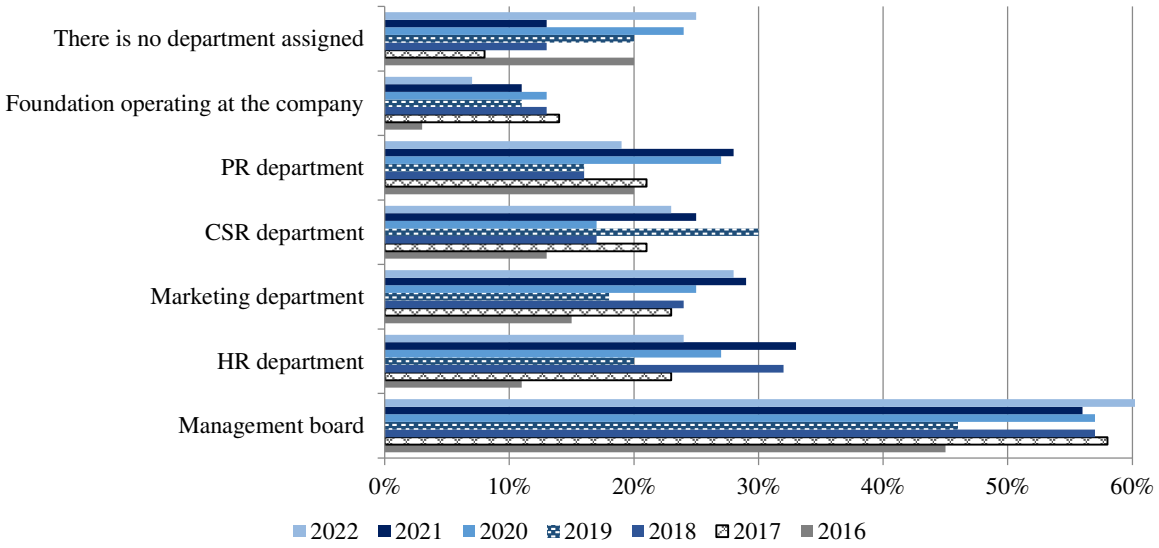

Figure 3. Who in your company is responsible for CSR activities?

Source: Own study based on the "CSR in practice – barometer of the French-Polish Chamber of Commerce" reports from 2016-2022.

Comparing data from the pre- and intra-pandemic periods, shown in Figure 3, changes, and trends indicating an increase in the rank of CSR were slight (measured by the increase in the involvement of top-level staff and specialists within CSR departments). The changes were not big enough to unequivocally claim the professionalization of CSR and, above all, talk about established positive trends.

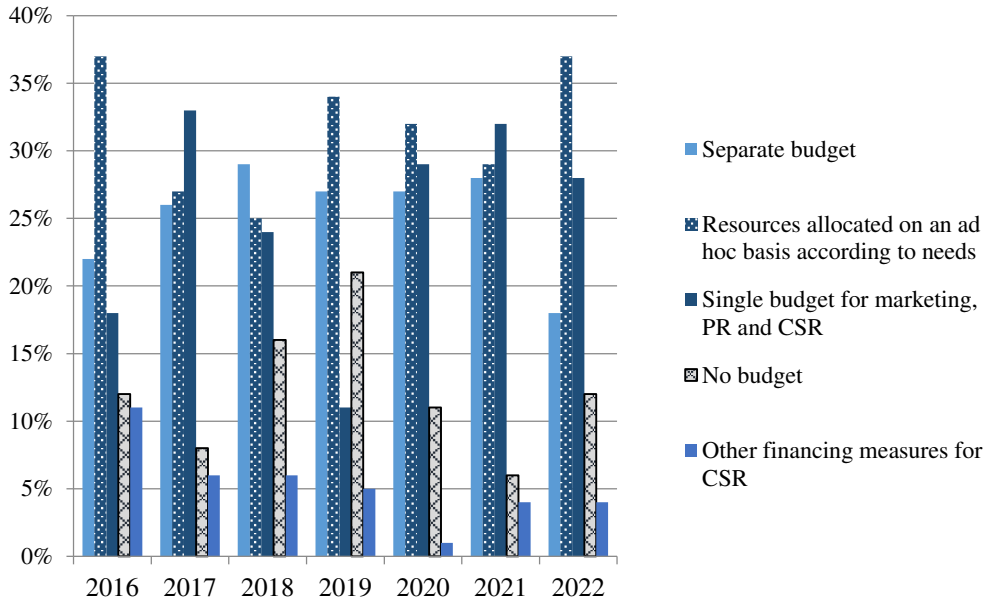

Figure 4. How are CSR activities financed in your company?

Source: Own study based on the "CSR in practice – barometer of the French-Polish Chamber of Commerce" reports from 2016-2022.

In addition to the level of management of CSR activities, their financial side, expressed in the method of financing and expenditures incurred, seems to be extremely important (Figures 4 and 5). Figure 4 shows that most of the surveyed companies allocated funds on an ad hoc basis depending on the needs (almost 33% of responses from the seven-year period: from 25% in 2018 to 37% in 2022). A slightly smaller percentages of companies had a separate budget for CSR or a single shared budget for marketing, PR and HR activities (about 25% of all the responses for each category). 12% of the respondents did not have budgets for socially responsible activities both in 2016 and in 2022. Regarding the method of financing CSR activities, it is particularly difficult to talk about unambiguous trends. In the pre-pandemic period, 22% (in 2016) to 29% (in 2018) of the surveyed companies had separate CSR budgets, while the extreme percentages were 28% in 2021 and 18% in 2022. For the opposite category, "no budget", the percentages of responses were 21% in 2019 and 6% in 2021. Looking at the percentages of the particular methods of financing CSR, we can see a significant variability (even randomness), while what seems to be significant is the consolidation of the ad hoc nature of the funds granted (thus the activities). This is also confirmed by the data on the volume of funding (Figure 5).

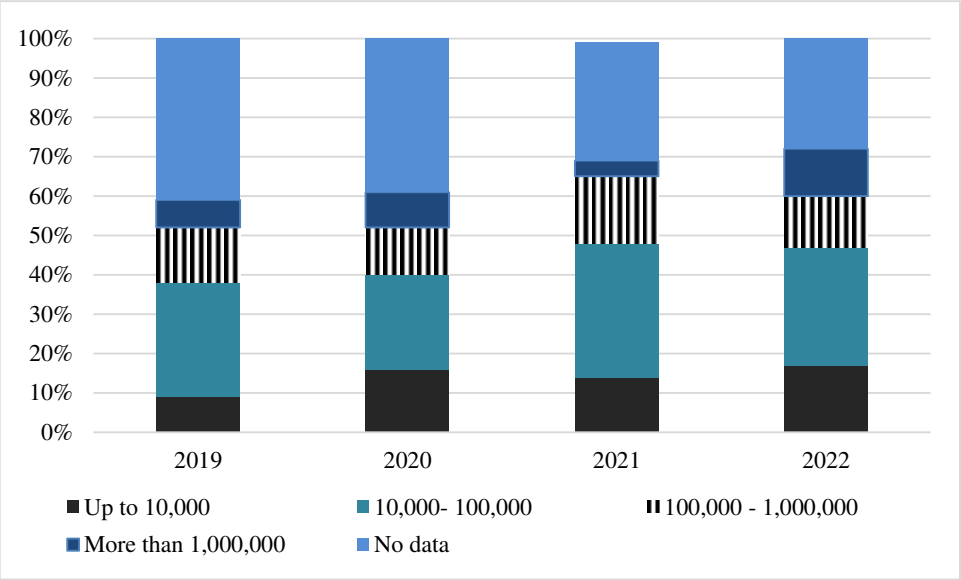

Figure 5. Annual CSR budgets (PLN).

Source: Own study based on the "CSR in practice – barometer of the French-Polish Chamber of Commerce" reports from 2016-2022.

In the years 2018-2022 (for which data on expenditures are available), from 41% of the respondents (in 2018 and 2019) to 28% (in 2022) were unable to estimate their CSR budgets. On the positive side, the percentage of enterprises that were unable to estimate these expenditures was systematically decreasing (from 41% in 2018 to 28% in 2022). In the years 2019-2022, the largest number of enterprises allocated up to PLN 100,000 to CSR (similarly in 2018). However, the percentage of enterprises which allocated over PLN 1,000,000 to socially responsible activities increased (from 7% in 2019 to 12% in 2022, with 4% in 2021). In 2018, 10% of the respondents spend between PLN 1,000,000 and PLN 10,000,000 on CSR. In the absence of comparable data, this cannot be compared with earlier and subsequent years, however, even despite the above-mentioned limitations, it is difficult to claim (based on financial aspects) that the CSR concept is an important element of enterprise management in Poland, or that the CoViD-19 pandemic has contributed to its flourishing. It is difficult to make this claim also based on the analysis of data on the companies' perception of benefits of being socially responsible. The most frequent answer was "non-financial benefits": 35% in 2016 and 36% in 2022. In the 2016 survey, the answers were "non-financial benefits" and as many as 54% of "difficult to estimate" answers. Importantly, in most of the survey years, about 33% of the respondents did not measure benefits associated with CSR (more than 40% in 2020 and 2022). When analyzing data for the pre-pandemic and the 2020-2022 periods, no significant differences can be seen. The answers "not measured", "difficult to estimate" and "non-financial benefits" prevailed in the both periods. Therefore, it is difficult to talk about the attribution of strategic importance to CSR (in any of these periods), about recognition of CSR as an important element of business management, or about an impact of the CoViD-19 pandemic on the developments in CSR.

4. Conclusions

CSR is analyzed in the literature from various perspectives: economic and social benefits, relations with the environment, or moral and ethical aspects. Recently, a new research perspective has also emerged, i.e. the pandemic crisis.

Analysis of numerous publications on this subject – mainly due to the lack of quantitative research that would clearly confirm a positive relationship between CSR and corporate profits[2] – permits the conclusion that the social involvement of companies is often based not on economic calculation but rather on the conviction of entrepreneurs and managers that CSR can significantly support the pursuit of the company's strategic goals (in a sense, as a side effect or as a synergy effect), therefore this concept should be part of its strategy and an element of its management. This has become particularly important in the face of the CoViD-19 pandemic which has changed the life of business around the world. Recently, there has been a growing demand and pressure on organizations to be more responsible towards the environment and society. These demands come from various stakeholder groups, including company shareholders, customers, national and European regulators, employees, suppliers, social and environmental activist groups, the media and creditors (Arif et al., 2021). The analysis of the literature on the subject allows to conclude that the health, economic and social consequences of the SARS-CoV-2 virus have highlighted the need for cooperation between all actors of the socio-economic system, in order to face events that the modern world has never seen before. They also highlighted the importance of being socially responsible. The pandemic has also become an opportunity to explore social responsibility practices. Numerous publications argue that while corporate efforts were stretched to the limit, the resulting situation served as a magnifying lens to examine CSR in its basic sense, rather than as a "nice to have" or a public relations campaign (Marom, Lussier, 2020). The pandemic has created an excellent opportunity for businesses to move to more authentic social responsibility and contribute to addressing pressing global social and environmental challenges. It offers companies great opportunities to actively engage in various CSR initiatives during the crisis and became a catalyst for a new era in the development of CSR (He, Harris, 2020). This new era includes the professionalization of CSR (among others through wider involvement of managerial staff, or intensification and "strategization" of activities), but it should also include its "authenticization".

The data presented in the article only partially corresponds to the statements presented in the literature, and cited in this study, about giving social involvement (especially in pandemic years) more and more importance. No big enough changes have been observed to make strong claims about a developmental leap, professionalization of CSR, growth of its role in the management of enterprises in Poland or, above all, about a consolidation of the observed

[2] More on this: (Otola, Tylec, 2016a; 2016b).

positive trends. Image concerns are still the most important motive for engaging in socially responsible activities (72-83 % of the answers in 2020-2022), while from 33% (2021) to 46% (2019) of the respondents had no CSR strategies and took ad hoc measures. Equally random were the ways of financing these activities. What should be particularly appreciated is a larger percentage of companies with long-term CSR strategies, (increase from 43% in 2016 to 45% in 2022), more managerial commitment and more entities with CSR departments (while about 20% had no such units) It also seems important that the percentage of enterprises that are unable to estimate their CSR expenditures was systematically decreasing and that the number and percentage of the surveyed entities whose budget for this purpose amounted to over PLN 1 million has grown. It is both important and debatable question whether these positive trends will consolidate in the coming years. The pandemic has certainly changed the visage of Polish CSR, but it is to be seen whether the actions taken and their financing will finally grow up of their hitherto randomness.

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BALANCED SCORECARD IN THE MANAGEMENT OF A PUBLIC UTILITY TRANSPORT COMPANY

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Purpose: The purpose of the article is to attempt to adapt the Balanced Scorecard to public utility transport companies operating under the public budget formula, i.e. those whose founders and owners are 100% or majority local governments.
Design/methodology/approach: Balanced score card, analysis of the needs of the public transport services market.
Findings: The need to adapt to the specificity of public utility transport companies operating under the public budget formula, i.e. those whose founders and owners are 100% or majority local governments.
Research limitations/implications: A detailed analysis of strategic goals and actions in necessary.

Originality/value: A new approach to the traditional strategic analysis tool.

Keywords: balanced scorecard, strategy, strategic management, public transport management.

Introduction

Strategic management is an indispensable part of comprehensive business management. To maintain their position in the market and ensure business continuity, companies are forced to constantly diagnose and analyse the situation in which they find themselves. Public utility transport companies must carry out tasks arising from the State's obligations to society. Due to the nature of the activities they carry out and the specific purpose and market conditions in which they operate, public utility companies are forced to look at efficiency somewhat differently. Despite the difference in the market environment, public utility transport companies should also be oriented towards the goals of their strategy. However, the difficulty in the public utility sphere becomes not so much to set the primary goal of the activity, but to adapt the strategy and tasks to the realities found in the area of operation. One of the tools used for formulating effective solutions is the Balanced Scorecard. A tool of economic analysis,

the Balanced Scorecard forces companies to look at strategy in detail, as the key element of the Balanced Scorecard has become the strategy map without which effective planning seems impossible. The purpose of the article is to attempt to adapt the Balanced Scorecard to public utility transport companies operating under the public budget formula, i.e. those whose founders and owners are 100% or majority local governments. In order to adapt this multidimensional research tool to the specifics of public utility transport companies, it is therefore necessary to focus primarily on their strategy and the goals that guide the activities they engage in.

1. The importance of strategy in business management

Today's economic reality forces companies to continuously improve their business management systems. Only those entities that function in an efficient manner have a chance to survive and thrive in a market subject to often unexpected and radical changes (Skorupka, 2022, p. 25). Variable market conditions such as galloping inflation, financial crisis, rising unemployment, dynamic changes in interest rates on capital or high fuel prices, make it necessary to analyse the market on an ongoing basis in relation to the company's conditions and capabilities, and consequently adjust the strategic assumptions that determine the company's position in the future. Therefore, the strategy will focus first on business continuity, then on development opportunities.

However, for business continuity to be viable, it is essential to seek the best way forward, i.e. to implement strategic management (Obłój, 2016, p. 12). To this end, according to the American Institute for Business Continuity, the following principles should be followed, among others (Kaczmarek, 2009, p. 34):

- all business activities should be in line with the company's strategy;
- by optimising the size of production and services, companies in their activity must strive to create an organisation that is resilient to undesirable pressures;
- business continuity must be the responsibility of the entire company, in every phase of operations;
- business continuity assurance should be based on a critical assessment of the most significant areas of activity (Mission Critical Activities), as well as an assessment of the severity of current and potential losses (Business Impact Analysis).

As is clear from the proposed rules – companies must move toward the implementation of the adopted strategy in their decisions. The basis of strategic management, therefore, is certainly to have a concretely defined strategy. The classic definition of strategy was established as early as 1962, when Alfred Chandler defined strategy as ‘determination of long-term goals and objectives, the adoption of courses of action and associated allocation of resources required to achieve goals (Nasierowski, 2018, p. 13). In the literature, we see the evolution of approaches

to strategy, which provides five basic approaches to strategy, which are the result of the evolution of strategic management approaches, the planning approach, the positional approach, the resource approach, the innovation approach and the network approach (Niemczyk, Trzaska, 2020, p. 6). All approaches are united by the existing category of economic rent (Światowiec-Szczepańska, 2012, p. 206) in economics. Strategic management theory was initially based on three basic trends: planning, positional and resource approaches. These three trends are built on two types of economic rent. The first is Ricardian, or resource, rent, and the second is the Chamberlin rent, also known as monopoly rent. Ricardian rent is defined as the surplus obtained from the use of scarce resources held; the surplus is therefore dependent on the demand for the resource. Chamberlin rent, on the other hand, is the result of monopoly and oligopoly in the market. Here, in simple terms, the surplus depends on market share (Niemczyk, 2013, p. 78).

Contemporary theory tends to base strategy on two more strands: innovation and networking. The Schumpeterian rent, which stems from the innovation approach, is directed at the theory of obtaining a surplus as a result of new innovative technologies, goods, sales techniques, etc. The theory is firmly based on promoting entrepreneurial action (Stańczyk-Hugiet, 2011, p. 7). Network rent is based on obtaining a surplus as a consequence of the establishment of contracts, alliances, and networks of companies, which in effect create additional potential in the form of resources – not only material, but also organisational and informational (Krzakiewicz, 2013, p. 114). Thus, economic rent, in principle, becomes a category, focusing the company on achieving competitive advantage (Światowiec-Szczepańska, 2012, p. 208). Achieving a competitive advantage and securing a desirable position in the market enables the company to pursue its goals and thus make its long-term strategy a reality.

Formulating a strategy is therefore not an easy thing. The strategy should be the result of the company's vision and mission, the answer to the question of how to achieve the company's mission while taking into account the reality in which the company operates (Sudoł, 2006, p. 242). Adopting the right strategy means focusing activities in each sphere of the company's activities in a specific direction, involving its most valuable resources (Godziszewski et al., 2011, p. 332).

The company, finding itself in a given environment and analysing its own capabilities and priorities, must determine its overarching goal. Regardless of what will guide the company as the main goal – value for the shareholders creation, the rate of return on capital employed, or economic profit (Grant, Kułaczkowski, 2011, p. 73) – the company must ensure that the goal is clear and understandable, as well as determine how to implement the company's strategy at each level and assign specific goals to them.

Thus, strategy is a process that is a coherent plan of action for the company that includes a diagnosis that simplifies the picture of reality, allowing to define an objective and realistic goal. The strategy must also include a key approach that defines sub-goals and specific goals in each area of operation, identifies how to meet the challenge of achieving the long-term main

goal, and defines a series of coherent, coordinated actions to effectively achieve this goal (Rumelt, 2013, p. 95).

Undoubtedly, strategy is an inseparable element of strategic management, defined as a purposeful process that, with the help of basic management functions such as planning, organising, motivating and controlling while taking into account the environment and its own potential, resolves the key problems of the company, determining its ability to survive and grow (Stabryła, 2000, p. 11). Strategic management is also sometimes referred to as a series of coordinated processes aimed at building, implementing, controlling and revising a company's strategy (Pierścionek, 2011, p. 22).

Building a strategy requires significant commitment from the company. However, methods are also needed to diagnose the company's environment as well as the organisation itself. According to the theory, when planning a strategy, one should forecast the future, identifying opportunities and threats in the environment and also assessing one's own potential and capabilities (Obłój, 2017, p. 184). Strategic management uses multiple methods that are the domain of strategic analysis. One such method worthy of consideration in transport companies is the Balanced Scorecard.

2. Balanced Scorecard as a tool for implementing and evaluating corporate strategy

For many years, the Balanced Scorecard – BSC – has been one of the most popular tools for strategy implementation and control. Introduced in 1992, it was intended to serve managers and provide insight into improving company performance. However, over time, the BSC has been expanded and made into a comprehensive strategic management tool (Tawse, Tabesh, 2023, p. 124). The undoubted advantage of the Balanced Scorecard is that it focuses on uniformity and targets processes that are key to success. The BSC is based on the strategic management process, which is a set of relationships between (Szumowski, 2023, p. 157):

- identifying strategic goals,
- improving systems for monitoring the implementation of the strategy,
- refining the vision and strategy,
- developing and defining strategic goals and metrics and grounding them in the management system.

Thus, the Balanced Scorecard consists primarily of a system of strategic objectives and operational activities, and a system of metrics to evaluate and interpret the effects of actions taken. The premise of the Balanced Scorecard is to take a forward-looking approach to the company's processes, based on the principle of balancing short-term goals with long-term ones. The four perspectives that the Balanced Scorecard proposes are the financial perspective,

the customer perspective, the internal process perspective and the growth perspective. A simplified diagram of the Balanced Scorecard is shown in Figure 1.

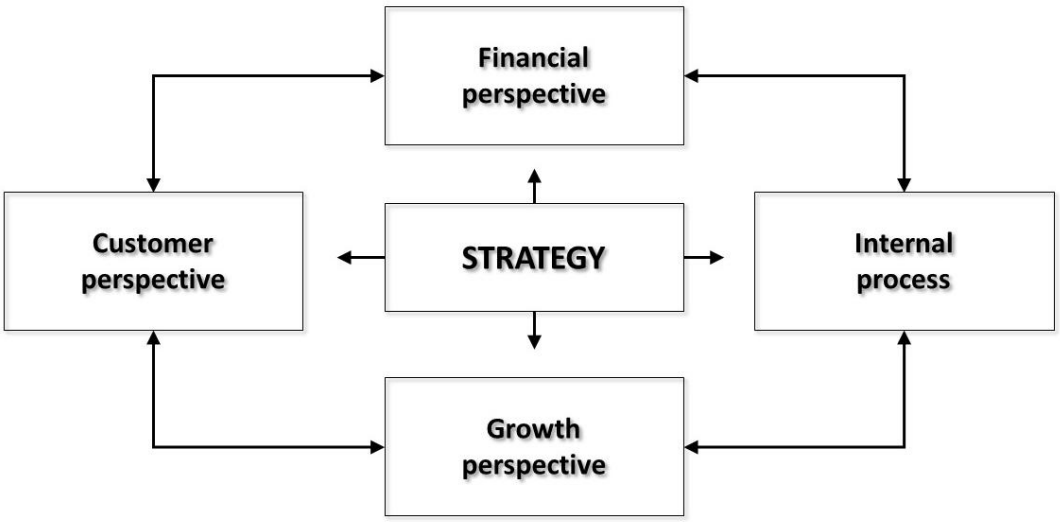

Figure 1. Dimensions of the Balanced Scorecard.

Source: Kaplan, Norton, Pniewski, Jarugowa, Polakowski, Kabalski, 2001, p. 28.

The basis for analysing a company from these perspectives is the establishment of cause-and-effect relationships, through which one can learn about the determinants of particular processes (Jabłoński, A., Jabłoński, M. 2011, p. 16). The financial perspective uses financial metrics to assess the company in terms of value growth for owners, but also in terms of financial health and the level and sources of financing (Wyszomirski et al., 2019, p. 186).

The customer perspective focuses on creating a market strategy by defining a market segment and characterising the target customer. The customer perspective therefore forces the company to answer the question, 'How do customers perceive us?' The third perspective of internal processes is to strive to improve internal processes within the company. This perspective forces us to define the path of development and determine the value we want to create in the future (Siemionek-Ruskań, 2018, p. 4). The lattermost growth perspective focuses on the identification of the company's potential, on its resources that should be maintained and developed in order to improve processes in the long term, as well as to achieve the goals contained in the customer, financial, and process perspectives. The goals of the growth perspective are thus complementary to the other three perspectives, as only the efficient use of resources will allow the smooth implementation of the other aspirations (Brzóska et al., 2012, pp. 13-16). In each of these four perspectives, the company diagnoses strategic goals and specific objectives, strategic tasks, and metrics that will be used to measure the degree to which each goal is achieved. To enable verification of the degree of strategy implementation, it is necessary to estimate the standards to be met by the defined metrics (Skrzypek, 2019, p. 40).

When applying the Balanced Scorecard, companies are bound to encounter numerous difficulties in its implementation. Difficulties associated with the implementation of the BSC in companies certainly include additional costs for the company, which include the need

to hire outside consultants, marketing research, additional management involvement, the development of IT tools, and oftentimes changes to the financial and accounting system associated with detailed classification of inputs. The need for significant investment in time could also pose a problem. Time both in the context of long-term planning, but also in the context of the implementation of the BSC, namely familiarising personnel with the process, preparing appropriate actions, and lastly, measuring and evaluating the effects of the actions taken (Waszczyk, Kubka, 2006, pp. 3-4).

The construction of a Balanced Scorecard due to its cause-and-effect context should be used in conjunction with other methods of strategic analysis (Jabłoński, A., Jabłoński, M., 2011, p. 34). The starting point for implementing the Balanced Scorecard should be the strategy map. A method proposed by Balanced Scorecard developers Robert S. Norton and David P. Kaplan, the strategy map, is extremely useful in building the strategic relationships needed when implementing a Balanced Scorecard. The strategy map makes it possible not only to recognise the cause-and-effect relationships between the adopted goals and the effects of activities, but also to facilitate the communication of the strategies, processes and systems necessary to implement the strategy (Szychta, 2009, p. 280). Thus, the strategy map is really a map of the company's strategic goals in its various spheres, along with an identification of the relationships between them. When planning the goal map and the goals themselves, it should be assumed that the implementation of one goal should contribute to the implementation of another (Kral, 2011, p. 125).

3. Balanced Scorecard in public transport companies

Public utility transport companies operate in a specific market for public services. Public utility involves the ongoing and uninterrupted satisfaction of the collective needs of the population through the provision of publicly available services (Ustawa o gospodarce komunalnej, 1996, Art. 1, ust. 2). Public utility transport companies, therefore, provide transport and transit services to meet the movement needs of the population. The hallmark of such a market is that it does not meet all the criteria of the market, if only because of the efficiency and specificity involving the formation of prices as well as the ways of forming competitiveness, which only the market can define. There are four basic models of organisational forms of urban transport in the public transport paradigm of European Union countries (Wąsowicz, 2009, p. 23):

- with an in-house operator,
- with competitive line contracting,
- with competitive network contracting,
- with a deregulated market.

There are, therefore, market/business models and the public budget model in the market space. Business models operate on general market principles. Companies or single entrepreneur businesses created for this purpose will be responsible for carrying out transport services. Transport will be provided on a commercial basis but in accordance with the Act on Public Collective Transport, on the basis of a contract for the provision of services in the field of public collective transport concluded with the organiser of transport, namely a municipality, district, or province (Ustawa o publicznym transporcie ziorowym, Art. 19). In business models, the measure of performance will be the bottom line and the increase in value for owners. Thus, the company's strategy will not differ from other companies operating in the market (Grzelec, 2011, p. 56). The public budget model, on the other hand, is based mainly on social economic premises. Efficiency is understood here by maintaining a balance between revenues and expenditures; therefore, they will not include in their goals the criterion of economic efficiency in the form of maximising the value of companies or profitability. The goal is to fulfil the obligation to provide mobility to the public (Szuścicka, 2013, p. 376).

Due to their frequent operating shortfalls, companies providing public utility services, including transport companies, require financial assistance from the state in the form of subsidies, grants, or subventions (Zagożdżon, 2003, p. 219). Due to their nature of operating for the benefit of society, public utility companies are restricted to thinking strategically, to the design of long-term strategies. The strategic problems of these companies primarily involve the maintenance of business continuity, with the core problem appearing to be the company's internal processes, which are not indifferent to the impact of the environment. One of the basic strategic problems in public utility transport companies is therefore continuity of operations, which can be ensured by maintaining continuity of financing. The second major problem seems to be the employment situation, namely ensuring adequate employment levels in the long term. In addition, it is also necessary to look from the perspective of the market served and ask whether this market is at risk in the long term. In addition, public utility transport companies are required to take into account in their operations the assumptions of the Sustainable Transport Development Strategy (STR2030), adopted in a resolution by the Council of Ministers on September 24, 2019 (Strategia zrównoważonego rozwoju Transportu, p. 65). The strategy is in line with the Strategy for Responsible Development (SOR) until 2020 with an outlook to 2030 and sets out the main assumptions and objective of transport policy for European countries. The goal set by STR2030 for the transport sector is to ‘increase transport accessibility and improve the safety of traffic participants and the efficiency of the transport sector through the creation of a coherent, sustainable innovative and user-friendly transport system on a national, European and global scale’ (Strategia zrównoważonego rozwoju Transportu, p. 67). Thus, transport companies face a considerable challenge in participating in the implementation of the SRT2030 goal and aligning their activities with the indicated directions of intervention, such as (Strategia zrównoważonego rozwoju Transportu, p. 68):

- building an integrated, interconnected transport network to serve a competitive economy,
- improving the way the transport system is organised and managed,
- changing individual and collective mobility,
- improving the safety of traffic participants and transported goods,
- reducing the negative impact of transport on the environment,
- improving the efficiency of the use of public funds for transport projects.

The answer to these and other problems of public utility companies can be found by applying universal tools for diagnosing the company and its environment. According to the principle that it is impossible to manage something that cannot be measured, all problems should be solved starting with the analysis, evaluation and measurement of phenomena. Thus, the ideal tool to help solve the strategic problems of public utility transport companies is certainly the Balanced Scorecard (Kaplan et al., p. 38).

According to the theory, the implementation of a Balanced Scorecard should be preceded by a strategy map. The most common strategy map developed by commercial companies operating in a typical market is shown in Figure 2.

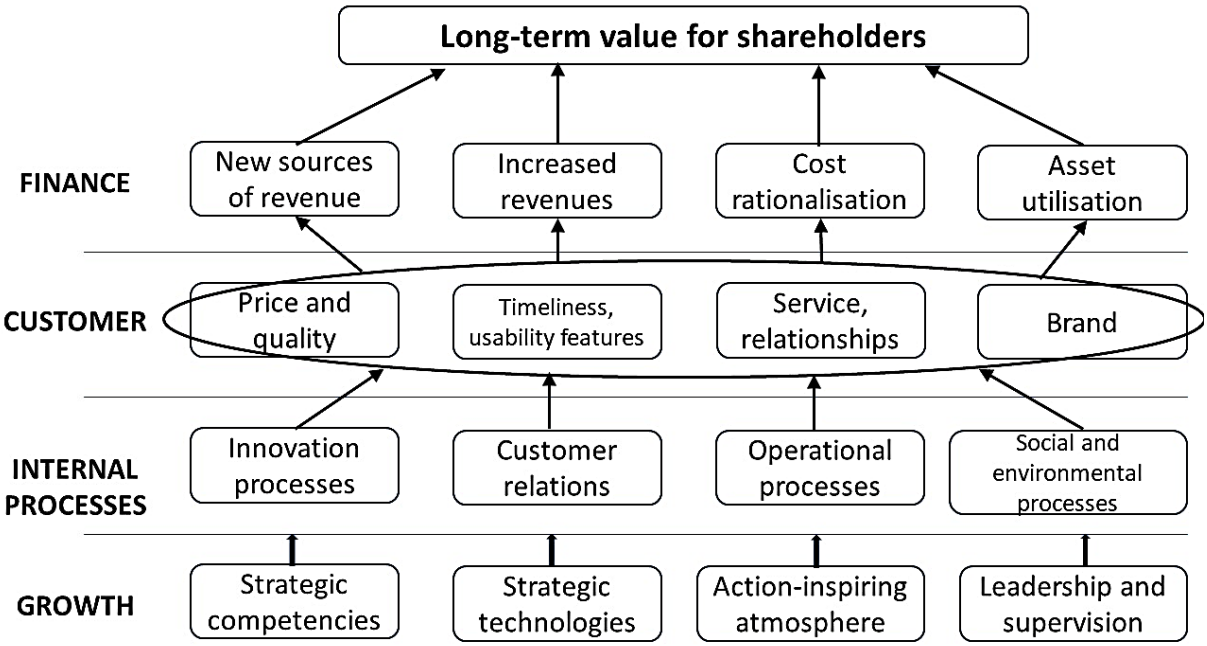

Figure 2. Strategy map.

Source: Training – brand and business strategy | PPT (slideshare.net), 8.09.2023.

As one can see, in commercial companies, the main goal is to achieve value for the shareholders. According to the proposed strategy map, this is made possible by visible connections. The development of the company should unequivocally contribute to the improvement of processes, while processes establish an optimal image as perceived by the customer. On the other hand, an established brand, a loyal customer, and an increase in the number of customers contribute to an increase in revenue, which, with a rational cost policy, enables the achievement of the desired goal.

Public utility transport companies, operating within the public budget model, take as their goal the operation of public transport that guarantees the mobility of residents in accordance with the principle of sustainable development (Kozłowska, 2018, p. 7). The goals of public utility transport companies, due to the market conditions in which they operate, must be consistent with the strategic documents adopted by public authorities, such as the city or municipality's development strategy, spatial development conditions, and the city or municipality's transport policy (Grzelec, Wyszomirski, 2013, p. 72). The strategy map of the public utility transport companies will therefore take on a slightly different structure. Indisputably, the goal pursued by public utility transport companies is to provide transport- while meeting certain sustainability objectives, but the bottom line is to survive, to maintain business continuity in order to carry out the entrusted task of providing transport services and enabling mobility for the public. One proposed structure of the strategy map for public utility transport companies is shown in Figure 3.

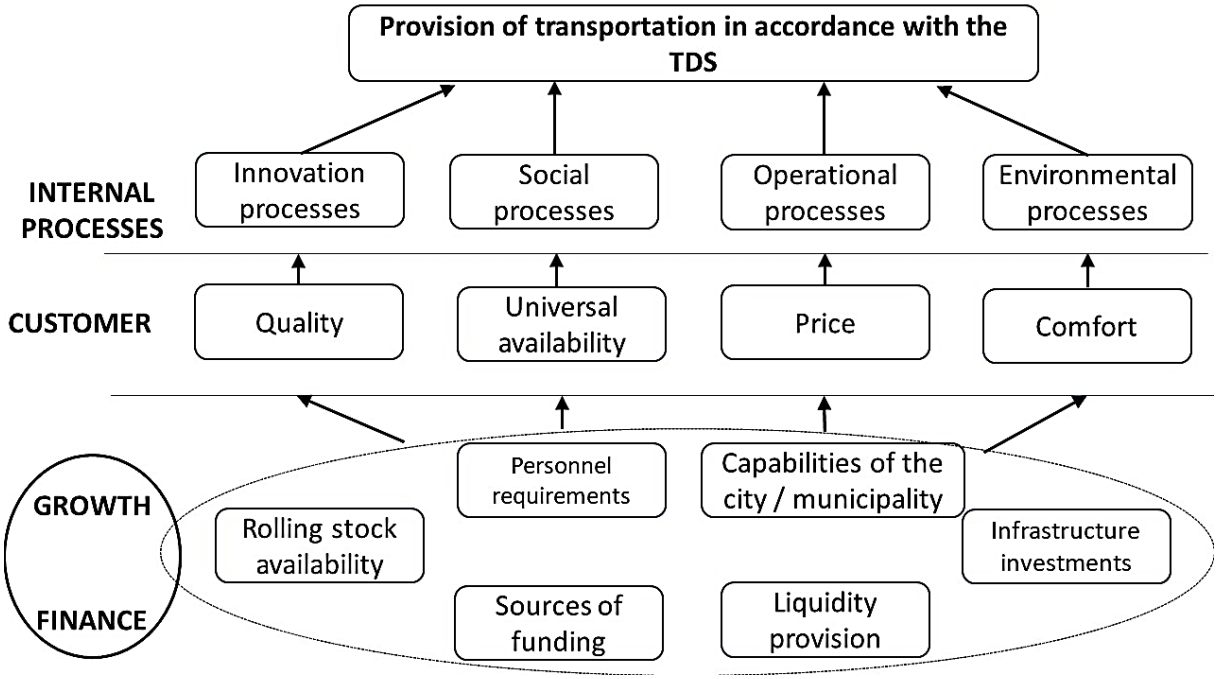

Figure 3. A strategy map for public utility transport companies.

Source: Own compilation based on 'Training – brand and business strategy | PPT (slideshare.net)', 8.09.2023.

As can be seen in the diagram, the strategies are blurring at the growth and financial levels. Public utility companies, due to the nature of their operations, often require subsidies from local governments. The financial capacity of municipalities and cities determines the possibilities associated with the purchase of rolling stock and infrastructure investment. Therefore, when planning the implementation of transport, companies must first and foremost take care of sources of funding for operations, thereby ensuring that liquidity is maintained. Public utility transport companies also need to plan for staffing needs over the long term. Analysing the market for the supply of workers in the long term will certainly make it possible to recognise

the problem of meeting staffing needs. The strategies contained in the customer perspective will enable public utility transport companies to solve the problem of the future demand on the part of the public as a customer for transport services, thus determining the possibility of survival in the market. The internal process perspective must build strategies that contribute to providing services at the highest possible level of passenger satisfaction. The level of these services is thus largely determined by the customer perspective. Internal processes should be implemented in four categories: with respect to operational processes; innovation; the environment; and society.

The task of the Balanced Scorecard will be to define specific objectives for each element of the strategy map and assign to them the actions necessary to achieve them. An example of a Balanced Scorecard structure for a public utility transport company is shown in Table 1.

Table 1.
The Balanced Scorecard of a public utility transport company

Perspective	Objective(s)	Measure	Activity
Internal processes	Environmental	Noise level Exhaust emissions	Rolling stock purchases Investing in existing means of transport
	Social	Territorial coverage of transport	Creating new connection networks, expanding existing networks
		Fluidity of transport	Improving technical readiness of rolling stock
	Operational	Rolling stock utilisation intensity	Increase in average daily working hours
	Innovative	Rolling stock age Electromobility level Passenger information	Modernisations, Purchases of rolling stock Implementation of innovative information media – passenger information systems Intelligent transport systems
Customer	Ensuring high quality services	Convenience Comfort Sense of security	Ensuring safety, convenience, taking care of regular and timely transport Streamlining the information flow process
Growth	Ensuring optimal employment levels Rolling stock availability Development of infrastructure investments	Employee turnover rate Employment level Number of means of transport Quality of means of transport (emission class, low-floor, electric vehicles)	Labour market analysis Personnel training Implementation of incentive systems Obtaining financing and rolling stock purchases
Financial	Maintaining liquidity Provision of funding	Cash ratio Level of funds received	Cost rationalisation Market analysis to seek alternative sources of financing Improving efficiency in the use of public funds

Source: Own compilation.

The fundamental goal of public utility transport companies in the financial perspective is to maintain a certain financing structure and ensure liquidity. It is also very important in this aspect to assess the sources and possibilities of financing – ticket surcharges, raising capital from external sources, grants, subsidies, national or EU funds, also enable ensuring the uninterrupted provision of transport services.

The development of public utility transport companies is strongly influenced by financial opportunities and economic conditions in the region. The development is conditioned by the provision of adequate, modern means of transport that meet quality standards and customer expectations. It is also important to provide all the infrastructure in the form of facilities that make up the entire transport network.

The customer will evaluate the attractiveness of the services consumed through the prism of quality, price, comfort and universal accessibility. Measures of quality can include: transport time, waiting time at stops, frequency, timeliness, skills, sense of security, skills and experience of drivers, information, and level of customer service. The measure of comfort will be the technical condition and cleanliness of the vehicles. Ticket prices, availability of reduced fees, and fares also determine customer satisfaction and their choice of the means of transport. Also important from the customer's point of view is the universal availability of transport, therefore it is important to ensure accessibility to transport services in as many areas as possible.

The internal process perspective is the result of previous perspectives, and given that it is analysed in relation to environmental processes, the goal may be to reduce negative environmental impacts and to reduce noise and exhaust emissions. Innovation processes are responsible, for example, for the implementation of intelligent transport systems, traffic control systems, and information for the passengers. Operational processes will be measured by transport productivity, labour intensity, rolling stock utilisation intensity, and the number of vehicle-kilometres. In social processes, the main goal will also be to ensure accessibility to public transport services for all citizens, including people with disabilities, and of its integration in spatial terms.

The biggest challenge for public utility transport companies operating within the public budget model appears to be the need to align operations with the goals of the EU Strategy for Sustainable Development and the Transport Development Strategy. The need to purchase modern rolling stock as well as to introduce innovative solutions for the operation of transport systems involves large financial outlays, so it requires the search for new opportunities and sources of funding. This is due to the fact that these companies are unable to make such investments from their own resources. In the long term, this certainly requires enhancing innovation capabilities and raising national and EU funds.

4. Conclusion

The Balanced Scorecard is a tool to support strategic management and can definitely be used in public utility transport companies. Theoretically, it is a universal tool, but the specific nature of the public utility transport company market makes it necessary to look at the structure of the Balanced Scorecard somewhat differently. The dissimilarity of the method is especially noticeable in the strategy map. It is at the level of strategy formulation that public utility transport companies must decide how to achieve the goal, which is not really their decision, as it is the result of State and European Union policies. The fulfilment of social tasks means that these companies are not oriented for the growth of market value or maximisation of profits. Their crucial goal is the fulfilment of the mission, the obligation to provide mobility to the society. Thus, the goals will be determined by public expectations and conditions in the region. Other standards are set by large cities while others are set by small towns where public expectations are often not so high, while local governments are also less capable to provide funding. It is therefore difficult to define general goals and actions for all public utility transport companies. However, the strategy will always be based on ensuring business continuity and providing transport services. The key in this aspect will be to find a compromise between passenger expectations and funding opportunities, while at the same time fulfilling the mission of sustainable development, fitting into the transport policy of the country and of the European Union as a whole.

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THE DEA MODEL IN THE MANAGEMENT OF ENERGY EFFICIENCY FROM PHOTOVOLTAICS IN SMES IN TERMS OF THE CONCEPT OF CORPORATE SOCIAL RESPONSIBILITY (CSR)

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Purpose: Renewable energy sources (RES) are currently one of the most important global issues. Renewable energy refers to energy derived from natural, recurring natural processes from renewable non-fossil energy sources. Renewable energy sources (RES) are an alternative to traditional primary non-renewable energy carriers (fossil fuels). In Poland, approximately 75% of electricity is produced from coal - the highest percentage in the entire European Union. Due to the problems of the domestic mining industry and underinvestment in the energy sector, as well as EU regulations, energy from coal regularly becomes more expensive. Therefore, energy transformation is a very important issue, especially for SMEs, which play an important role in the economies of countries all over the world. The SME sector in Poland accounts for 99% of the total number of enterprises in Poland (according to GUS 2020). SMEs are a stimulator of economic development, and their number and potential can be one of the measures for assessing economic growth. Thanks to the use of renewable energy sources by the SME sector, including mainly photovoltaic panels, we can achieve a major energy transformation by supporting the concept of sustainable development economics (ESD), whose message is to ensure sufficiently high environmental, economic and socio-cultural standards for all people living today and future generations within the limits of the Earth's natural endurance, applying the principle of intra- and intergenerational equity. Companies, in response to the increasing expectations of their environment, are increasingly taking environmental management into account from a social and ecological perspective by implementing the concept of social responsibility (CSR). The primary objective of the research was to identify stimulants and barriers to the development of investments in photovoltaic panels in the SME sector and to assess their energy efficiency.

Design/methodology/approach: In 2021, a survey was conducted, included in the quantitative research, and the obtained data were subjected to the analysis with statistical methods (CATI). The aim of the survey was to analyses the determinants of photovoltaic energy efficiency management in the sector of micro, small and medium-sized enterprises in Poland. Another part of the research carried out concerned the assessment of energy efficiency from photovoltaics in SME companies using the DEA model.

Findings: A study identifying the stimulants and barriers to the development of investments in photovoltaic panels as the main source of renewable energy for the SME sector (technical, economic considerations) should contribute to the construction of an optimal support system, for example by subsidizing investments by at least 80%. Money is both a major barrier and can

also be a major stimulant. Research has confirmed that SME companies that have already invested in photovoltaic energy are energy efficient, using the energy cost saving effect and actively pursuing a green CSR strategy achieving a competitive advantage.
Originality/value: The value of the article is the research on the use of renewable energy sources, in particular the construction of an energy efficiency management model from photovoltaics in SMEs with the concept of CSR. The results are mainly aimed at managers of MSME enterprises.

Keywords: PV energy efficiency management, renewable energy sources, EZR, CSR, DEA, SMEs.

Category of the paper: Research paper.

1. Introduction

The idea of social responsibility concerning voluntary action on environmental protection and social aspects in the activities of enterprises gained popularity in the 1990s (Kulczycka, Wirth, 2010, pp. 147-148). The concept of organizational social responsibility is a multifaceted notion, which is why many definitions of this concept can be found (Arouri, Pijourlet, 2017, pp. 263). Corporate social responsibility is an issue increasingly addressed by theoreticians and practitioners of socio-economic life (Tylec, 2017, p. 510). Currently, in the literature one can encounter opinions that nowadays, from the point of view of management, CSR is a business strategy, one of the most modern and promising (Sikorska, 2010, p. 143). The problem of CSR is considered, among others, in the fields of economics, law, sociology, philosophy or ethics. One of the oldest books related to the topic of CSR was written in 1953 by H. Bowen (The Social Responsibilities of Businessman). In this book, social responsibility was defined for the first time. According to Bowen's conception, CSR is the commitment of a businessman to make policies, decisions and follow such lines of action as will be desirable as the goals and values of our society (Bowen, 1963, p. 6). It is worth noting that the concept used to refer to the activities of the entrepreneur, whereas today CSR is mainly associated with the activities of organisations. Nowadays, corporate social responsibility can be understood as an economic organisation taking into account pro-social and pro-environmental aspects in its business activities. Responsible practices include adherence to ethical standards in relations with employees, competitors and contractors, increased investment in human resources, activities for the development of the local community or environmental protection, i.e. voluntary involvement (Białasiewicz, Marek, p. 99). R.W. Griffin and R.J. Ebert present a model of organisational responsibility based on activities directed at stakeholders. According to a European Union document, CSR is defined as the responsibility of companies for their society. A prerequisite for CSR is respect for legislation and collective agreements between social partners (Caroll, 2008, pp. 8-16). In order to effectively implement the CSR concept,

economic operators should have a mechanism to integrate social, environmental, ethical as well as consumer concerns into their operations and strategy, in close cooperation with their stakeholders (Hopkins, 2007, p. 15). It is worth mentioning that in an earlier definition of CSR, the European Commission presented the concept as a voluntary commitment, going beyond legal requirements.

Corporate management should be systemic, flexible and open to the changing environment, adapted to it and, where possible, shaped to achieve the organisation's objectives. An important management challenge with renewed relevance is corporate social responsibility (Kazmierczak, 2017, p. 49). Social impact and social responsibility need to be managed (Drucker, 1976, p. 327). This is a new direction of change in the strategic management of organisations (Lisiecka, 2015, p. 296). In the context of deliberations on socially responsible management, an important problem concerns the qualification of CSR issues to a theory, concept or method of management. The literature on the subject does not offer unambiguous solutions in this respect. Most often, CSR is considered a management concept. Socially responsible management requires that organisational culture should include social and environmental values in addition to economic values. In management in line with the CSR concept in the SME sector, the person of the owner plays an important role. It is the owner who decides whether his or her enterprise will follow the direction of social responsibility, including the use of ecological solutions such as the use of renewable energy.

2. Energy from photovoltaic panels as a renewable energy source in SMEs

Renewable energy sources (RES) are currently one of the most important global issues. RES is one of the fastest growing economic sectors influencing growth in the associated sectors: transport, construction, energy storage and is the source of many eco-innovations influencing technological progress. Renewable energy refers to energy derived from natural, recurring natural processes from renewable non-fossil energy sources. Renewable energy sources (RES) are an alternative to traditional primary non-renewable energy carriers (fossil fuels). Their resources are replenished by natural processes, which practically allows them to be considered inexhaustible. Furthermore, obtaining energy from these sources is, compared to traditional (fossil) sources, more environmentally friendly. The use of RES significantly reduces the harmful impact of energy on the environment, mainly by reducing emissions of harmful substances, especially greenhouse gases. In domestic conditions, energy from renewable sources includes energy from solar radiation, water, wind, geothermal resources, energy generated from solid biofuels, biogas and liquid biofuels, as well as ambient energy from heat pumps. The acquisition of energy from RES has shown a slight upward trend in recent years. The share of renewable energy in total primary energy generation increased from

13.25% to 15.96% between 2015 and 2019. The structure of renewable energy generation for Poland is primarily due to the geographical conditions and developable resources characteristic of our country. Energy obtained from renewable sources in Poland in 2019 comes predominantly from solid biofuels (65.56%), wind energy (13.72%) and liquid biofuels (10.36%). The total energy value of acquired primary energy from renewable sources in Poland in 2019 was 396 498 TJ. The national total energy consumption from renewable sources between 2015 and 2019 increased by 8.80%, i.e. from 381 129 TJ in 2015 to 414 682 TJ in 2019. Over the same period, gross final energy consumption from renewable sources increased by 15.57%, i.e. from 325,387 TJ in 2015 to 376,063 TJ in 2019.

The renewable energy market by installation size can be divided into the following categories (Grudzinski, Sulich, 2018, pp. 174):

- large photovoltaic or wind installations designed to produce large amounts of electricity fed into the grid, called farms,
- medium-sized installations, invested in by small and medium-sized enterprises and individual consumers, which supply energy for their own needs and sell any surplus to the grid, thus becoming prosumers,
- specialized installations which are not connected to the power grid and which supply energy to facilities where there is no access to mains power or where its connection is uneconomic (off-gird), for example solar lighting of a mountain path,
- very low-power installations that power specialized applications, for example IoT (Internet of Things), which use free energy from the environment (Magdziak, 2016, p. 26).

The potential of renewable energy systems for cogeneration of electricity and heat installed in RES installations in Poland is high. It naturally depends on the geographical location of the installations concerned. For installations solar collectors and photovoltaic cells, latitude will play the most significant role in energy production, due to the location of the sun. For these installations installations, the energy source is solar radiation (Sowa, 2018, p. 188).

In Poland, wind energy has the largest share among renewable energies, reaching 6401.9 MW in 2020, followed by solar energy of 3960 MW, which has the highest growth rate of 259%. Considering the possibilities for the development of renewable energy sources, photovoltaic energy in Poland has the greatest potential for development both among individual households and among the SME sector (taking into account costs, technical conditions, environmental impact). Therefore, it is important to identify barriers and stimulators for the use of this energy source among the SME sector in order to sustain or increase the development dynamics of this energy source in the coming years. The draft Polish Energy Policy until 2040 envisages the development of photovoltaics as a primary renewable source alongside offshore wind power. The IEO forecast "Photovoltaic Market in Poland 2019" shows that the largest group of PV installation customers are individual prosumers, i.e. households. Their share will decrease from more than 50% in 2019 to less than 45% in 2030 in favour of business

prosumers, whose share will increase to almost 30% in 2030. Due to the increase in energy prices for SME companies in particular, companies in the PV market have recognised the growing interest among business prosumers and see them as future customers.

3. Determinants of energy efficiency management from photovoltaics in the SME sector

A survey based on an interview questionnaire, categorized as quantitative research, was conducted in 2021 and the data obtained were analyses using statistical methods. The aim of the survey was to analyse the determinants of photovoltaic energy efficiency management in the sector of micro, small and medium-sized enterprises in Poland. Interviews were conducted with owners, co-owners and persons responsible for finance in the segment of SME companies from all over the country, from different industries. A total of 96 interviews were conducted of which 40% were micro-entrepreneurs employing up to 9 persons, 30% small entrepreneurs employing up to 49 persons and 30% medium-sized entrepreneurs employing up to 249 people. The structure of the survey was reweighted to the structure of companies in Poland according to the Regon database operator (GUS). The research sample thus prepared allows data to be analyses at the level of the entire SME population in Poland. The survey was conducted using the CATI (Computer Assisted Telephone Interview) telephone survey method in 2021. This is one of the methods of collecting information in quantitative research. The CATI survey was conducted using a special program that assisted the caller to the respondent throughout the call. The interview questionnaire consisted of a core part (pertinent questions) and a metric (classification questions). The core part of the questionnaire was designed to elicit information on the determinants of photovoltaic energy efficiency management. The metric included information on the companies surveyed: number of employees, revenue size, balance sheet total, legal form, type of business according to PKD, period of operation, official position of the person completing the questionnaire. The main research concerned the identification of determinants and their relevance in socially responsible management in the SME sector. The surveyed companies responded to each group of factors according to the following scale 1 - unimportant factor, 2 - unimportant factor, 3 - moderately important factor, 4 - rather important factor, 5 - very important factor. After receiving the results, the scores were added up and the contribution to the total number of points possible was quantified (number of interviews received x 5). One of the factors examined was the awareness of CSR in terms of environmental solutions. The companies surveyed showed a high level of environmental awareness among SME entrepreneurs, with more than 96% of the surveyed entities being aware of renewable energy sources, including 94% who had heard of photovoltaics as a potential source of renewable energy. Surveyed SMEs rate their knowledge

of RES quite highly, with nearly 78% of managers of surveyed entities declaring that their knowledge of photovoltaics is extensive. Unfortunately, when asked about the practical use of RES, the vast majority of surveyed Polish SMEs 93% do not use renewable energy. An optimistic factor behind the development of photovoltaic energy is that if these companies already use RES, they choose energy from photovoltaic panels 6%. 18% of micro and small companies are planning to install photovoltaic panels in the future (up to three years), while among medium-sized companies, more than 37% are planning to invest in solar eclectic energy installations. If investments in photovoltaic panels were subsidised to a minimum of 80%, more than 96% of the companies surveyed would be willing to install such an energy source. Therefore, the size of the possible subsidy is very strongly correlated with the number of potential installations. Only 8% of those surveyed who already have a photovoltaic installation financed it with their own funds, 74% used credit and 16% leasing. The development of green energy sources in the SME segment is most influenced by the investment costs. When deciding to install RES in a company, costs were indicated as the biggest barrier by 93% of the surveyed entities. Currently, Poland is at a favourable moment in terms of the economics of RES use in a company. On the one hand, the costs of the installations themselves are falling due to the increasing scale of production, growing competition on the market, on the other hand, subsidies and support from local authorities and the government are increasing. In addition, the support of EU funds in future years for the use of RES will be very significant. Also, the current situation on the energy market - its continuous increases - is prompting more and more entities to consider investing in photovoltaic panels. It is worth adding that the larger the company and thus the greater the demand. Another barrier indicated in the survey is the long payback period (78%), as well as low or no subsidies (76%). Micro-companies, as one of the categories of SME companies surveyed, are far more likely than other respondents to indicate that energy expenses are too small a part of costs to invest in photovoltaic panels. On the other hand, as the size of the company increased, entrepreneurs more often indicated complicated procedures and legal regulations as well as a lack of knowledge and space to install renewable energy installations.

Subsidies of at least 80% of the investment costs are the biggest driver for the development of PV investments, followed by cheaper and increasingly efficient technology (74% of the surveyed entities), tax breaks (62%) less bureaucracy related to the installation and notification of investments (36%) and other factors (18%). Funds, on the one hand, are holding back the transition of SMEs to 'green energy', on the other hand, they can help accelerate the process. In the last two years, a number of new measures have been adopted, called the 'clean energy' package for all Europeans. These documents clearly show the direction in which the European Union will develop over the next decade (in line with the so-called 'green deal'). Climate neutrality is set for 2050. Which means that the energy industry should get rid of emission power plants apparently by 2040, i.e. within the next 20 years. The entire new energy system of the future will be based on renewable energy sources. To a large extent this will be solar and

wind, all other regulations are aimed at phasing out coal-fired and, in the future, gas-fired power plants and building flexibility into the energy system. An appropriately structured system of incentives and support, making use of the new EU funds, should further boost the development of energy from photovoltaic panels installed in the SME sector, which wants to operate in line with the CSR concept, wants to invest in RES, which is firstly cost-effective and secondly means complying with legal requirements. Under Polish market conditions, PV installations are already a solution that is price-competitive compared to grid energy. It is therefore associated with measurable savings, which will become increasingly significant in the future as energy prices rise. In Poland, approximately 75 per cent of electricity is produced from coal - the highest proportion in the entire EU. From the problems of the country's mining industry and underinvested power industry, as well as EU regulations, energy from coal regularly becomes more expensive. At the same time, RES technologies are constantly being developed. As a result, their efficiency is increasing and the investment costs, which are so important for SMEs, are decreasing - a trend that will continue in the future. Given these circumstances, the largest companies, looking for opportunities to purchase cheap energy, are signing long-term PPAs (Power Purchase Agreements) for the supply of energy from wind farms. Unfortunately, given the scale of wind projects and their technical conditions, they are too large for the SME sector. The conditions for a moderate initial outlay are met by investments in photovoltaic installations. An appropriately sized solar installation makes it possible to reduce energy expenses in each SME, indirectly improving their profitability. As a result of the research, an optimal organisational model for energy efficiency management with PV in the SME sector was formulated.

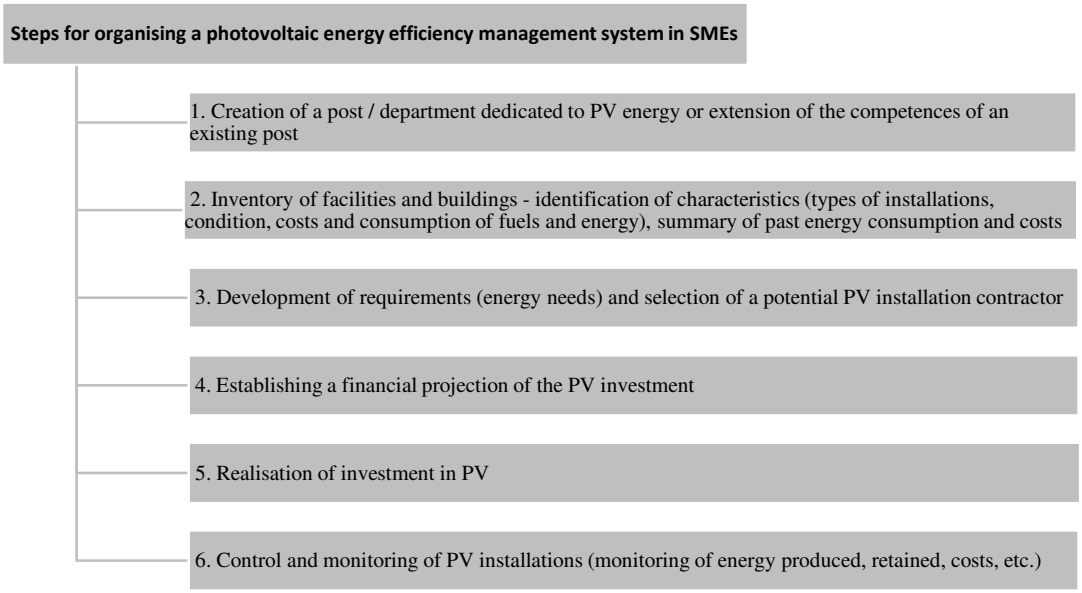

Figure 1. Photovoltaic energy efficiency management model for SMEs.

Source: Own study based on the conducted research.

By applying the above model, the benefits of investing in photovoltaic panels can be optimised. With these investments, companies can also emphasise the realisation of CSR concepts in addition to financial benefits.

4. Evaluation of PV energy efficiency in SME companies using the DEA model

The next part of the research conducted concerned the assessment of photovoltaic efficiency in SME companies using a DEA model. Efficiency analysis using the non-parametric DEA method is based on a two-factor concept - technical efficiency (TE) (Lang, Welzel, 1996, p. 1004), meaning a firm's ability to produce maximum output (effects) for a given level of inputs, and allocative efficiency (AE) (Rogowski, 2008, p. 130), meaning in turn that a firm can use inputs in the optimal proportion to particular prices (input costs). It is often used to study efficiency (Tavares, 2002, p. 6). An important element in the study of firm efficiency is the assessment of economies of scale. Failure to exploit existing economies of scale results in efficiency losses for the enterprise (Wielgórka, 2008, p. 71). The DEA method makes it possible to determine the presence or absence of scale effects. Proponents of non-parametric methods, including the authors of the DEA method, rely on the concept of productivity, defining a measure of productivity as the quotient of a single output and a single input. By having one input (x) and one output (y), we obtain an efficiency curve. This curve contains the set of objects with inputs (x) and outputs (y) that have achieved the maximum technologically possible results, given a given level of inputs. All combinations of inputs and technologically possible outcomes lie between the OX axis and the efficiency curve (production frontier), i.e. the input-output relationship curve. The first point in assessing efficiency using DEA is to define the relevant technology, which is the reference point for the measurements to be made. For this purpose, a set of n decision-making units (DMUs) that produce s outputs using m inputs is considered. For each DMU, the vector of inputs and effects are labelled respectively as $X_j = (x_{1j}, ..., x_{ij}, ..., x_{mj})$ and $Y_j = (y_{1j}, ..., y_{rj}, ...y_{sj})$. With x > 0 and y > 0, that is, each decision-making unit is assumed to have at least one input and one output. A production technology defined in this way (Banker 1992, pp. 75):

$$T = \{(X,Y) : X \geq \sum_{j=1}^{n} \lambda jXj, Y \leq \sum_{j=1}^{n} \lambda jXj, \lambda j \geq 0\}$$

Implementation of the DEA method requires defining inputs and outputs, and then subjecting these factors to an effectiveness analysis. After analyzing all possible inputs and effects, it was assumed that the following factors have the main impact on the individual PV energy efficiency of enterprises: savings in energy costs thanks to the installation of photovoltaic panels and the use of a CSR strategy through the use of "green energy" included

in the effects and expenditure on fixed assets (investment in PV) and the power of installed panels included in the expenditure. Energy cost savings achieved by using PV were estimated over a ten-year period. The basic sources of data were CATI surveys; in the case of enterprises that confirmed an investment in PV, an extended interview was conducted, including questions about the costs of investing in PV, installed capacity, energy costs before PV installation, estimated annual cost savings, and CSR effects.

Table 1.
Statistics of CRS TE effectiveness measures in the surveyed SMEs

Statystics CRS TE	**Value**
Average	0,64
Standard deviation	0,21
Minimum value	0,24
% energy-efficient PV SMEs	96%
% energy-inefficient PV SMEs	4%

Own study based on the conducted research.

The measures obtained from the estimation of input-oriented models will determine the ratio of the actual production of an enterprise from the SME sector to that which it should have if it used the same amount of inputs effectively. In the analyzed period, the share of energy-efficient PV enterprises is at a high level, reaching 96% (Table 1). By estimating the CCR model, it is possible to calculate technical efficiency (TE), which determines the possible amounts of inputs that can be used in given technological conditions to produce at least the same number of effects. During the period under review, only 4% of enterprises showed inefficiency in the use of energy from photovoltaic panels. After the research, it should be concluded that enterprises from the SME sector that have invested in energy from photovoltaic panels are energy efficient thanks to the effect of saving energy costs and actively implement the CSR strategy in the field of ecology, achieving a competitive advantage.

5. Summary

Resources of conventional energy raw materials are being depleted at a rapid pace, while the global demand for electricity is increasing. If we want to rationally use the energy potential that nature gives us, the renewable energy sector should be developed. Otherwise, we will contribute to environmental pollution and the rapid depletion of our planet's natural resources. To avoid this, we should create conditions conducive to the development of renewable energy, mainly for the sector that dominates the economy, i.e. SMEs. The conducted research identifying stimulants and barriers to the development of investments in photovoltaic panels as the main source of renewable energy for the SME sector (technical and economic reasons) should contribute to the construction of an optimal support system, for example by

co-financing the investment in the amount of at least 80%. Money is both the main barrier and can also be the main stimulator. The conducted research confirmed that enterprises from the SME sector that have already invested in energy from photovoltaic panels are energy efficient thanks to the effect of saving energy costs and actively implement the CSR strategy in the field of ecology, achieving a competitive advantage. It is possible to create a business model of an economically effective and CSR-implementing enterprise that uses energy from photovoltaic panels, uses energy-saving technologies, uses electric cars in its logistics processes, etc. We should currently use all possible instruments to make this vision of the "future" as soon as possible. present". European Union funds can be used for this purpose, which will have a positive impact on the global environment. Energy supplied from renewable sources is able to reduce the consumption of primary raw materials and limit the emission of harmful substances that enter the atmosphere in the process of producing electricity and heat, negatively impacting the natural environment. The development trend in the sector of renewable energy systems, including PV panels, should be maintained and strengthened, providing support and solutions ensuring the implementation of new technologies and the profitability of "clean energy" production.

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RESEARCH OF ISSUES RELATED TO THE DEVELOPMENT OF DIGITAL SIGNAGE SYSTEMS AND CURRENTLY EXISTING SOLUTIONS

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Purpose: This article aims to explore what problems digital signage systems solve and therefore what caused their development. In the paper it is also examined the currently existing solutions to the problems presented.
Design/methodology/approach: The objectives have been achieved through a review of the literature and available software on the market, as well as the observation method and individual case method based on specific problems. This will allow research to be carried out on either the theoretical or practical side.
Findings: In the course of the work, individual cases of communication in the public sphere were analyzed, and therefore, on the basis of the presented cases, the features and functions that the solution should have been extracted. An analysis of the software available on the market was also carried out.
Research limitations/implications: In future research, it is worth investigating the experience of users when managing a particular digital signage system, depending on the level of competence of the specific users.
Practical implications: This research is an excellent starting point for enterprises developing digital signage systems wishing to create well-tailored software for the client. This allows one to make correct decisions already on the design phase which translates into cheaper and shorter software development process. Examples of how to analyze customer requirements are shown.
Social implications: This research can have a positive impact on communication in the public sphere. The cases in this paper can help improve the user experience of newly developed digital signage systems by better analyzing the needs of these users.
Originality/value: This paper is valuable especially for the public-sphere communications industry and companies developing digital signage systems. It makes it possible to note guidelines that enable the development of well-tailored digital signage software by analyzing individual cases and the tools currently in use. This topic is very important to provide appropriate tools for communication in the public sphere. On the other hand, the rarity of addressing this topic makes it important to study and makes it more innovative.

Keywords: digital signage systems, public sphere communication tools, software user experience, case study of public communication, VJ software.

Category of the paper: Research paper, Case study.

1. Introduction

The way information is presented in public places varies quite a bit and depends on many factors. This is best seen when analyzing real-life problems. It allows one to find an appropriate and well-tailored solution. An efficient and flexible solution can be provided by appropriate software.

By appropriate software, we mean software that will allow us to adequately present information to the public in a way that is appropriate to the existing circumstances and provide functions that will be needed under those circumstances. An example of a type of software whose main functionality is to spread information in the public sphere is Digital Signage.

The definition of Digital Signage is best summarized in a document "Digital Out of Home - A Primer-Section 1 – Introduction" written in collaboration with companies dealing with these topics. "Digital signage is a network of digital displays that is centrally manageable and addressable for targeted information, entertainment, merchandising and advertising" (Abrons et al., 2019, p. 3). Another rather specialized software is VJ software, which is used, for example, during concerts by so-called VJs. VJs are "mixing live visuals in front of real people" (D-Fuse, 2006, p. 10).

However, in addition to such a rather specialized type of software, there are also more general solutions available, such as video players. Player was defined as "a client program or control that receives digital media content streamed from a server or played from local files" (Rigdon, 2016, p. 932). So, the video player is a program that allows users to play back video. And, video is defined as "an audiovisual recording" (Rigdon, 2016, p. 1365). Another quite commonly used type of program is presentation program. The presentation program "is a category of software used to create content where information is often represented in a graphical or visual way" (Awati, 2023). Such programs are often used for business purposes, but also for education and information.

We can observe that there are several categories of programs that would suit the purpose of providing information in the public sphere. To decide which program will be the best choice, one needs to define the requirements corresponding to the use case. And now we are going to present some case studies on communication in public spaces. From each case, the features that the solution should meet in order to work in a given situation will be extracted.

2. Case study of communication in public space

Issues for specific type of public communication will be presented below under various conditions, which will give a broad overview of the requirements for appropriate solution. That solution will be software with specific features.

2.1. First use case: Periodic usage, for example in educational institutions

Everyone remembers well the various assemblies, speeches and performances that occur in schools at different stages of education. The largest of these are the beginning and end of the school year. Sometimes on the stage or in the hall where the event takes place there is a projection screen with a projector and computer in the background. And then an idea or request is made to have something projected in the background during that event.

At this point, it would be necessary to analyze how to solve the problem. We know that someone will speak, there will be time for the handing out of diplomas, and, at the end, some performances by students. This indicates that the content displayed must change dynamically.

Schools usually do not have the extra budget to purchase additional hardware or software, so free or already purchased versions will have to be used.

We also learn that it is possible to use photos and videos from the school archives and that each class will have to be presented. At this point, we know that the content displayed will be photos, videos and text.

Every video ends at some point, and we don't know how long the speeches, diploma handing, or performances will last. We need, therefore, also the ability to loop the videos.

Since the placement of the computer connected to the projector is in a visible location, the person operating it cannot be on the computer during the event.

Specifying the software requirements in this case, we can highlight:

- the ability to display videos, images and text,
- the need to control the displayed content to adapt what is displayed to the current situation on stage,
- the need to use freeware software,
- the ability to loop the displayed content,
- the ability to remotely control the displayed content.

2.2. Second use case: Family events and more

During the organization of a large event, such as a family event, like a wedding, wedding anniversary, birthday, etc., a lot of different equipment and software is used.

The organizers have rented a beautiful hall, taken care of the invitations, flowers, food, and now it is time to provide music and the right mood in the room. At this point, it is necessary to make an analysis of how to deal with the situation.

We know that the hall has a projector with a screen and two TVs that can be used. All these devices support the same resolution, but each is connected to a different computer. All computers are on the same network. At this point, we know that the system will have to display content on several screens simultaneously over the network.

Music issues will be provided, but the displayed content must change dynamically, each song lasting a different length of time, so the ability to loop the displayed content and control what is displayed will also be needed.

Stage lighting will be rented to provide the right mood. To achieve a good effect and make an impression on guests, the content displayed on the screens and the way, the movement of the stage lighting should be synchronized with each other.

Since most of the budget has been spent on providing the venue, music and appropriate equipment, the software used must be very cheap or preferably free.

In summary, the following software requirements occurred in this case:

- the ability to add new screens connected to different computers,
- the ability to display content on different screens simultaneously,
- the ability to change the displayed content and control what is displayed,
- the ability to loop the displayed content,
- the ability to synchronize with specialized stage lighting control software,
- the software must be as cheap or free as possible,
- ability to display photos and videos.

2.3. Third use case: Continuous usage, for example in organizations

For example, the university has purchased new monitors to display content for students and employees, which will be mounted in the corridors. It is necessary to find a way to display content on them. To do this, we will analyze the requirements.

We have received information that there will be a need to display photos, videos and texts. We already know that the system needs to support video, graphic files and be able to display content.

Sometimes, there will also be a need to display more than one type of content at the same time, such as two photos on one screen. With this information, we know that the system must be able to display many different contents on one screen at the same time.

All monitors were connected to their corresponding computers and these connected to one local network. The software will need to be able to add screens over the network.

It is also important to be able to easily change the displayed content, even from a phone. The system must have a mobile-friendly interface and the ability to change content remotely.

Many employees have different responsibilities; some will manage the technical side, others will prepare and post content. Sometimes new employees also come in. At this point, we know that it will be necessary for access to the system's control panel to be secured with a log-in and that it will be necessary to be able to add users with different levels of privileges.

It turned out that the screens are spread across different departments, and although they are connected to one local network, they need to display different content at the same time. The system will need to be able to assign displayed content to specific screens.

Specifically selected content is to display in a specified order, and then start the display from the beginning. This indicates that the system must have the ability to make playlists, where it will be possible to set the order and length of display of given content, and to loop the entire playlist so that the content is displayed all the time.

In addition to displaying current content, there must be the ability to quickly turn on an emergency message on all screens about a sudden event, such as a fire. The system will need to be able to quickly display a single message on all screens in the system.

The screens are located over a wide area and there is no way to physically verify that they are on. The software must be able to verify if a one is online and which screen it is.

After analyzing the problem, the following requirements were listed:

- ability to display images and videos,
- the ability to display several contents of different types on one screen at the same time,
- the ability to add screens via a local network,
- the ability to remotely change content and control its display,
- interface optimized for mobile devices,
- adding and managing users with different privileges,
- access to the administration panel after logging in,
- creation of playlists from specific content,
- ability to set the duration of content display in a playlist,
- assigning playlists to specific screens,
- selected playlist should be looped to ensure continuous display of content,
- the ability to quickly display a single message on all screens in the system,
- the software must be able to verify the current status of the screen.

2.4. Summary of the use cases described

In summary, software to display content display in the above-described situations must have a range of functions to meet the various requirements. It can be said that the requirements vary depending on the character of the use, whether it will be a continuously operating system or only a temporary one. Different requirements can also be seen depending on the size of the place where the system will be used, as well as who will operate it and on what device. In some cases, the functions needed conflicted with each other, depending on the location. Once the same content is needed on different screens, and once it should be different content. There are also industry-specific functions, such as integration with specialized software or the ability to suddenly change a different displayed content to one that is the same on all screens.

In each of these cases, you need to use the appropriate software which in a specific case will include other necessary functions. In some cases, there are also functionalities that overlap no matter where they are applied, i.e., the ability to display images, videos, or the ability to change and control the displayed content. In many cases, digital signage software will be a good solution. In more specific cases, such as at a dance event, it will be VJ software. But in some cases, simple software, such as a video player or presentation program, may be sufficient.

3. Case study of existing software on the market

So now let us see what software in this category is currently available on the market. Software of various types can be used to present content. From the simplest to those with a powerful technical background.

3.1. Video player

The simplest programs that allow for the presentation of video content and sometimes even photos, are video players. They allow one to control the content being played, arrange playlists, and often loop the video or the entire playlist. It is also possible to display the video on the full screen. However, it does not allow for the distribution of content on multiple screens, and the control panel, in most players, is displayed above the file being played. It also does not have an access authorization function, and it does not allow to display text, or display multiple different types of content on the same screen at the same time. Some of the most popular video players are VLC, ALLPlayer, or players built into the operating system. VLC also has a basic web interface that allows you to control the content being displayed without displaying a control panel over the content being played. It is also free and allows you to loop as well a single video as a whole playlist. This is an interesting compromise solution for displaying basic content on a single screen, but in the long-term it may not be convenient and causes the need to prepare

the content in advance, e.g. with text in other programs. Video players are mostly used in home environments.

3.2. Presentation program

To present various data, charts and content, we can use presentation programs. They allow rich editing of the created slides, adding text, photos, videos. Most often, they also have a built-in function to display a slideshow. The user can control the running presentation with the mouse or keyboard. This tool is designed more for one-time presentation of content on a specific topic. There is no possibility of authorized access, or connecting several screens and displaying selected playlists. The role of playlists is usually played by a file that contains previously composed slides. The creation of the presentation itself is also quite a time-consuming process. Some looping options exist, but the setup is quite complicated. It is also impossible to change the content invisibly during playback. The most popular programs to create presentations are the paid Microsoft Office PowerPoint, the free Apache OpenOffice Impress, or the online solution Prezi (prezi.com).

3.3. VJ software

VJ is an acronym for Visual Jockey. Compared to the more popular acronym DJ, from Disc Jockey. Just as a DJ is a person who uses specialized hardware and software to mix and play live music, a VJ is a person who, with the help of specialized hardware and software, mixes and plays live visual content such as movies and animations. Software known as VJ Software allows one to play live video and animation and has a panel to control the content being played and mix it. Allow for detailed adjustment of the file being played, trimming, rotating, repositioning, looping, working on layers. They usually have the ability to sync with other programs, such as those that play music or control the lighting on stage. They also often have a ready-to-use library of visual effects. Such programs are very professional, adapted to work live, for example, during concerts. Due to their large capabilities, these types of programs are more difficult to work on a use and are more suited to work on live. Usually have no access authorization, it must already be provided by the operating system. In exchange for specialized software, their price is quite high. The most popular programs of this type are ArKaos GrandVJ and Resolume Avenue VJ.

3.4. Digital Signage software

Programs of this type usually have the ability to play content such as videos, photos and text. Often, they allow you to display content on multiple screens, create playlists, access via user login, and some even allow to create displayed content directly in the software. Sometimes there is also the ability to report on the status of the screens. Such programs are for commercial use. Unfortunately, most of them are paid and complicated to use for the user. The rarely available free version of this type of program does not provide all the available functions or has

limitations on the number of screens displaying content. Often these solutions are also cloud-based, but not every user wants to upload their data to the cloud. Examples of such programs are AD SCREEN, intuiface and Yodeck.

3.5. Summary of available solutions

In conclusion, the appropriate program to display content can be searched through the wide range of available solutions. However, none of them is universal enough to work under all conditions. Each type of program allows for something different. In some, the priority is to quickly play a single file, while in others, to prepare a polished presentation, at the cost of consuming more time. Some other programs are more complicated and designed for live professionals, while others allow one to schedule what to play when. Some will work well for single-screen playback, and others for multiple screens. Much also depends on the available budget. With free solutions, we can count on rather basic functionality. Looking for a program for professional use and with specific functions, a paid version is already necessary, which is usually complicated to use. Nevertheless, each of them has some interesting feature that stands out and allows one to be inspired while developing new software.

4. Usage of appropriate software in the analyzed use cases

Already knowing the possible cases of need for specialized software and the category of software that can meet these needs, the matching of sample programs available on the market to specific uses will be presented.

4.1. Appropriate software for first use case

We assume an example of a periodic use case, as a use in a school during an end-of-year academy. To summarize the analysis of this case, it can be determined that the software should be cost-free and allow the display of videos, images, text and control of the displayed content live, along with the ability to loop and remote control.

Software such as a video player or presentation program will work well here. Examples of commercially available software that performs these functions are the VLC video player, or the Apache OpenOffice Impress presentation program. Both solutions are cost-free. The target customers for these solutions are average users who use a computer to perform basic tasks such as browsing the Internet, handling e-mail. This results in a user-friendly interface for these solutions. Although the Apache OpenOffice Impress interface due to the multitude of editing functions is more complicated at first. Using tools with a customized, user-friendly interface can improve the user experience.

The strengths of the VLC software are:

- cost-free,
- user-friendly interface,
- the ability to display images and videos,
- the ability to loop videos, create playlists and control playback,
- possibility of remote control via web interface,
- low hardware requirements.

The weaknesses of VLC software are:

- the need for advance preparation of the displayed materials in the form of photos and videos including the need to prepare texts in advance for display in the form of images or videos,
- lack of ability to use eye-friendly transitions between playbacks, should be considered when creating content,
- the need to configure and understand the basics of computer network operation in order to take advantage of remote control through a web interface.

On the other hand, the strengths of Apache OpenOffice Impress are:

- cost-free,
- the ability to display images, videos and text,
- the ability to loop slide with content, create playlists and control playback,
- the ability to edit content slides,
- the ability to use eye-friendly transitions between slides,
- low hardware requirements.

The weaknesses of Apache OpenOffice Impress software are:

- more complicated interface compared to VLC,
- lack of remote control, the need for additional solutions such as a wireless USB presenter for changing slides.

The mentioned tools could be used for the first use case. A better selection of the right tool is possible by listing the strengths and weaknesses of these tools, allowing the selection to be tailored to the needs of the customer.

4.2. Appropriate software for second use case

In the second use case, we are dealing with the use at different types of events, for example, weddings, anniversaries, etc.. To summarize the analysis of this case, it can be determined that the software should be cheap and allow the display of videos, images and control of the displayed content live, along with the ability to loop and remote control. Software should also allow for display on several screens simultaneously, and synchronization with music and stage lighting.

In this case, software from the VJ Software category will provide the best coverage of the needs. Since this type of software is targeted at professionals, it has a much more advanced interface, and its price can be high. An example of a solution in this category is Resolume Avenue VJ software. The price of this software may be high for a customer who wants to use the software for personal use, but for companies organizing events, the price may be acceptable (At the end of 2023, the price is € 299 per 1 computer with 12 months of free updates). The software interface will be more intuitive for professional users. It is not as user-friendly as the interface for a video player, but taking into account the purpose and huge amount of functions, professional users should have a good user experience.

The strengths of the Resolume Avenue VJ software are:

- The ability to display video, images and animations.
- The ability to synchronize displayed content with music.
- The ability to synchronize displayed content with stage lighting.
- The ability to display content on multiple screens simultaneously.
- Advanced functions for effects, synchronization, projection.
- Possibility of integration with external software and use of plug-ins.
- Intuitive interface for professionals.
- Live video mixing and audio analysis.

The weaknesses of Resolume Avenue VJ software are:

- High price for personal users.
- The interface may not be very intuitive for non-professionals and beginners.
- The use of integration with external software results in the need to perform the appropriate configuration and the need for knowledge of communication protocols.
- The need for a high-performance computer to use the software.

The described software can be used for the second use case by the event company. Individual organizers can decide, on the basis of the weaknesses and strengths presented, whether it is better to use specialized software and accept the weaknesses of this solution or to outsource this task to a company that already has suitable software.

4.3. Appropriate software for third use case

The third use case concerns continuous use. For example, use to display information at the university in public areas. To summarize the use case described earlier, the software to solve this problem should allow the display of videos and images, as well as several elements of different types on one screen and create, loop, playback playlists. It should be possible to display on several screens at the same time using the network, verify the current status of the screens, be able to manage the system and change content from a mobile device, authenticate through a user account with appropriate permissions and display priority messages.

This is where digital signage software comes into play. Most often, it is only the paid version of the software that allows the use of all the functions of digital signage software. The multitude of functions of this type of software can result in a quite complex interface. A well-prepared manual and instructional videos can improve the user experience. Users of digital signage solutions will be diverse. An experienced user will be needed for initial system configuration. Ongoing insertion of content can be carried out by users less experienced in the context of system configuration, but closer to the subject matter of the company where the content is to be displayed. This creates the need for users with different levels of authorization to access the system. An example of software that can be used in this situation is Yodeck. It is a web-based digital signage system that requires Internet access to use. The fee is on a subscription model. At the end of 2023, the monthly cost should close at $13 per screen.

The strengths of the Yodeck software are:

- the ability to display images, videos and text**,**
- the ability to create slides that display multiple types of content at the same time on one screen,
- possibility to use several screens through the network,
- the ability to access the administration panel over the network, including from a mobile device,
- the ability to create users with appropriate permissions,
- the ability to create, loop and play playlists,
- templates for easy content creation,
- the ability to play content according to a schedule,
- the ability to add screens to the system, check their status and manage them,
- the ability to display emergency alerts.

The weaknesses of Yodeck software are:

- necessity of a monthly or annually fee,
- more detailed user rights are only possible in a more expensive package, in the cheaper one, standard roles can be assigned,
- the need to connect display devices to the Internet,
- data is not stored locally, but on remote servers,
- possibility to manage the system from a mobile device via a customized web interface, but not via a mobile application,
- more advanced network security is only available in a more expensive package.

The software presented has many functions that meet the requirements. The best choice is the most expensive package because of the greater amount of network security. The weakness is the need to operate over the Internet, which means that data is not stored locally. Making the strengths and weaknesses visible will enable one to make an informed decision about the use of digital signage software.

4.4. Summary of the examples and solutions analyzed

An analysis of the available solutions in the context of the mentioned use cases shows that each of the given software categories meets the needs of a different group of users. Providing specific software examples for each use case and analyzing their strengths and weaknesses will enable a more informed decision to be made when selecting software to present content to a larger audience. The features presented demonstrate the capabilities of software currently available on the market. Attention is also focused on the character of the application of a given solution. It is necessary to use tailored software in order to achieve the best results. No software has ever been so universal that it can be used in every use case to meet all requirements.

5. Discussion

Research shows that there are many cases where providing a well-tailored way of communication in the public sphere is worth using well-tailored software. Despite the same goal of communication in the public sphere, other functionalities are needed from the software depending on the circumstances and the character of their use. Also, the user's level of experience significantly affects the required functionality.

Interestingly, it was also observed that certain features were the same independently of use cases, e.g., the ability to display images, videos and the ability to change and control the displayed content. These are specific to programs for communication in the public sphere. The information transmitted in this case is images and videos. The user has the ability to communicate this information to the audience by displaying this content at the appropriate place and time.

Of course, there was no lack of case-specific features, e.g. the ability to synchronize with specialized stage lighting control software and the ability to quickly display a single message on all screens in the system. These are features designed for professional use. Their presence is determined by specific requirements and where the information is to be distributed.

On the other hand, there is software to meet user requirements. Four main types of software, whose main function is to transmit information in the form of, among others, images and videos, are video player, presentation program, VJ software and digital signage software. The selection of the appropriate software will depend on the advancement of the user, the type and character of the information transmitted, and the functions that the software provides.

These results need to be interpreted with care because every use case is very individual. Much depends on the requirements placed on the software to help with the provision of communications in the public sphere. This research is a great starting point that shows the analysis of the situation to specify the requirements and selection of software.

6. Conclusions

In summary, communication in public sphere can be supported by software. Development of software led to creation more specifically types of software. From simple programs like the video player, to advanced programs that maintain entire communication systems like digital signage software. Choosing the right program depends on the needs of the particular situation. The results of this study highlight that a good specification of requirements is crucial to select the appropriate software. What is interesting here is that there is no universal program that works perfectly in every case.

Highlighting several major types of software gives a clear overview of what kind of software is currently available and for what purpose it was created. This shows solutions to the problems identified during the case study. Insufficient functionality of programs such as video players and presentation programs has led to the development of more specialized software such as VJ software and digital signage software. This study indicated what functionality digital signage software provides that had not previously been addressed in other types of software.

6.1. Further developments

This study provides the backbone for further investigation into areas related to digital signage software, the support of communication in the public sphere through software, and its adaptation to the user. As a precursor to future directions, this article allows the reader to explore the topic of software designed for communication in the public sphere, such as digital signage type systems. It is possible to further deepen the subject. There is potential in exploring the use of the software in other use cases. It is possible to explore the degree of versatility of the software in use. It would also be interesting to investigate the effectiveness of digital signage systems. It would also be curious to explore the use of artificial intelligence in this type of system.

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THE USAGE OF QUALITY FUNCION DEPLOYMENT (QFD) IN INDUSTRY 4.0 CONDITIONS

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Purpose: The purpose of this publication is to present the usage of Quality Function Deployment (TQM) approach in Industry 4.0 conditions.
Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.
Findings: The integration of Total Quality Management (TQM) with Industry 4.0 signifies a transformative collaboration, representing a profound evolution in the approach to quality management within modern industries. By combining the foundational principles of TQM, rooted in the early 20th century and shaped by influential figures like Frederick W. Taylor and W. Edwards Deming, with the advanced technologies of Industry 4.0, organizations gain a potent strategy for achieving excellence, efficiency, and sustained success. This integration leverages smart technologies, digitalization, and data analytics to enhance decision-making processes, preserving and amplifying the core tenets of TQM through the innovative technologies of the fourth industrial revolution. The historical journey of TQM, coupled with insights into its principles and the subsequent application of Lean Management within Industry 4.0, establishes a comprehensive and forward-looking approach. As organizations navigate the dynamic landscape of modern manufacturing, this integration serves as a strategic roadmap for upholding traditional quality management principles and thriving in the era of digital transformation.

Keywords: Industry 4.0; Quality 4.0, quality management; quality methods, QFD, Quality Function Deployment.

Category of the paper: literature review.

1. Introduction

Quality Function Deployment (QFD) can play a crucial role in the context of Industry 4.0 by integrating its principles with the advancements of the fourth industrial revolution. In Industry 4.0, where connectivity, data, and digitalization are paramount, QFD can be

effectively utilized to ensure that product development and manufacturing processes align with evolving market demands and customer expectations.

One way QFD contributes to Industry 4.0 is through the integration of digital customer feedback. With the proliferation of online platforms and sensors, organizations can use QFD to systematically capture and analyze real-time customer feedback (Alrabadi et al., 2023). This ensures a dynamic and responsive approach to product development, where customer preferences and market trends are continuously monitored and incorporated into decision-making processes (Bousdekis et al., 2023).

Predictive analytics, a feature of Industry 4.0 for quality assurance, can be incorporated into QFD processes (Liu et al., 2023). By anticipating potential quality issues during product development, organizations employing QFD with predictive analytics can address these issues proactively, reducing the risk of defects and ensuring that products consistently meet or exceed customer expectations (Antony et al., 2023; Escobar et al., 2023; Antony et al., 2023; Salimbeni, Redchuk, 2023).

QFD's integration with Industry 4.0 principles empowers organizations to navigate the complexities of the modern industrial landscape. By embracing digitalization, data analytics, simulation, collaboration, IoT, and predictive analytics within the QFD framework, companies can enhance their agility, efficiency, and overall responsiveness to the evolving demands of customers and markets (Maganga, Taifa, 2023).

The purpose of this publication is to present the usage of Lean Management approach in Industry 4.0 condition.

2. The basics of Quality Function Deployment (QFD) approach

Quality Function Deployment (QFD) is a methodology used in product and process development to ensure that customer needs and expectations are fully understood and addressed. It originated in Japan in the 1960s and has since been widely adopted in various industries around the world. The primary goal of QFD is to translate customer requirements into specific engineering characteristics and components, thereby guiding the design and development process.).

The history of Quality Function Deployment (QFD) can be traced back to the 1960s in Japan, where it originated as a methodology to enhance the quality and efficiency of product development processes. The primary contributors to the development of QFD were Dr. Yoji Akao and Shigeru Mizuno. The genesis of QFD lies in the manufacturing practices of Japanese industries, particularly within the Toyota Motor Corporation. As Japan sought to rebuild its economy after World War II, there was a growing emphasis on quality and efficiency in

manufacturing. The need for systematic methods to ensure that customer requirements were not just met but exceeded became increasingly apparent.

In 1966, Dr. Yoji Akao, a Japanese professor, is credited with formalizing the early concepts of QFD. His initial focus was on translating customer requirements into specific product characteristics and features. Akao's work laid the foundation for what would later become known as QFD. The methodology gained further momentum with the work of Shigeru Mizuno, who collaborated with Akao in the 1970s. Together, they expanded QFD beyond its initial applications in the automotive industry to a broader range of sectors. The duo developed the House of Quality, a visual representation that became a hallmark of QFD and is still widely used today (Maganga, Taifa, 2023).

QFD attracted international attention in the 1980s when it was introduced to Western audiences. The methodology gained recognition for its effectiveness in aligning customer needs with product development processes. American quality experts, including Dr. Joseph M. Juran, played a role in popularizing QFD in the United States. As QFD spread globally, it evolved to accommodate various industries and applications. Different versions and adaptations of the methodology emerged to suit the specific needs of diverse organizations, from manufacturing to services.

Over the years, QFD has continued to be refined and expanded, with practitioners incorporating new tools and techniques. It has become an integral part of quality management and product development methodologies, helping organizations systematically integrate customer feedback into their processes (Jonek-Kowalska, Wolniak, 2021; 2022). Today, QFD is recognized as a valuable tool for improving customer satisfaction, enhancing product and service quality, and optimizing the design and development processes across a wide range of industries worldwide. Its enduring popularity is a testament to its effectiveness in ensuring that customer needs remain at the forefront of organizational efforts.

Table 1 contains description of Quality Function Deployment key principles.

Table 1.
Key principles of QFD

Key principle	Description
Voice of the Customer (VOC)	*Definition:* The process of capturing and understanding customer needs, expectations, and preferences. *Purpose:* To ensure that the product or service design is aligned with customer requirements.
House of Quality (HOQ)	*Definition:* A matrix that visually represents the relationships between customer requirements and engineering characteristics. *Purpose:* Provides a structured framework for translating customer needs into specific design elements.
Customer Requirements (WHATs)	*Definition:* The essential attributes or features that customers expect from a product or service. *Purpose:* Forms the basis for design decisions and serves as a reference point for aligning engineering characteristics.
Engineering Characteristics (HOWs)	*Definition:* The specific technical or functional features that will fulfill customer requirements. *Purpose:* Guides the development team in implementing design elements that directly address and satisfy customer needs.

Cont. table 1.

Relationship Matrix	*Definition:* A part of the House of Quality, illustrating the correlations between customer requirements and engineering characteristics. *Purpose:* Helps quantify the impact of design decisions on customer satisfaction.
Priority (Roof)	*Definition:* The top part of the House of Quality, indicating the relative importance of engineering characteristics. *Purpose:* Guides the team in prioritizing design elements based on their impact on customer satisfaction.
Competitive Assessment	*Definition:* An analysis of how well competing products or services meet customer requirements. *Purpose:* Helps in benchmarking and ensuring that the design efforts go beyond meeting minimum industry standards.
Continuous Improvement	*Definition:* The ongoing process of refining and enhancing the product or service based on feedback and changing customer needs. *Purpose:* Ensures that the organization remains adaptable and responsive to evolving market demands.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

3. How Quality Function Deployment method can be integrated with Industry 4.0 and Quality 4.0 concept

Integrating Quality Function Deployment (QFD) with Industry 4.0 and Quality 4.0 concepts enhances the efficiency, agility, and responsiveness of organizations in the modern industrial landscape. Industry 4.0 emphasizes the use of digital technologies to create smart, connected factories. QFD can be integrated into digital platforms that facilitate the collection, analysis, and utilization of vast amounts of data from various sources. By leveraging digital technologies, organizations can enhance the speed and accuracy of gathering customer feedback, market trends, and real-time performance data. This information can then be seamlessly integrated into the QFD process, providing a more dynamic and data-driven approach to decision-making (Singh et al., 2023).

Industry 4.0 promotes the use of the Internet of Things (IoT) to create interconnected and intelligent products. QFD can incorporate IoT data to understand how products are used in real-world scenarios, enabling better alignment of design decisions with actual customer experiences. IoT-enabled devices can provide valuable insights into product performance, usage patterns, and potential areas for improvement. This real-time data can feed directly into the QFD process, allowing organizations to continuously adapt and enhance their products based on evolving customer needs and preferences (Gajdzik et al., 2023).

Quality 4.0 introduces advanced analytics and predictive quality techniques. QFD can benefit from predictive analytics models that forecast potential issues in product development or manufacturing processes, allowing organizations to proactively address quality concerns before they impact customers (Barsalou, 2023; Maganga, Taifa, 2023). By integrating

predictive quality analytics into the QFD framework, organizations can identify potential risks and opportunities early in the development process. This proactive approach aligns with the QFD principle of continuous improvement, enabling organizations to optimize product design and quality (Jokovic et al., 2023).

Industry 4.0 emphasizes the use of digital twin technology, creating virtual replicas of physical products or processes. QFD can leverage digital twins to simulate and analyze different design scenarios, allowing for more informed decision-making during the product development phase. Digital twins enable organizations to visualize and assess the potential impact of design decisions in a virtual environment. This integration helps in identifying and addressing issues before physical prototypes are produced, reducing development time and costs (Yanamandra et al., 2023).

Industry 4.0 encourages the use of cloud computing for collaborative work environments. QFD processes can benefit from cloud-based platforms, enabling cross-functional teams to collaborate in real-time on product development, ensuring that all stakeholders have access to the latest information. Cloud-based collaboration enhances communication and transparency in the QFD process, allowing teams to work together seamlessly, irrespective of geographical locations. This integration promotes efficient information sharing and accelerates decision-making.

Table 2 is listing examples of integration of Quality Function Deployment method with Industry 4.0. This table highlights how QFD can be integrated with various aspects of Industry 4.0, aligning traditional quality methodologies with digital technologies, data analytics, simulation, collaboration tools, and advanced predictive techniques.

Table 2.
QFD integration with Industry 4.0

Aspect	Description
Digital Customer Feedback Integration	Integration of digital platforms and sensors to capture real-time customer feedback from online sources, social media, and other digital channels.
Big Data Analytics for Decision-Making	Leveraging big data analytics to analyze vast amounts of data from various sources, providing insights into market dynamics, customer behavior, and performance metrics.
Simulation and Digital Twin Technology	Utilizing simulation and digital twin technology to create virtual prototypes for assessing different design scenarios before physical prototypes are produced.
Cross-Functional Collaboration	Integration of cloud computing for real-time collaboration among cross-functional teams involved in product development, ensuring accessibility to up-to-date information.
IoT Integration for Real-Time Monitoring	Incorporating the Internet of Things (IoT) for real-time monitoring of product performance, usage patterns, and other relevant data, enabling proactive adjustments to design elements.
Predictive Analytics for Quality Assurance	Integration of predictive analytics models to anticipate potential quality issues during product development, allowing proactive measures to be taken to prevent defects and ensure consistent quality.
Blockchain for Supply Chain Transparency	Leveraging blockchain technology to enhance transparency and traceability in the supply chain, ensuring that the sourcing and production processes align with quality standards and customer expectations.

Cont. table 2.

Augmented Reality (AR) for Design Review	Integration of augmented reality tools for virtual design reviews, allowing teams to collaboratively assess and modify designs in real-time, enhancing the efficiency of the design process and ensuring alignment with customer requirements.
Additive Manufacturing (3D Printing)	Integration of additive manufacturing technologies, such as 3D printing, into the design and prototyping phases, enabling rapid iteration and customization of product designs based on real-time feedback and market demands.
Cyber-Physical Systems in Production	Incorporating cyber-physical systems into the production process, where physical production systems are interconnected with digital technologies, allowing for real-time monitoring, control, and optimization of manufacturing processes.
Human-Machine Collaboration in Production	Integration of collaborative robots (cobots) and other human-machine interfaces in the production environment, promoting a flexible and adaptive manufacturing process that can quickly respond to changes in product specifications and customer demands.
Sustainable and Eco-Friendly Practices	Integration of sustainable and eco-friendly practices into the product development and manufacturing processes, aligning with Industry 4.0's emphasis on environmental responsibility and meeting the growing demand for environmentally conscious products.
Continuous Cybersecurity Measures	Incorporating continuous cybersecurity measures to safeguard digital assets, intellectual property, and sensitive information throughout the product development and manufacturing lifecycle, ensuring the integrity and security of digitalized processes.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

Table 3 is describe the advantages of Quality Function Deployment approach usage in industry 4.0. This table highlights the numerous advantages that arise from the seamless integration of QFD with Industry 4.0, ranging from customer-centric insights and data-driven decision-making to enhanced collaboration, rapid prototyping, and sustainability considerations.

Table 3.
The advantages of QFD integration with Industry 4.0

Advantage	Description
Real-Time Customer Insights	Integration with Industry 4.0 allows for the real-time capture and analysis of customer feedback, ensuring that product development remains aligned with evolving customer preferences and market trends.
Data-Driven Decision-Making	Leveraging big data analytics within the QFD process enables more informed decision-making by analyzing vast amounts of data from various sources, providing comprehensive insights into market dynamics and performance metrics.
Efficient Virtual Prototyping	Integration with simulation and digital twin technology facilitates efficient virtual prototyping, allowing organizations to assess different design scenarios before physical prototypes are produced, leading to cost savings and faster development cycles.
Cross-Functional Collaboration	Cloud-based collaboration enhances communication and transparency among cross-functional teams, ensuring that all stakeholders have access to up-to-date information, fostering efficient teamwork and streamlined decision-making.
Proactive Quality Assurance	Integration with predictive analytics models enables proactive quality assurance by anticipating and addressing potential issues during product development, reducing the risk of defects and ensuring consistent product quality.

Cont. table 3.

Real-Time Monitoring and Adaptation	IoT integration enables real-time monitoring of product performance and usage patterns, facilitating proactive adjustments to design elements based on actual usage data, ensuring continuous alignment with customer expectations.
Blockchain-Enhanced Supply Chain Transparency	Integration with blockchain technology enhances transparency and traceability in the supply chain, ensuring that sourcing and production processes align with quality standards and meet customer expectations for ethical and sustainable practices.
Enhanced Design Review through Augmented Reality (AR)	AR integration enhances design reviews by providing virtual platforms for collaborative assessments and modifications in real-time, improving the efficiency of the design process and ensuring alignment with customer requirements.
Rapid Prototyping with Additive Manufacturing	Integration with additive manufacturing technologies, such as 3D printing, enables rapid prototyping and customization of product designs based on real-time feedback and market demands, fostering agility and innovation in product development.
Optimized Production with Cyber-Physical Systems	Integration with cyber-physical systems in production allows for real-time monitoring, control, and optimization of manufacturing processes, enhancing overall production efficiency and adaptability to changing product specifications and demands.
Flexible Human-Machine Collaboration	Integration with collaborative robots (cobots) and human-machine interfaces promotes a flexible and adaptive manufacturing process, allowing quick responses to changes in product specifications and customer demands, increasing overall production flexibility.
Sustainable and Environmentally Conscious Practices	Integration with sustainable and eco-friendly practices aligns with Industry 4.0's emphasis on environmental responsibility, meeting the growing demand for environmentally conscious products and contributing to corporate social responsibility goals.
Continuous Cybersecurity Measures	Incorporating continuous cybersecurity measures safeguards digital assets, intellectual property, and sensitive information throughout the product development and manufacturing lifecycle, ensuring the integrity and security of digitalized processes.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

Table 4 is describe the problems of Quality Function Deployment approach usage in Industry 4.0 and methods to overcome them. Addressing these problems requires a strategic and thoughtful approach, involving a combination of technological solutions, organizational change management, and ongoing adaptation to evolving industry standards and practices.

Table 4.
The problems of QFD integration with Industry 4.0

Problems	Description of Problem	Overcoming Strategies
Data Security and Privacy Concerns	Integration with Industry 4.0 involves the collection and utilization of vast amounts of sensitive data, raising concerns about data security and privacy breaches.	Implement robust cybersecurity measures, including encryption, access controls, and regular security audits. Ensure compliance with data protection regulations and establish transparent communication with stakeholders about data usage and protection policies.

Cont. table 4.

Interoperability Challenges	Industry 4.0 relies on diverse technologies and systems; integrating them seamlessly with QFD processes may encounter challenges related to interoperability.	Prioritize the use of standardized communication protocols and data formats. Foster collaboration among technology providers to ensure compatibility. Invest in middleware solutions that facilitate communication between different technologies. Conduct thorough testing and validation to identify and address interoperability issues early in the integration process.
Skills Gap and Workforce Training Needs	The integration of QFD with Industry 4.0 requires a workforce with expertise in both traditional quality methodologies and emerging technologies, creating a potential skills gap.	Invest in training programs to upskill existing workforce members or hire individuals with a blend of traditional quality management and Industry 4.0-related skills. Foster a culture of continuous learning and provide resources for employees to acquire relevant certifications. Collaborate with educational institutions to develop tailored programs that address the specific skill sets needed for QFD integration with Industry 4.0.
Costs and Resource Allocation	Integrating QFD with Industry 4.0 technologies may require significant upfront investments in technology, training, and infrastructure, posing challenges for organizations with limited resources.	Conduct a thorough cost-benefit analysis to justify the investments and highlight the potential long-term benefits. Prioritize phased implementations to spread costs over time. Explore collaborative partnerships or seek government grants and incentives to alleviate financial burdens. Foster a strategic approach to resource allocation, ensuring that investments align with organizational goals and expected returns.
Resistance to Change	The adoption of Industry 4.0 technologies, including the integration of QFD, may face resistance from employees accustomed to traditional methods and skeptical about the benefits of technological changes.	Implement change management strategies to communicate the benefits of integration and address concerns. Involve employees in the decision-making process and provide training and support to help them adapt to new technologies. Create a positive organizational culture that embraces innovation and continuous improvement. Recognize and celebrate achievements resulting from the integration to build a positive narrative around change.
Complexity in Technology Implementation	Implementing Industry 4.0 technologies alongside QFD may introduce complexity, particularly for organizations with limited experience in deploying advanced technological solutions.	Engage external experts or consultants with experience in Industry 4.0 implementations to guide the integration process. Develop a phased implementation plan to gradually introduce technologies and minimize disruption. Provide comprehensive training for employees involved in the implementation. Foster a culture of collaboration and knowledge-sharing to collectively address challenges and learn from experiences.
Lack of Standardization in Technologies	Industry 4.0 technologies often lack universal standards, leading to challenges in selecting compatible technologies and ensuring seamless integration.	Stay informed about emerging standards and select technologies that align with widely accepted norms. Advocate for industry collaboration to establish standards and participate in standardization initiatives. Work closely with technology vendors to ensure that their solutions adhere to interoperability standards. Prioritize technologies with open architectures that facilitate integration with other systems. Ensure flexibility in the integration approach to accommodate evolving standards.

Cont. table 4.

Shortage of Skilled Professionals	The demand for professionals with expertise in both QFD and Industry 4.0 technologies may exceed the available talent pool, resulting in a shortage of skilled individuals.	Collaborate with educational institutions to tailor programs that address the specific skill sets required for QFD integration with Industry 4.0. Implement apprenticeship programs and internships to provide hands-on training. Participate in industry collaborations to foster the development of talent pipelines. Encourage employees to pursue continuous learning and professional development. Explore remote work options to tap into a broader talent pool.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

4. Conclusion

The integration of Quality Function Deployment (QFD) with the principles of Industry 4.0 marks a significant stride in enhancing the efficiency and responsiveness of organizations within the modern industrial landscape. As Industry 4.0 emphasizes the digital transformation of manufacturing processes, QFD seamlessly aligns with these advancements to ensure that customer needs and market demands remain at the forefront of product development. QFD's role in Industry 4.0 is multifaceted. Firstly, it facilitates the integration of digital customer feedback, harnessing the power of online platforms and sensors to systematically capture and analyze real-time customer insights. This dynamic approach enables organizations to stay responsive to evolving customer preferences and market trends.

Moreover, by incorporating predictive analytics – a hallmark feature of Industry 4.0 – into QFD processes, organizations can proactively address potential quality issues during product development. This not only reduces the risk of defects but ensures that products consistently meet or exceed customer expectations. The integration of QFD with Industry 4.0 principles empowers organizations to navigate the complexities of the modern industrial landscape. By embracing digitalization, data analytics, simulation, collaboration, IoT, and predictive analytics within the QFD framework, companies can enhance their agility, efficiency, and overall responsiveness to the evolving demands of customers and markets.

This publication serves to illuminate the integration of the Lean Management approach in Industry 4.0 conditions, emphasizing the continued evolution and relevance of QFD in contemporary industrial practices. The historical journey of QFD from its origins in 1960s Japan to its global recognition in the 1980s underscores its adaptability and effectiveness. Developed by Dr. Yoji Akao and further refined by Shigeru Mizuno, QFD found resonance in diverse industries, evolving to accommodate various applications.

Table 1 encapsulates the key principles of QFD, providing a foundational understanding of its components, such as the Voice of the Customer, House of Quality, Customer Requirements, Engineering Characteristics, Relationship Matrix, Priority (Roof), Competitive Assessment, and Continuous Improvement. Moving forward, the integration of QFD with Industry 4.0 unfolds a realm of possibilities. Table 2 outlines how QFD can seamlessly merge with various Industry 4.0 aspects, including digital customer feedback integration, big data analytics, simulation, cross-functional collaboration, IoT integration, predictive analytics, blockchain for supply chain transparency, augmented reality for design review, additive manufacturing, cyber-physical systems, human-machine collaboration, sustainable practices, and continuous cybersecurity measures.

Table 3 enumerates the advantages of this integration, emphasizing real-time customer insights, data-driven decision-making, efficient virtual prototyping, cross-functional collaboration, proactive quality assurance, real-time monitoring and adaptation, blockchain-enhanced supply chain transparency, enhanced design review through augmented reality, rapid prototyping with additive manufacturing, optimized production with cyber-physical systems, flexible human-machine collaboration, sustainable practices, and continuous cybersecurity measures. However, the journey towards seamless integration is not without challenges. Table 4 identifies potential problems, such as data security and privacy concerns, interoperability challenges, skills gap, resource allocation issues, resistance to change, complexity in technology implementation, lack of standardization, and a shortage of skilled professionals. Strategies to overcome these challenges involve robust cybersecurity measures, prioritizing standardized communication, investing in workforce training, conducting cost-benefit analyses, implementing change management, engaging external experts, advocating for standards, and collaborating with educational institutions.

The integration of QFD with Industry 4.0 is a transformative journey that aligns traditional quality methodologies with cutting-edge digital technologies. As organizations embark on this integration, addressing challenges strategically and leveraging the myriad benefits will position them at the forefront of innovation, ensuring a dynamic and customer-centric approach to product development in the era of Industry 4.0.

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THE USAGE OF TOTAL QUALITY MANAGEMENT (TQM) IN INDUSTRY 4.0 CONDITIONS

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Purpose: The purpose of this publication is to present the usage of Total Quality Management (TQM) approach in Industry 4.0 conditions.
Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.
Findings: The integration of Total Quality Management (TQM) with Industry 4.0 signifies a transformative collaboration, representing a profound evolution in the approach to quality management within modern industries. By combining the foundational principles of TQM, rooted in the early 20th century and shaped by influential figures like Frederick W. Taylor and W. Edwards Deming, with the advanced technologies of Industry 4.0, organizations gain a potent strategy for achieving excellence, efficiency, and sustained success. This integration leverages smart technologies, digitalization, and data analytics to enhance decision-making processes, preserving and amplifying the core tenets of TQM through the innovative technologies of the fourth industrial revolution. The historical journey of TQM, coupled with insights into its principles and the subsequent application of Lean Management within Industry 4.0, establishes a comprehensive and forward-looking approach. As organizations navigate the dynamic landscape of modern manufacturing, this integration serves as a strategic roadmap for upholding traditional quality management principles and thriving in the era of digital transformation.

Keywords: Industry 4.0; Quality 4.0, quality management; quality methods, TQM, Total Quality Management.

Category of the paper: literature review.

1. Introduction

Total Quality Management (TQM) has found new relevance and efficacy in the era of Industry 4.0. The marriage of TQM principles with the transformative technologies of Industry 4.0 signifies a significant evolution in the way organizations approach quality management.

In Industry 4.0, the integration of smart technologies, digitalization, and data analytics provides a fertile ground for the application of TQM principles. TQM's emphasis on continuous improvement aligns seamlessly with the real-time monitoring capabilities offered by Industry 4.0. The convergence of IoT devices, sensors, and advanced analytics allows for the immediate detection and correction of deviations, fostering a proactive approach to quality management.

The integration of TQM with Industry 4.0 not only preserves the foundational principles of TQM but also amplifies its impact through the innovative technologies of the fourth industrial revolution. As organizations navigate the complexities of modern manufacturing, the symbiotic relationship between TQM and Industry 4.0 emerges as a potent strategy for achieving excellence, efficiency, and sustained success.

The purpose of this publication is to present the usage of Total Quality Management (TQM) approach in Industry 4.0 conditions.

2. The basics of Total Quality Management (TQM) approach

Total Quality Management (TQM) is a comprehensive and systematic management philosophy that strives to achieve excellence in all aspects of an organization. Originating in the 1950s and gaining prominence in the 1980s and 1990s, TQM has evolved into a powerful framework for enhancing organizational performance, customer satisfaction, and employee engagement. This holistic approach to management emphasizes the integration of quality principles into every facet of an organization, fostering a culture of continuous improvement (Liu et al., 2023).

The history of Total Quality Management (TQM) is a fascinating journey that evolved over several decades, shaped by the experiences of various industries and the contributions of key figures. The roots of TQM can be traced back to the early 20th century, but it gained significant traction in the latter half of the century. The foundations of TQM can be linked to the work of quality pioneers such as Frederick W. Taylor, who introduced scientific management principles in the early 1900s. Taylor emphasized the importance of systematic approaches to improve efficiency and quality in manufacturing (Alrabadi et al., 2023).

Walter A. Shewhart, an American physicist and statistician, developed statistical methods for quality control at Bell Telephone Laboratories. Shewhart's work laid the groundwork for statistical process control (SPC), a crucial aspect of TQM. W. Edwards Deming, an American statistician, and quality control expert, played a pivotal role in shaping the principles of TQM. After World War II, Deming contributed significantly to the reconstruction efforts in Japan. His teachings on statistical quality control and management principles had a profound impact on Japanese industry (Bousdekis et al., 2023).

Joseph M. Juran, another quality management pioneer, emphasized the importance of quality planning, quality control, and quality improvement. Juran's concepts, combined with Deming's teachings, became fundamental to the development of TQM. Japanese industries, particularly companies like Toyota, embraced TQM principles to recover from the economic devastation of World War II. The Toyota Production System, with its focus on continuous improvement (Kaizen), became a cornerstone of TQM (Yanamandra et al., 2023).

TQM gained widespread recognition in the United States during the 1980s. This decade marked a shift in focus from traditional quality control methods to a more holistic and strategic approach to quality management. The term "Total Quality Management" became popularized during this period (Almeida, Abreu, 2023). The International Organization for Standardization (ISO) introduced the ISO 9000 series, providing a set of standards for quality management systems. While not specifically about TQM, these standards became closely associated with TQM principles and practices (Jokovic et al., 2023).

TQM continued to evolve, with organizations worldwide adopting its principles. Many companies implemented TQM as a strategic initiative, recognizing its potential to enhance customer satisfaction, reduce costs, and improve overall organizational performance. TQM principles have become ingrained in the fabric of modern management practices. While the terminology might evolve, the core concepts of customer focus, continuous improvement, and employee involvement remain influential in various industries (Barsalou, 2023; Maganga, Taifa, 2023).

Throughout its history, TQM has transformed from a set of statistical tools to a comprehensive management philosophy. The contributions of key figures like Deming, Juran, and the lessons learned from Japanese manufacturing practices have shaped TQM into a powerful approach for organizations striving for excellence and sustained success.

Table 1 contains description of Total Quality Management key principles.

Table 1.
Key principles of TQM

Principle	Description
Customer Focus	Emphasizes understanding and meeting customer needs and expectations. TQM organizations prioritize customer satisfaction as a primary objective and actively seek customer feedback.
Continuous Improvement	Promotes an ongoing process of incremental and systematic improvement in all aspects of the organization. Encourages the concept of "Kaizen", where small, continuous improvements lead to overall excellence over time.
Employee Involvement	Acknowledges the importance of all employees in contributing to quality and improvement efforts. TQM encourages a culture where every individual feels empowered to participate in decision-making and innovation.
Process Orientation	Focuses on the analysis, optimization, and improvement of organizational processes. TQM organizations prioritize understanding and refining workflows to enhance efficiency and eliminate waste.
Management Leadership	Requires strong leadership committed to championing the TQM philosophy. Leaders set the vision, establish clear quality objectives, and provide the necessary resources and support for the successful implementation of TQM.

Cont. table 1.

Supplier Relationships	Recognizes the interdependence between an organization and its suppliers. TQM emphasizes the establishment of collaborative and trusting partnerships with suppliers to ensure the consistent delivery of high-quality inputs.
Data-Driven Decision Making	Advocates the use of data and performance metrics to inform decision-making. TQM organizations collect, analyze, and interpret data to identify areas for improvement, monitor progress, and make informed, strategic decisions.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

3. How Total Quality Management approach can be integrated with industry 4.0 and Quality 4.0 concept

Integrating Total Quality Management (TQM) with Industry 4.0 and Quality 4.0 represents a powerful synergy, combining traditional quality management principles with the transformative capabilities of advanced technologies. In Industry 4.0, technologies such as the Internet of Things (IoT), sensors, and advanced analytics generate vast amounts of real-time data. TQM can leverage this data to enhance decision-making processes. Quality 4.0 introduces the concept of using Big Data analytics and artificial intelligence to derive actionable insights from data, allowing organizations to make informed decisions quickly and efficiently (Singh et al., 2023).

Industry 4.0 introduces smart technologies such as automation, robotics, and cyber-physical systems. TQM principles can be integrated by using these technologies to automate repetitive tasks, streamline processes, and enable real-time monitoring. Quality 4.0 takes this a step further by incorporating advanced analytics and machine learning algorithms to identify patterns and trends for continuous improvement initiatives, fostering a culture of data-driven Kaizen. Industry 4.0 enables organizations to create personalized and customized products through digitalization and smart manufacturing (Gajdzik et al., 2023). TQM can leverage these capabilities to tailor products to specific customer needs, enhancing overall customer satisfaction. Quality 4.0 introduces the concept of individualized customer experiences, where data analytics and digital technologies are employed to understand and fulfill unique customer requirements.

Industry 4.0 technologies allow for real-time monitoring of manufacturing processes through sensors and connected devices (Jonek-Kowalska, Wolniak, 2021; 2022). TQM can integrate these capabilities for immediate detection and correction of quality issues. Quality 4.0 introduces predictive quality analytics, where machine learning algorithms can predict potential quality issues before they occur, enabling proactive measures to maintain high levels of quality. Industry 4.0 promotes connectivity among different elements of the production process, creating a connected ecosystem (Kordel, Wolniak, 2021). TQM can leverage these

collaborative platforms to facilitate communication and knowledge sharing among team members (Maganga, Taifa, 2023). Quality 4.0 emphasizes the use of collaborative technologies such as digital twins and cloud-based platforms to enhance communication and collaboration for quality management processes (Antony et al., 2023; Escobar et al., 2023; Antony et al., 2023; Salimbeni, Redchuk, 2023).

Table 2 is listing examples of integration of Total Quality Management approach with industry 4.0. The integration of TQM principles with Industry 4.0 technologies creates a powerful framework for organizations to achieve higher levels of quality, efficiency, and innovation in the rapidly evolving industrial landscape.

Table 2.
TQM integration with industry 4.0

Aspect	Description
Definition	TQM is a management philosophy focused on continuous improvement, customer satisfaction, and employee involvement. Industry 4.0 represents the fourth industrial revolution, integrating smart technologies for automation and data exchange.
Objectives	TQM aims at achieving quality excellence, reducing defects, and meeting customer expectations. Industry 4.0 aims at creating smart, interconnected systems for enhanced productivity, automation, and decision-making.
Data-Driven Decision Making	TQM relies on data for analysis and decision-making to improve processes. Industry 4.0 leverages real-time data from connected devices and sensors for intelligent decision-making.
Technology Integration	TQM integrates quality management tools. Industry 4.0 integrates technologies like IoT, AI, machine learning, and cyber-physical systems for seamless connectivity and automation.
Process Optimization	TQM focuses on optimizing existing processes. Industry 4.0 enables the redesign of entire value chains through digitalization and interconnected processes.
Customer-Centric Approach	TQM emphasizes meeting customer needs and expectations. Industry 4.0 facilitates customization and personalization through data-driven insights and flexible manufacturing.
Employee Involvement	TQM encourages employee participation in decision-making. Industry 4.0 involves employees in the implementation and maintenance of smart technologies, fostering a culture of innovation.
Quality Monitoring	TQM employs statistical process control and quality audits. Industry 4.0 utilizes sensors and real-time monitoring to ensure quality throughout the production process.
Supply Chain Integration	TQM seeks collaboration with suppliers for quality improvement. Industry 4.0 integrates the entire supply chain through digital platforms, enhancing transparency and responsiveness.
Continuous Improvement	TQM promotes a culture of continuous improvement. Industry 4.0 facilitates adaptive processes and continuous learning through feedback loops and data analytics.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

Table 3 is describe the advantages of Total Quality Management approach usage in Industry 4.0. The integration of TQM with Industry 4.0 provides a holistic approach, combining quality management principles with advanced technologies to drive competitiveness, efficiency, and innovation in the modern industrial landscape.

Table 3.
The advantages of TQM integration with industry 4.0

Advantage	Description
Enhanced Quality	Integration ensures a higher standard of quality throughout the product life cycle. Real-time data analytics identify and address quality issues promptly, reducing defects and improving overall product quality.
Operational Efficiency	Industry 4.0 technologies such as IoT and automation optimize production processes, reducing lead times, minimizing errors, and increasing overall operational efficiency.
Data-Driven Decision Making	The integration enables organizations to make informed decisions based on real-time data analytics. Data-driven insights contribute to better strategic planning and operational decision-making.
Improved Customer Satisfaction	Enhanced quality and customization capabilities lead to products and services that better align with customer needs, ultimately improving customer satisfaction and loyalty.
Agile and Adaptive Processes	The combination of TQM and Industry 4.0 fosters agile and adaptive processes, allowing organizations to respond quickly to market changes, customer demands, and emerging technological trends.
Reduced Costs and Waste	Automation, process optimization, and predictive maintenance contribute to cost reduction by minimizing operational inefficiencies, waste, and unplanned downtime.
Supply Chain Visibility and Collaboration	Industry 4.0's integration across the supply chain enhances visibility, fosters collaboration among stakeholders, and ensures efficient coordination, reducing delays and improving overall supply chain performance.
Innovation and Product Development	The synergy of TQM and Industry 4.0 creates an environment conducive to innovation. Digital technologies accelerate product development cycles, encourage creativity, and facilitate the introduction of new, market-responsive products.
Employee Empowerment and Engagement	Integration involves employees in the digital transformation process. This fosters a sense of ownership, engagement, and innovation among employees, contributing to a positive organizational culture.
Predictive Maintenance	Industry 4.0 enables predictive maintenance through the use of sensors and data analytics, allowing organizations to anticipate equipment failures, schedule maintenance proactively, and extend the lifespan of machinery.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

Table 4 is describe the problems of Total Quality Management approach usage in Industry 4.0 and methods to overcome them. Addressing these problems requires a strategic and thoughtful approach, involving a combination of technological solutions, organizational change management, and ongoing adaptation to evolving industry standards and practices.

Table 4.
The problems of TQM integration with industry 4.0

Problems	Description of Problem	Overcoming Strategies
Data Security and Privacy Concerns	The integration of Industry 4.0 involves extensive data collection, raising concerns about the security and privacy of sensitive information.	Implement robust cybersecurity measures, encryption, and compliance with data protection regulations. Conduct employee training on data security best practices.
Skill Gaps and Workforce Training	The adoption of Industry 4.0 technologies may create skill gaps within the workforce, as employees need training to operate and maintain advanced systems.	Invest in comprehensive training programs to upskill employees. Collaborate with educational institutions and offer continuous learning opportunities.
Integration Complexity and Compatibility	Integrating TQM with Industry 4.0 technologies can be complex, especially when dealing with legacy systems and ensuring compatibility between different technologies.	Conduct thorough system assessments and plan a phased integration. Prioritize interoperability and select technologies with open standards. Engage with experienced consultants for seamless integration.
Resistance to Change	Employees may resist changes associated with the adoption of new technologies and quality management practices, leading to implementation challenges.	Foster a culture of change by communicating the benefits of integration. Involve employees in the decision-making process and address concerns through transparent communication.
Initial Implementation Costs	The upfront costs of implementing Industry 4.0 technologies can be significant, posing financial challenges for organizations, especially smaller ones.	Develop a detailed cost-benefit analysis to showcase the long-term advantages. Explore financing options and government incentives. Start with pilot projects to minimize initial investment risks.
Overemphasis on Technology	Organizations may prioritize technology adoption over cultural and process changes, leading to a disconnect between technological capabilities and organizational goals.	Balance technology adoption with organizational culture and process improvements. Ensure alignment between technology implementation and strategic objectives.
Lack of Standardization	The absence of standardized processes and technologies in the Industry 4.0 landscape can hinder seamless collaboration and interoperability.	Advocate for industry-wide standards and collaborate with stakeholders to establish common protocols. Prioritize technologies that adhere to recognized standards.
Continuous Maintenance and Upkeep	Industry 4.0 systems require ongoing maintenance, and failure to address this can lead to disruptions and decreased overall system effectiveness.	Develop a robust maintenance plan with scheduled updates and repairs. Invest in predictive maintenance technologies to anticipate issues before they become critical.
Ethical Considerations in AI and Automation	The use of artificial intelligence and automation in Industry 4.0 raises ethical concerns related to job displacement, bias in algorithms, and accountability.	Establish ethical guidelines for the use of AI and automation. Implement transparent decision-making processes and mechanisms for addressing ethical concerns.
Supplier and Supply Chain Risks	Dependence on a complex network of suppliers and interconnected supply chains can expose organizations to risks such as disruptions, delays, and quality issues.	Diversify suppliers and establish strong collaboration. Implement risk management strategies, including real-time monitoring and contingency planning.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

4. Conclusion

The integration of Total Quality Management (TQM) with Industry 4.0 represents a transformative synergy, marking a significant evolution in how organizations approach quality management. The marriage of TQM principles with the advanced technologies of Industry 4.0 creates a potent strategy for achieving excellence, efficiency, and sustained success in the modern industrial landscape. The history of TQM, rooted in the early 20th century and shaped by key figures like Frederick W. Taylor, Walter A. Shewhart, and W. Edwards Deming, has evolved into a comprehensive management philosophy. TQM's core principles, including customer focus, continuous improvement, and employee involvement, have become integral to modern management practices.

The integration of TQM with Industry 4.0 leverages the capabilities of smart technologies, digitalization, and data analytics to enhance decision-making processes. This integration not only preserves the foundational principles of TQM but also amplifies its impact through the innovative technologies of the fourth industrial revolution. Table 1 outlines the key principles of TQM, emphasizing its holistic approach to management. Moving forward, the publication focuses on the application of the Lean Management approach within the context of Industry 4.0.

In detailing the basics of TQM, the historical journey from its early roots to its widespread recognition during the 1980s is explored. The principles of quality pioneers such as Deming and Juran, coupled with the influence of Japanese manufacturing practices, have shaped TQM into a powerful approach for organizational excellence. The subsequent tables delve into the integration of TQM with Industry 4.0, providing insights into the ways these principles can be applied in a modern context. Table 2 highlights specific aspects of integration, demonstrating how TQM principles align with Industry 4.0 objectives, technology integration, and customer-centric approaches.

Table 3 emphasizes the advantages of this integration, showcasing how enhanced quality, operational efficiency, and data-driven decision-making contribute to improved customer satisfaction, adaptive processes, and overall cost reduction. Finally, Table 4 addresses potential challenges in integrating TQM with Industry 4.0 and provides overcoming strategies. From data security concerns to resistance to change and ethical considerations, the table offers practical solutions for organizations to navigate and overcome these obstacles.

In essence, the integration of TQM with Industry 4.0 presents a comprehensive and forward-looking approach, allowing organizations to not only uphold traditional quality management principles but also thrive in the era of digital transformation and smart technologies. As industries continue to evolve, this integration serves as a strategic roadmap for achieving and sustaining excellence in the dynamic landscape of modern manufacturing.

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ENVIRONMENTAL MONITORING IN SMART CITY – SMARTPHONE APPLICATIONS ASPECTS

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Purpose: The purpose of this publication is to present the usage of smartphone application in Smart Cities in environmental monitoring.
Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.
Findings: This publication delves into the multifaceted role of smartphone applications within smart cities, with a specific focus on key areas like air quality, noise pollution, water quality, and weather conditions. The integration of these applications not only tackles environmental issues but also empowers citizens to actively participate in the protection of their surroundings. Notably, air quality monitoring emerges as a standout domain, leveraging built-in sensors to measure pollutants in real-time, thereby enabling informed decision-making and contributing to public health awareness. The comprehensive overview presented in this publication underscores the transformative impact of smartphone applications, emphasizing their role in fostering smarter and more sustainable urban environments. The democratization of environmental data through these tools not only raises awareness but also encourages behavioral changes, cultivating a sense of environmental stewardship among citizens. As citizens increasingly engage in assessing air quality, noise pollution, water quality, and weather conditions, the publication highlights the transformative leap that smartphone applications represent in the journey towards smart cities. This evolution not only enhances individual decision-making but also nurtures a collective responsibility for creating urban environments that are both sustainable and resilient. Looking ahead, as technology continues to advance, smartphone applications are poised to play an increasingly pivotal role, promising a future where citizens and smart cities collaborate to ensure the well-being of both urban dwellers and the planet.
Originality/value: Detailed analysis of usage smartphone applications in environmental monitoring area.

Keywords: Smart City, energy efficiency, energy efficiency management, smartphone applications, environmental monitoring.

Category of the paper: literature review.

1. Introduction

Smartphone applications have emerged as powerful tools in the realm of environmental monitoring, particularly in the context of smart cities. As urbanization continues to advance at an unprecedented pace, the need for efficient and real-time monitoring of environmental parameters has become increasingly crucial. Smartphones, equipped with a myriad of sensors and connectivity options, have proven to be invaluable instruments in this regard.

One of the key areas where smartphone applications excel is air quality monitoring. With built-in sensors such as GPS, accelerometers, and ambient light sensors, smartphones can provide real-time data on air quality by measuring parameters like particulate matter (PM), nitrogen dioxide (NO2), and ozone (O3). Citizens can leverage these applications to access up-to-date information about air quality in their vicinity, allowing them to make informed decisions about outdoor activities and contributing to their overall health and well-being (Rachmawati et al., 2021; Dutta et al, 2021; Ivanyi, Biro-Szigeti, 2019).

The purpose of this publication is to present the usage of smartphone application in Smart Cities in the case of environmental monitoring.

2. The usage of smartphone applications in environmental monitoring

Smartphone applications play a pivotal role in noise pollution monitoring. By utilizing the device's microphone, these applications can measure ambient noise levels and identify sources of excessive noise. This functionality not only empowers individuals to avoid noisy areas but also aids city planners in identifying and mitigating noise pollution hotspots. This, in turn, contributes to the creation of more livable and sustainable urban environments (Herdiansayah, 2023; Rose et al., 2021).

In the realm of water quality monitoring, smartphones equipped with specialized sensors can be employed to assess the quality of water sources. Users can collect data on parameters such as pH, turbidity, and dissolved oxygen by utilizing external attachments or built-in sensors. This democratization of water quality monitoring enables citizens to actively participate in safeguarding their water resources and alerts authorities to potential issues in real time, fostering a more responsive and adaptive approach to environmental management (Jonek-Kowalska, Wolniak, 2021; 2022; Gajdzik et al., 2023). Additionally, smartphone applications contribute significantly to weather monitoring in smart cities. The devices' GPS capabilities allow for precise location-based weather forecasting, enabling users to receive hyper-local weather updates. This functionality proves invaluable in disaster preparedness and response, allowing authorities to disseminate timely information to citizens and plan for extreme weather events effectively (Rahman, Dura, 2022).

The integration of smartphone applications into environmental monitoring also fosters a sense of environmental stewardship among citizens. By actively engaging with these applications, individuals become more aware of their surroundings and the impact of their actions on the environment. This heightened awareness can lead to behavioral changes, such as adopting eco-friendly practices and participating in community-driven environmental initiatives. The utilization of smartphone applications in environmental monitoring represents a transformative leap in the quest for smart cities. These applications empower citizens to actively engage with and contribute to the monitoring of air quality, noise pollution, water quality, and weather conditions. The democratization of environmental data not only enhances individual decision-making but also fosters a collective sense of responsibility towards creating sustainable and resilient urban environments. As technology continues to advance, the role of smartphone applications in environmental monitoring is poised to grow, promising a future where citizens and smart cities work hand in hand to ensure the well-being of both urban dwellers and the planet (Chmielarz et al., 2021).

Smartphone applications have revolutionized the field of environmental monitoring, offering versatile tools that empower individuals to actively engage in safeguarding the planet. These applications leverage the capabilities of modern smartphones, including GPS, sensors, and connectivity, to collect, analyze, and share real-time environmental data. The integration of technology into environmental monitoring has democratized access to information, transforming ordinary citizens into contributors to scientific research and environmental conservation efforts.

One prominent aspect of smartphone applications in environmental monitoring is air quality assessment. Apps like AirVisual and Breezometer utilize smartphone sensors to measure concentrations of pollutants such as PM2.5, PM10, ozone, and nitrogen dioxide. Users can access up-to-date air quality information, receive alerts, and contribute to a collective understanding of air pollution levels, promoting public health awareness and advocacy for cleaner air. Water quality assessment is another critical domain where smartphone applications play a pivotal role. Apps such as WaterRangers and Clean Swell enable users to monitor and evaluate water quality by inputting data from water tests or leveraging built-in sensors. This fosters citizen science, empowering individuals to contribute valuable information to environmental initiatives, track water pollution trends, and promote responsible water management practices (Simonofski et al., 2023; Chmielarz et al., 2021).

Biodiversity tracking applications leverage the GPS and camera features of smartphones to enable users to document and share observations of plants, animals, and insects. Platforms like iNaturalist and eBird encourage citizen scientists to contribute to biodiversity databases, aiding conservation efforts and providing valuable insights into the distribution and health of various species.

Smartphone apps also address noise pollution, a pervasive environmental issue in urban areas. NoiseTube and SoundPrint, for instance, utilize smartphone microphones to measure and map noise levels. Users can actively participate in noise mapping initiatives, raising awareness

about the impacts of noise pollution and advocating for policies to create quieter and healthier living environments. Climate change tracking applications provide users with weather data, temperature trends, and climate event information. Apps like Climate Reality and Climate Monitor not only offer insights into global climate patterns but also engage users in contributing their observations to climate databases, fostering a sense of shared responsibility in addressing climate-related challenges.

Waste management and recycling applications, such as Recycle Coach and TrashOut, provide users with information on recycling locations, waste sorting guidelines, and reminders for collection days. By promoting responsible waste disposal practices, these apps contribute to environmental sustainability and encourage communities to reduce their ecological footprint (Dutta et al, 2019).

Table 1 contains descriptions of how smartphone applications are used in environmental monitoring. This table illustrates the diverse ways in which smartphone applications are employed for environmental monitoring across various aspects, promoting citizen engagement, data collection, and awareness in environmental conservation efforts.

Table 1.
How smartphone applications are used in environmental monitoring

Aspect of Environmental Monitoring	Use of Smartphone Applications
Air Quality Monitoring	Smartphone applications measure and report air quality levels, including pollutants such as PM2.5, PM10, ozone, and nitrogen dioxide. Apps like AirVisual, Plume Labs, and Breezometer provide real-time air quality data, alerts, and historical trends, aiding public awareness and health protection.
Water Quality Assessment	Apps enable users to monitor and assess water quality by inputting data from water tests or using built-in sensors to measure pH, turbidity, dissolved oxygen, and nutrient levels. WaterRangers and Clean Swell engage citizens in collecting water quality data, contributing to environmental initiatives and raising awareness about water pollution.
Biodiversity Tracking	Smartphone apps support biodiversity monitoring by allowing users to record observations of plants, animals, and insects. iNaturalist and eBird use GPS and image recognition to identify species, facilitating citizen science and contributing valuable data to conservation efforts and scientific research.
Noise Pollution Measurement	Applications with sound sensors enable users to measure and monitor noise pollution levels. NoiseTube and SoundPrint provide real-time noise data, track trends, and empower individuals to contribute to noise mapping initiatives, fostering advocacy for quieter and healthier living environments.
Climate Change Tracking	Apps contribute to climate change monitoring by providing weather information, temperature trends, and climate event data. Climate Reality and Climate Monitor allow users to access climate data, forecasts, and contribute observations to global databases, promoting awareness and participation in climate action initiatives.
Waste Management and Recycling	Smartphone apps provide information on recycling locations, waste sorting guidelines, and track personal waste reduction efforts. Recycle Coach and TrashOut offer features such as recycling reminders, educational resources, and community engagement, encouraging responsible waste disposal and recycling practices.
Soil Health Assessment	Apps equipped with soil sensors or user input facilitate soil health monitoring, analyzing composition, moisture levels, and nutrient content. Agrobase and SoilGrids support farmers and gardeners in optimizing agricultural practices, promoting sustainable soil management, and contributing to soil health initiatives.

Cont. table 1.

Wildfire Detection and Prevention	Smartphone applications use satellite data and user reports to detect and track wildfires. Apps like FireChat and Wildfire Alert provide real-time information, evacuation alerts, and prevention tips, empowering users to stay safe and participate in early response efforts to mitigate the impact of wildfires.
Energy Consumption Monitoring	Apps help users monitor and analyze energy consumption patterns in homes or businesses. EnergyHub and Sense provide real-time energy data, insights, and recommendations, promoting energy efficiency and enabling individuals to make informed decisions to reduce their environmental footprint.
Urban Green Spaces Mapping	Smartphone applications contribute to mapping and monitoring urban green spaces. Apps like CityNature Challenge and TreeSnap enable users to document and share information about parks, trees, and greenery, fostering community engagement in preserving and enhancing urban ecosystems.
Ocean and Marine Conservation	Apps support marine conservation by providing information on marine life, coral reefs, and ocean conditions. Ocean Wise and Seafood Watch help users make sustainable seafood choices, contribute to marine research through data collection, and stay informed about threats to ocean health, encouraging responsible consumption and conservation efforts.

Source: (Kalasova et al., 2021; Chmielarz et al., 2021; Rose et al., 2021; Dutta et al., 2019; Ivani, Biro-Szigeti, 2019; Leal et al., 2023; Chowdhury et al., 2023; Sanchez et al., 2018; Aguilera, Boutueil, 2018).

Smartphone applications have emerged as powerful tools in the realm of environmental management, offering a host of advantages that enhance efficiency, accessibility, and overall effectiveness in addressing environmental challenges. These applications leverage the ubiquity of smartphones and their integrated features to engage individuals, communities, and organizations in active participation in environmental monitoring and conservation efforts. One of the key advantages is real-time data collection. Environmental management applications enable the collection of data in real-time, providing instant insights into various parameters such as air quality, water quality, and biodiversity. This real-time capability facilitates timely decision-making, allowing for quick responses to emerging environmental issues and the implementation of effective mitigation strategies.

Cost-effectiveness is another notable advantage. Smartphone applications often offer cost-effective solutions compared to traditional monitoring methods. They capitalize on existing technology infrastructure, minimizing the need for additional hardware or specialized equipment. This cost-effectiveness makes environmental monitoring more accessible to a wider audience, including resource-constrained communities. The widespread accessibility of smartphones ensures that environmental management information is within reach of a broad user base. This democratization of data allows individuals and communities to actively participate in monitoring efforts, transforming ordinary citizens into contributors to scientific research. This increased participation fosters a sense of community ownership and responsibility for environmental stewardship (Kalasova et al., 2021).

Efficient data management is facilitated through environmental management applications. These apps often incorporate features such as cloud storage, data synchronization, and automated analysis, streamlining the handling of large volumes of environmental data. Such efficiency not only saves time but also enhances the overall organization and accessibility of valuable environmental information. The integration of various sensors and technologies within smartphones enhances their capabilities for environmental monitoring. Innovative

sensor integration allows these applications to measure an array of parameters, from air and water quality to noise levels and soil health. This diversity in monitoring contributes to a comprehensive understanding of ecosystems, supporting informed decision-making in environmental management (Boichuk, 2020).

Smartphone applications also promote public awareness and education. Many environmental management apps serve as educational tools, providing information about environmental issues, sustainable practices, and the impact of individual actions. By raising awareness and fostering environmental literacy, these apps contribute to a more informed and environmentally conscious society. The ability to visualize environmental data on maps supports geospatial mapping and visualization. This feature aids in understanding spatial patterns and trends, enabling environmental managers to make informed decisions based on the geographical distribution of environmental parameters.

Table 2 highlighting the advantages of using smartphone applications in environmental management within smart cities. The advantages outlined in this table underscore the transformative role of smartphone applications in enhancing the efficiency, accessibility, and impact of environmental management initiatives.

Table 2.
Advantages of using smartphone applications in environmental management

Advantage	Description
Community Empowerment	Smartphone applications empower local communities by providing them with the tools to actively participate in environmental monitoring, fostering a sense of ownership and responsibility.
Continuous Monitoring	The ability of smartphone apps to operate continuously allows for ongoing environmental monitoring, capturing dynamic changes and trends over time, which is essential for effective management and decision-making.
Data Standardization	Many environmental monitoring apps adhere to standardized data formats and protocols, promoting consistency and compatibility, facilitating data sharing and collaboration among different stakeholders.
Education and Outreach	Applications serve as educational tools, providing information about environmental issues, sustainable practices, and the impact of individual actions, contributing to environmental literacy and awareness.
Efficient Resource Allocation	The real-time nature of data collection and analysis enables more efficient allocation of resources, allowing organizations and policymakers to address environmental challenges based on current and accurate information.
Innovative Sensor Integration	Smartphone apps can integrate with a variety of innovative sensors and IoT devices, expanding the range of environmental parameters that can be monitored, offering a more comprehensive understanding of ecosystems.
Remote Monitoring and Control	Environmental managers can remotely monitor and control monitoring devices through smartphone apps, facilitating efficient management of dispersed monitoring stations and reducing the need for physical presence.
Data Privacy and Security Features	Many environmental apps prioritize data privacy and security, implementing features such as encryption and user authentication to protect sensitive information, ensuring the integrity of environmental data.
Public Participation in Research	Smartphone apps facilitate public participation in scientific research, allowing individuals to contribute valuable data to research projects and environmental studies, thereby enhancing the scope and depth of research efforts.
Easier Regulatory Compliance	Organizations can use environmental monitoring apps to simplify regulatory compliance by automating data collection, analysis, and reporting processes, reducing the administrative burden associated with compliance.

Cont. table 2.

Global Collaboration and Data Sharing	Environmental apps enable global collaboration by facilitating the sharing of environmental data across borders. This international data sharing enhances our understanding of global environmental challenges and promotes collaborative solutions.

Source: (Kalasova et al., 2021; Chmielarz et al., 2021; Rose et al., 2021; Dutta et al., 2019; Ivani, Biro-Szigeti, 2019; Leal et al., 2023; Chowdhury et al., 2023; Sanchez et al., 2018; Aguilera, Boutueil, 2018).

While smartphone applications offer promising solutions for environmental management within smart cities, they also present several challenges that need careful consideration and mitigation. These problems encompass issues related to data security, accessibility, reliability, and community engagement. One significant challenge is data privacy concerns. The collection of environmental data through smartphone applications often involves the gathering of personal information, raising privacy issues. The potential misuse, unauthorized access, or data breaches can undermine public trust and compromise the integrity of environmental monitoring initiatives.

Unequal access to technology poses another problem. Not all residents may have equal access to smartphones or the necessary technological infrastructure, leading to disparities in participation. This digital divide can result in incomplete or biased datasets, limiting the inclusivity and effectiveness of environmental management efforts. The reliance on user-generated data introduces challenges related to data accuracy and reliability. Users may provide inconsistent or inaccurate information, affecting the quality of the collected environmental data. Ensuring the reliability of data becomes crucial for making informed decisions and implementing effective environmental policies (Dutta et al, 2019).

Limited representativeness is a concern, as the user base of environmental apps may not fully represent the diverse demographics of a smart city. This lack of diversity in participants can lead to biased data collection and exclude certain communities, impacting the comprehensiveness of environmental monitoring and management. Digital literacy barriers represent a significant hurdle. Despite the increasing prevalence of smartphones, some residents may lack the necessary digital literacy skills to effectively use environmental monitoring applications. Overcoming these barriers is essential to ensure the active and meaningful participation of all segments of the population.

The integration of sensors into environmental apps introduces challenges related to sensor calibration and maintenance. Ensuring the accuracy of sensor readings over time requires regular calibration and maintenance efforts. Sensor malfunctions or inaccuracies can lead to unreliable data, impacting the overall effectiveness of environmental monitoring. Security vulnerabilities present a substantial risk. Both the applications and the underlying infrastructure are susceptible to hacking, malware, or unauthorized access. Protecting sensitive environmental and personal data requires robust cybersecurity measures to prevent potential breaches and data manipulation (Boichuk, 2020).

The lack of standardization in data formats and protocols among different environmental apps hinders interoperability and data sharing. Standardization challenges may impede collaboration between different stakeholders and limit the comprehensive analysis of environmental data collected from various sources. Community engagement barriers are significant challenges in smart city environmental management. Despite the potential for increased community involvement, factors such as language barriers, cultural differences, and a lack of incentives may hinder active participation, affecting the effectiveness of environmental initiatives (Benevolo et al., 2016; Kalasova et al., 2021).

Table 3 highlighting some of the common problems and challenges associated with the usage of smartphone applications in environmental management within smart cities. These problems underscore the need for careful consideration and strategic planning when integrating smartphone applications into environmental management initiatives within smart cities. Addressing these challenges is crucial to ensure the effectiveness, equity, and ethical use of technology in urban environmental monitoring.

Table 3.
Problems of using smartphone applications in environmental management within smart cities

Problem	Description
Data Privacy Concerns	The collection of personal and environmental data through smartphone apps raises concerns about data privacy. Unauthorized access, misuse, or data breaches can compromise the privacy and security of individuals and communities.
Unequal Access to Technology	Not all residents may have equal access to smartphones or the necessary technology infrastructure, potentially leading to disparities in environmental data collection and participation in smart city initiatives.
Limited Representativeness	The user base of environmental apps may not be fully representative of the city's population, leading to potential biases in collected data and excluding certain demographics from participating in environmental monitoring.
Data Accuracy and Reliability	Reliance on user-generated data may introduce challenges related to accuracy and reliability. Users may provide inconsistent or erroneous data, impacting the quality of environmental information and decision-making processes.
Digital Literacy Barriers	Limited digital literacy among certain demographics may hinder effective participation in environmental monitoring initiatives. Ensuring inclusivity requires addressing barriers related to technology literacy and access.
Sensor Calibration and Maintenance	Environmental monitoring apps that integrate with sensors require proper calibration and maintenance. Issues such as sensor drift, calibration errors, or malfunction can compromise the accuracy of collected data.
Security Vulnerabilities	Smartphone apps and the underlying infrastructure may be susceptible to security vulnerabilities, including hacking, malware, or unauthorized access. Ensuring robust cybersecurity measures is crucial to protect sensitive data.
Lack of Standardization	The absence of standardized data formats and protocols among different environmental apps can hinder interoperability and data sharing. Standardization challenges may impede collaboration and comprehensive analysis of environmental data.
Technological Obsolescence	Rapid advancements in technology may lead to the obsolescence of smartphones and sensors, rendering certain environmental monitoring apps and devices outdated. This can pose challenges in maintaining a consistent and up-to-date monitoring system.
Community Engagement Barriers	Despite the potential for community engagement, some residents may face barriers to active participation, such as language barriers, cultural differences, or a lack of incentives, impacting the effectiveness of smart city environmental initiatives.

Cont. table 3.

Infrastructure Dependency	Environmental monitoring apps heavily depend on the availability of robust technology infrastructure, including network connectivity and server capabilities. Cities with inadequate infrastructure may face limitations in implementing such solutions.
Regulatory and Ethical Challenges	The use of environmental monitoring apps may raise regulatory and ethical challenges, such as compliance with data protection laws, consent for data collection, and ethical considerations related to the use of technology for surveillance.

Source: (Kalasova et al., 2021; Chmielarz et al., 2021; Rose et al., 2021; Dutta et al., 2019; Ivani, Biro-Szigeti, 2019; Leal et al., 2023; Chowdhury et al., 2023; Sanchez et al., 2018; Aguilera, Boutueil, 2018).

3. Conclusion

Smartphone applications have become indispensable tools in the field of environmental monitoring, particularly in the dynamic landscape of smart cities. The relentless pace of urbanization necessitates efficient, real-time monitoring of environmental parameters, and smartphones, equipped with an array of sensors and connectivity options, have emerged as invaluable instruments for this purpose. This publication explores the role of smartphone applications in environmental monitoring within the context of smart cities, focusing on key areas such as air quality, noise pollution, water quality, and weather conditions. The integration of smartphone applications addresses critical environmental challenges and empowers citizens to actively participate in safeguarding their surroundings.

Air quality monitoring stands out as a prominent domain where smartphones excel, utilizing built-in sensors to measure pollutants such as particulate matter, nitrogen dioxide, and ozone. This real-time data enables citizens to make informed decisions about outdoor activities, contributing to public health awareness. The publication emphasizes the usage of smartphone applications across various aspects of environmental monitoring, presenting a comprehensive overview of their role in creating smarter and more sustainable urban environments. Furthermore, the publication delves into the democratization of environmental data facilitated by smartphone applications. These tools foster a sense of environmental stewardship among citizens by promoting awareness and encouraging behavioral changes. The transformative impact of smartphone applications on environmental monitoring is evident, with citizens actively engaging in the assessment of air quality, noise pollution, water quality, and weather conditions.

The publication underscores the transformative leap that smartphone applications represent in the journey toward smart cities. By enabling citizens to actively contribute to environmental monitoring, these applications not only enhance individual decision-making but also cultivate a collective sense of responsibility for creating sustainable and resilient urban environments. As technology continues to advance, the role of smartphone applications in environmental monitoring is poised to grow, promising a future where citizens and smart cities collaboratively ensure the well-being of both urban dwellers and the planet.

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SENTIMENT ANALYSIS OF COMMENTS POSTED ON YOUTUBE VIDEOS RELATED TO PHOTOVOLTAICS

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Purpose: Based on sentiment analysis of comments posted on YouTube, determining people's thoughts, feelings and opinions on photovoltaics.
Design/methodology/approach: Comments posted on videos were downloaded automatically. The comments' content has undergone preprocessing. All characters other than letters, URLs, hashtags, emojis, and words used to search for videos taken out of their text. The comment's sentiment value was determined. To display the proportion of favourable, negative, and neutral comments, visualisations were created. The word cloud was employed to display the comments' most popular words.
Findings: For comments posted on videos related to photovoltaics, proportions of positive, negative and neutral comments were determined. The information about the number of published videos, the view count of videos, the length of videos, the number of published comments, and the length of comments has been obtained.
Research limitations/implications: Only comments posted on videos which contained the word "photovoltaic" were downloaded, Only Polish-language comments' content was examined. Without author oversight, sentiment analysis was carried out automatically by the "ccl emo" service. Only viewpoints expressed by YouTube users were analysed. It was assumed that if the title of the video contains the word photovoltaic, its comments content is related to photovoltaic.
Practical implications: Automated assessment of people's opinions regarding photovoltaics.
Originality/value: Opinions on photovoltaics were collected. Based on the growing number of videos and comments, it was found that interest in photovoltaics in Poland is steadily growing.

Keywords: sentiment analysis, YouTube, photovoltaics, text mining.

Category of the paper: research paper, case study.

1. Introduction

As the impacts of global warming become increasingly evident, there is a rising concern regarding the adverse effects of the conventional energy industry on the environment. Communities are actively engaging in measures aimed at decreasing the emission of greenhouse gases (Decuypere et al., 2022; Peng et al., 2013; Pestana et al., 2018). On a global scale, the adoption of renewable energy sources is expanding to contribute towards the mitigation of air pollution and the reduction of carbon emissions (Dincer et al., 2000; Moriarty, Honnery, 2011). Numerous nations recognize the advantages of green energy, resulting in policy shifts concerning energy procurement (Bórawski et al., 2019; Eyl-Mazzega, Mathieu, 2020; Omri et al., 2015; Pellerin-Carlin et al., n.d.; Salim, Rafiq, 2012).

Public acceptance and support for renewable energy play a crucial role in facilitating the transition towards a low-carbon energy system (Kim et al., 2021). Public sentiment and opinions regarding renewable energy have been conducted (Hamilton et al., 2019; Kim et al., 2021; Lee, 2022; Noblet et al., 2015; Peñaloza et al., 2022; Qazi et al., 2019; Stokes, Warshaw, 2017).

The worldwide market for renewable energy sources (RES), particularly in the solar and wind sectors, is experiencing a consistent growth trajectory, unaffected even by the challenges posed by the coronavirus pandemic (Bhuiyan et al., 2021; Bilgili, Ozturk, 2015; Eroğlu, 2021; Quitzow et al., 2021). Out of all renewable energy sources, photovoltaic technology holds the highest potential due to its affordability and straightforward installation process (Alves dos Santos et al., 2021; C.B. et al., 2021; Castilho et al., 2021; Mota et al., 2020).

The photovoltaic sector in Poland is characterized by a decentralized structure, predominantly relying on micro installations. By the conclusion of 2019, micro-installations represented over 70% of Poland's overall installed photovoltaic capacity. Residential participation in photovoltaics was promoted through solar energy support programs such as the governmental initiative “My Electricity”, and long-term European Union support under the Regional Operational Programs (Gręboszc-Krawczyk et al., 2021).

In recent years, Poland's households, industries, and service sectors have grappled with escalating electricity bills (Chomać-Pierzecka et al., 2022). Rising electricity prices have increased interest in photovoltaics as an alternative, but choosing the right solution can be complex. In Poland, several factors contribute to this situation, including but not limited to:

- optimal installation size (avoiding excessive electricity production that may not be economically viable) (Zrównoważonego et al., 2015),
- terms and conditions for accounting for excess electricity production with the distribution system operator (Zator, Lambert-Torres, 2021),
- evaluating the cost-effectiveness of investing in an electricity storage system (Zator, Lambert-Torres, 2021),

– limited familiarity with technical criteria for selecting the suitable energy solution, often leading to purchase decisions primarily driven by factors such as installation cost, lifespan of photovoltaic panels, availability of implementation options, and aesthetic considerations (Chomać-Pierzecka et al., 2022).

In the era of digital advancements, individuals often share their thoughts and opinions on social media platforms, expressing their ideas to a wide audience. Sentiment analysis can be utilized as a means to analyse and understand people's thoughts, emotions, and opinions. Sentiment analysis can be an alternative approach to traditional surveys and interviews. It provides an automated approach to analyse sentiment, emotions, and opinions expressed in written language. It is a process of analysing, processing, generalizing and making sense of emotionally charged subjective texts (Deng et al., 2022). It offers a method for extracting valuable insights from textual data efficiently and effectively (Xu et al., 2022). It can be performed to assess an individual's perspective or inclination towards a subject or issue, determining whether it leans towards a positive or negative viewpoint (Pang et al., 2002).

A big source of data with people's opinions can be the comments posted on YouTube videos. YouTube is an online video platform that is quickly expanding and receives nearly two billion views daily (Aydın, Yılmaz, 2021; Snelson, 2011). According to data as of March 14, 2023, more than 5 billion YouTube videos are viewed each day, there are 2.5 billion monthly active YouTube users, and more than 500 hours of YouTube videos are uploaded per minute (Omnicore, 2021). As the world's biggest video platform, YouTube showcases a diverse range of media content produced by either companies or individuals. This content encompasses music videos, promotional videos for products, vlogs, review videos, and educational content (Muhammad et al., 2019).

A variety of tools can be used for analysing data retrieved from the Internet. Due to a significant volume of data, methods such as text mining, data mining, machine learning, topic modelling, sentiment analysis and similar approaches are employed. The exploration of data collected from social media constitutes a new field. Its popularity is growing due to cost-effectiveness, easy access, and the element of anonymity (Das et al., 2015, 2019; Evans-Cowley, Griffin, 2012). There are many studies in the literature about sentiment analysis on data extracted from the Internet (Ağrali, AYDIN, 2021; Pang, Lee, 2004, 2008; Read, 2005). The use of sentiment analysis of text to find out people's opinions on renewables was presented in (Corbett, Savarimuthu, 2022; Ibar-Alonso et al., 2022; Jain, Jain, 2019a, 2019b; Kim et al., 2021; Loureiro, Alló, 2020; Zarrabeitia-Bilbao et al., 2022).

Sentiment analysis is a tool to understand how society perceives photovoltaics. It is a valuable tool for policymakers, investors and businesses alike, helping to shape a positive image and support the development of this sustainable form of energy. Sentiment analysis provides valuable feedback on societal attitudes towards photovoltaics, which, in turn, can impact decision-making, investments, and actions in the field.

2. Research Methodology

On March 22, 2023, in service, YouTube 2.960 videos related to photovoltaics were found. This was accomplished using the Python “scrapetube” (Twersky, n.d.) library. This library allows search for videos without the official YouTube API (application programming interface). The title of the video had to include one or more of the following nouns and/or adjectives in Polish:

- nouns: “fotowoltaika”, “fotowoltaice”, “fotowoltaiką”, “fotowoltaikę”, “fotowoltaiki”, “fotowoltaiko”, “fotowoltaik”, “fotowoltaikach”, “fotowoltaikami”, “fotowoltaikom”,
- adjectives: “fotowoltaiczna”, “fotowoltaiczną”, “fotowoltaicznego”, “fotowoltaicznej”, “fotowoltaicznemu”, “fotowoltaiczni”, “fotowoltaicznych”, “fotowoltaicznym”, “fotowoltaicznymi”, “fotowoltaiczne”, “fotowoltaiczny”.

These nouns and adjectives are in all possible grammatical cases for the Polish language and are translations of the terms “photovoltaics”.

In the next step for each video, comments posted by users were downloaded. The “youtube-comment-downloader” package was used for this. It is a simple script for downloading YouTube comments without using the YouTube API (*Youtube-Comment-Downloader*, n.d.).

In the next step, the author removed:

- comments were written in languages other than Polish,
- the comments whose content was the same as the content of other comments and were posted by the same user (it was frequently an advertisement for a company's services, products, or jobs); the content was treated as a string of characters and compared using the comparison operator “==”.

Then the comments' content was pre-processed. URLs, hashtags, emojis, user names, terms used to search for videos, and all characters other than letters were removed from the comments. Next, the number of words in the cleaned content of each comment was checked. Comments with less than 4 words have been removed. After these operations, the number of comments was 136.416. These comments were posted on one of the 1565 videos. The remaining 1395 videos had no comments, or those comments were removed during the pre-processed stage.

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

[1] https://wiki.clarin-pl.eu/pl/nlpws/services/ccl_emo; https://clarin-pl.eu/index.php/wydzwiek/

[2] CLARIN-PL is a Polish scientific consortium, part of the European Research Infrastructure CLARIN (Common Language Resources and Technology Infrastructure) (*CLARIN-PL*, n.d.)

- Any2txt - a service that transforms text files (e.g. doc, docx, xlsx) into text.
- Speller2 - a service that verifies the text's spelling. It uses a tool called Autocorrect[3] for this.
- Wcrft2 - is a basic morpho-syntactic tagger for Polish.
- WSD - a service for word sense disambiguation, which works for Polish texts. As a source of possible senses, it uses plWordNet, which consists of lexical units grouped into synsets that 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.).

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

- sentiment polarity: it was assessed on a 5-point scale: strong and weak vs. negative and positive, plus neutral;
- basic emotions: gladness, trust, enjoyment of something expected, sadness, anger, fear, disgust, and surprise with something unpredictable - these emotions were derived from the 8 basic emotions identified by Plutchik and his Wheel of Emotions (Plutchik, 1980; Wierzbicka, 1992a, 1992b);
- fundamental human values: utility, good of another man, truth, knowledge, beauty, happiness, uselessness, harm, ignorance, error, ugliness, unhappiness - basic human values indicated by (Puzynina, 1992) were used.

Table 1.
Example of calculating the sentiment of a comment

Sample comment	Niech ***sprawdzi*** [1] lodówkę. U mnie przez ***uszkodzoną*** [-1] uszczelkę rachunki ***mocno*** [1] latem wzrosły.
Sentiment calculation	***sprawdzi*** [1] + ***mocno*** [1] = 2 ***uszkodzoną*** [-1] = -1
	The number of positive words (2) **>** The number of negative words (1)
	The sentiment of the comment = positive

Sources: original research.

In the next step, each comment was examined to determine the number of words it contained with annotated basic emotions and fundamental human values. According to Table 2, the example comment consisted of 3 words expressing "gladness", 1 word indicating " enjoying something expected ", and 1 word conveying "trust".

[3] https://languagetool.org/pl/

Table 2.
The number of words with annotated basic emotions for sample comment

Comment Id	gladness	enjoying something expected	trust	disgust	fear	anger	surprise with something unpredictable	sadness
Ugw3f5BC2Nq6nDyXWA14AaABAg	1	1	1	0	0	0	0	0

Sources: original research.

3. Results

Using a ribbon chart shown in Figure 1, the number of retrieved videos has been presented with a division into videos that received comments and videos without comments. More detailed information on this subject has also been presented in Table 3. As can be seen, the number of movies began to significantly increase in the year 2021 (with 547 published videos), reaching its peak in the year 2022 (with 1805 videos). In the year 2023, the number of videos is smaller. However, it's important to remember that the movies were searched on March 22, 2023. Therefore, it's uncertain how many more videos will be published in the upcoming months of 2023. Attempting to estimate their number in the year 2023 is difficult because the month of publication is unknown (only the year was known).

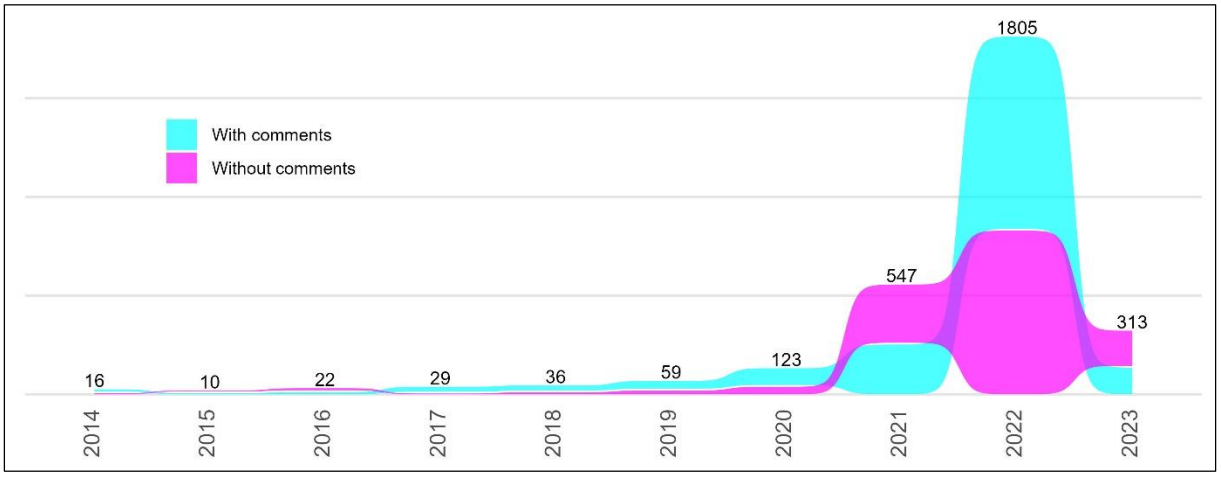

Figure 1. Distribution of the retrieved videos over the years. Note: videos for 2023 only gathered until March 22, 2023.

Source: original research.

Table 3.
Distribution of the retrieved videos over the years. Note: videos for 2023 only gathered until March 22, 2023

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
With comments	11 (69%)	5 (50%)	11 (50%)	25 (86%)	26 (72%)	40 (68%)	85 (69%)	252 (46%)	975 (54%)	135 (43%)	**1565** (53%)
Without comments	5 (31%)	5 (50%)	11 (50%)	4 (14%)	10 (28%)	19 (32%)	38 (31%)	295 (54%)	830 (46%)	178 (57%)	**1395** (47%)
Total	**16**	**10**	**22**	**29**	**36**	**59**	**123**	**547**	**1805**	**313**	**2960**

Sources: original research.

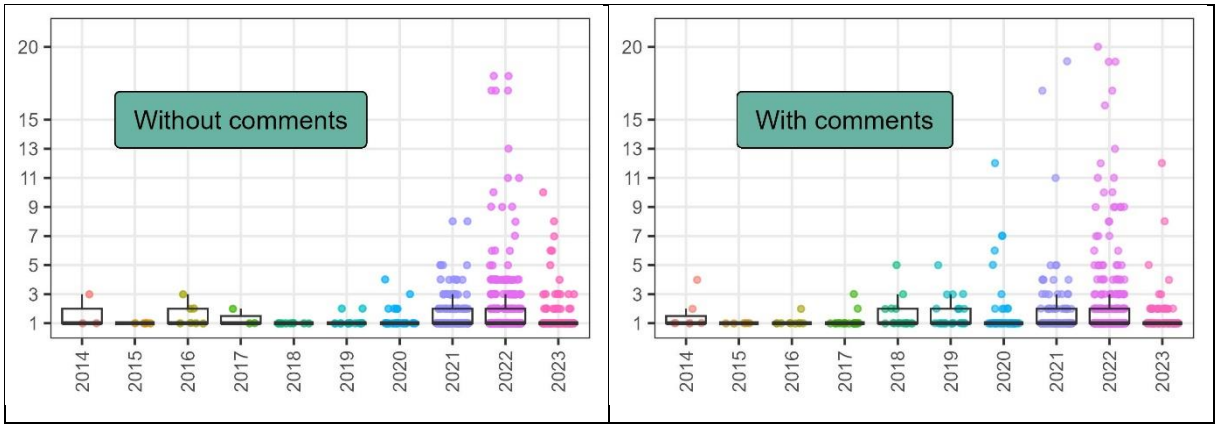

Figure 2. The number of videos published by users.

Sources: original research.

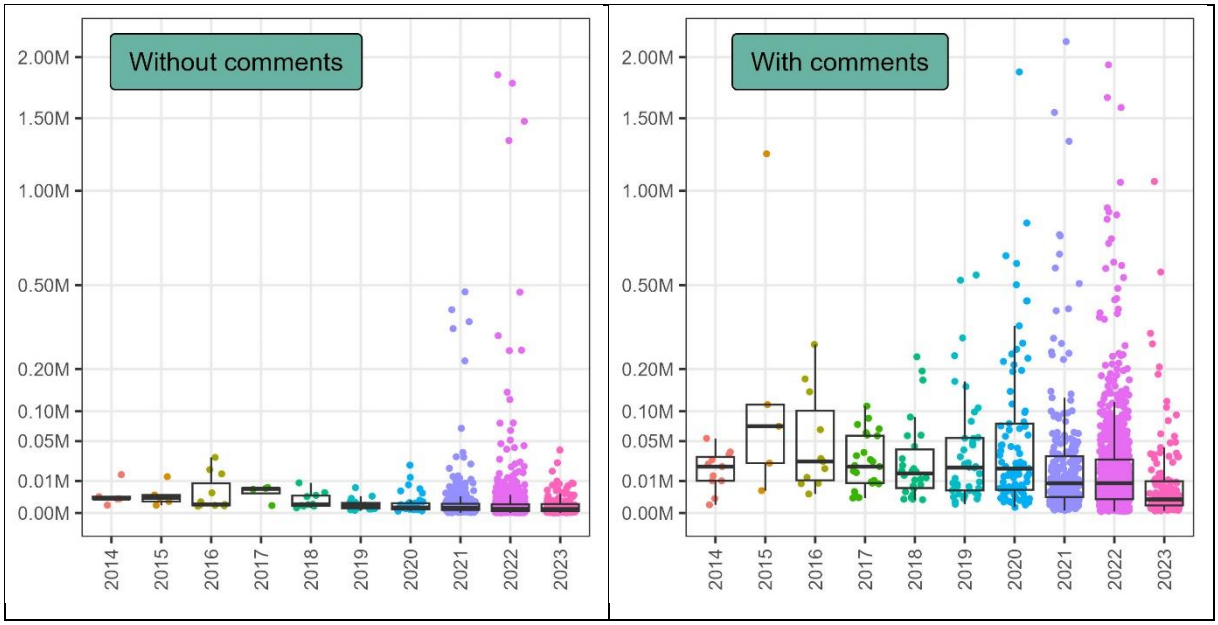

Figure 3. Views count of videos.

Sources: original research.

In Figure 3, the views count of videos is depicted, divided into videos with comments and without comments. To improve the clarity of the figure, a square root transformation was applied to the values presented on the y-axis. This has compressed high values while making low values more spread out. The successive values on the y-axis were determined by the author. Each point on the chart represents the number of views for a single video. The box plots

depicted in the figure provide insights into the distribution of view counts for the videos. It can be observed that videos with comments were more frequently viewed compared to those without comments. Longer box plots for videos with comments indicate that the view counts exhibited more diverse values. From the figure, it's also evident that one of the videos from 2021 has been viewed more than 2 million times.

Table 4 presents the number of comments obtained by videos categorized by years. It's evident, for instance, that the total number of comments received by videos from 2021 is 21,909. Some of these (12,991 comments) were replies to other comments. The presence of comments that are replies to other comments indicates an exchange of information between users.

Table 4.
Total number of comments by year

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Comments	3 (100%)	20 (50%)	52 (44%)	139 (55%)	184 (32%)	714 (40%)	4438 (39%)	8918 (41%)	40990 (47%)	6700 (52%)
Comments as replies	0 (0%)	20 (50%)	65 (56%)	113 (45%)	384 (68%)	1050 (60%)	7046 (61%)	12991 (59%)	46463 (53%)	6121 (48%)
Total	**3**	**40**	**117**	**252**	**568**	**1764**	**11484**	**21909**	**87453**	**12821**

Sources: original research.

The left side of Figure 4 depicts the number of comments received by videos in each year. Each video is represented as a single point on the chart. For example, one of the videos in 2016 received 51 comments. The box plots in the figures allow us to observe the distribution of the number of comments received. For instance, the third quartile for the year 2021 is 52, indicating that 75% of the films in that year received 52 or fewer comments. To improve the clarity of the figure, some numbers have been modified. If the number of comments exceeded 500, it was randomly replaced with a whole number ranging from 501 to 600. The number of videos with comments above 500 was 37 (for the year 2019: 660 comments; for the year 2020: 820, 959 and 2963 comments; for the year 2021: 508, 516, 548, 550, 587, 724, 958, 973, 1025 and 1206 comments; for the year 2022: 502, 517, 519, 530, 543, 546, 587, 620, 629, 678, 710, 888, 1106, 1155, 1370, 1408, 1533, 1788, 2370 and 2470 comments; for the year 2023: 689, 867, and 1264 comments). These numbers are now represented on the charts in the range of 500 to 600. The maximum number of comments received by one of the films in the year 2020, was 2963 comments. The right side of the figure represents the distribution of the number of comments received without categorization by year. In addition to the box plot, a density plot is also included. We can deduct from it, that the most frequently received number of comments is 1.

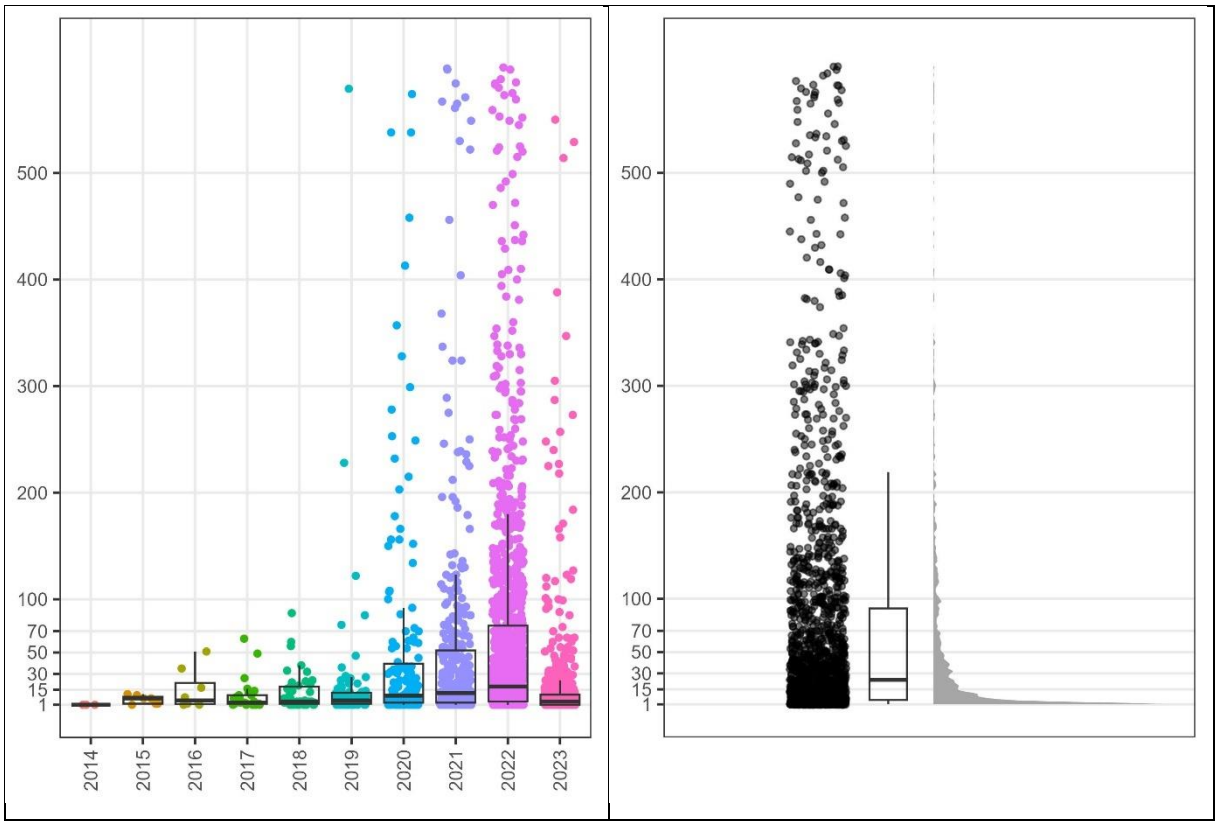

Figure 4. The number of comments received by videos.

Sources: original research.

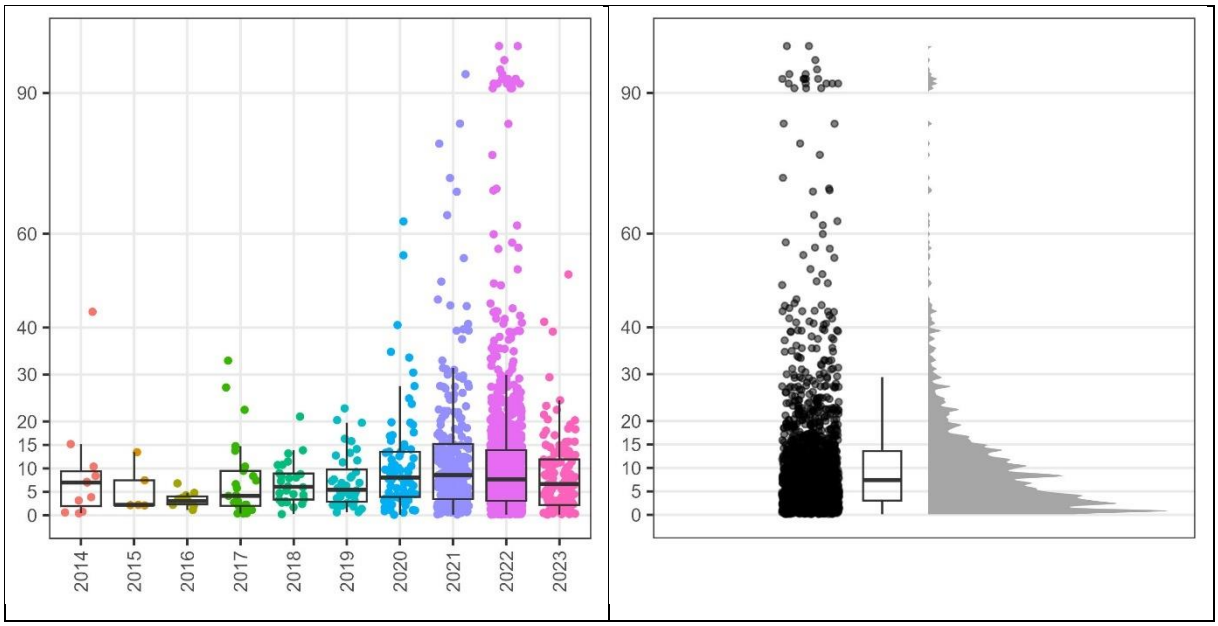

Figure 5. The duration of videos with comments in minutes.

Sources: original research.

Figure 5 presents in minutes the duration of films with comments. The left side represents the length of films divided by year. For example, the longest film from 2018 lasted approximately 21 minutes. The box plots shown in the figure allow us to see the distribution of film durations. For instance, the third quartile for the year 2021 is around 15.2 minutes, meaning that 75% of films in that year lasted 15.2 minutes or less. To enhance the readability of the

drawing, some durations have been modified. If the duration exceeded 90 minutes, it was randomly changed to a number between 90 and 100. The number of films with a duration over 90 minutes was 17 (the durations of these films were as follows: 91, 101, 104, 104, 109, 115, 130, 132, 142, 150, 153, 169, 185, 186, 187, 191, 202, 438, 607 minutes). These durations are represented on the plots in the range from 90 to 100. The maximum film duration was 607 minutes. The right side of the drawing presents the distribution of film durations without division by years. In addition to the box plot, a density plot is included. From it, we can infer that films most commonly lasted around 1 minute.

Figure 6 and Table 5 present information about the number of words in comments. Figure 6 illustrates the number of comments containing from 4 to 100 words. These comments constituted approximately 95% of all comments. The largest group consisted of comments composed of 5 words. The largest group of comments consisted of 5 words. There were 6191 such comments.

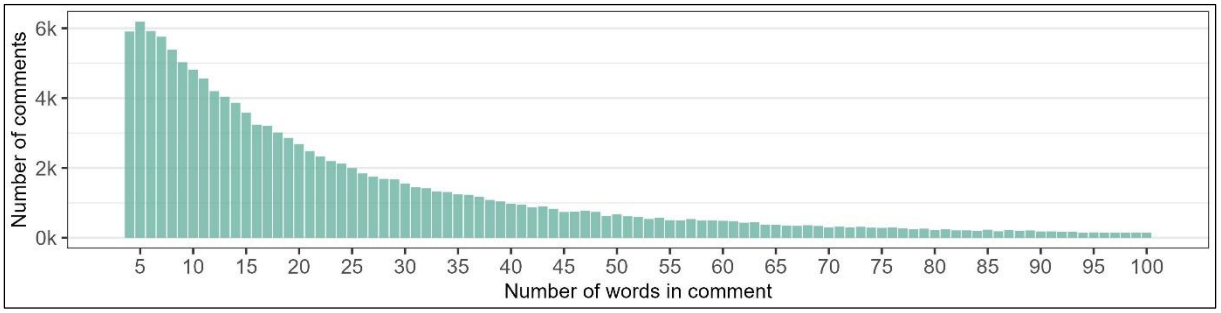

Figure 6. Number of words in comments.

Sources: original research.

Table 5.

Number of words in comments

Number of words in the comment	Number of comments
from 04 to 10	39016 (28,6%)
from 11 to 20	35268 (25,85%)
from 21 to 40	31900 (23,39%)
from 41 to 100	23467 (17,2%)
from 101 to 250	5996 (4,4%)
from 251 to 500	668 (0,49%)
from 501 to 1000	82 (0,06%)
from 1001 to 1388	14 (0,01%)
Total	**136411 (100%)**

Source: original research.

Table 5 shows the percentage distribution of comments based on the number of words. The largest group consisted of comments composed of 4 to 10 words, making up 28.6 per cent of all comments. 14 comments had between 1001 and 1388 words.

Figure 7 presents the relationship among three film parameters: duration (measured in minutes), number of received comments, and number of views. The relationship is visualized through three scatter plots. No adjustments were made to the outliers. The publication year of each film is represented by colour.

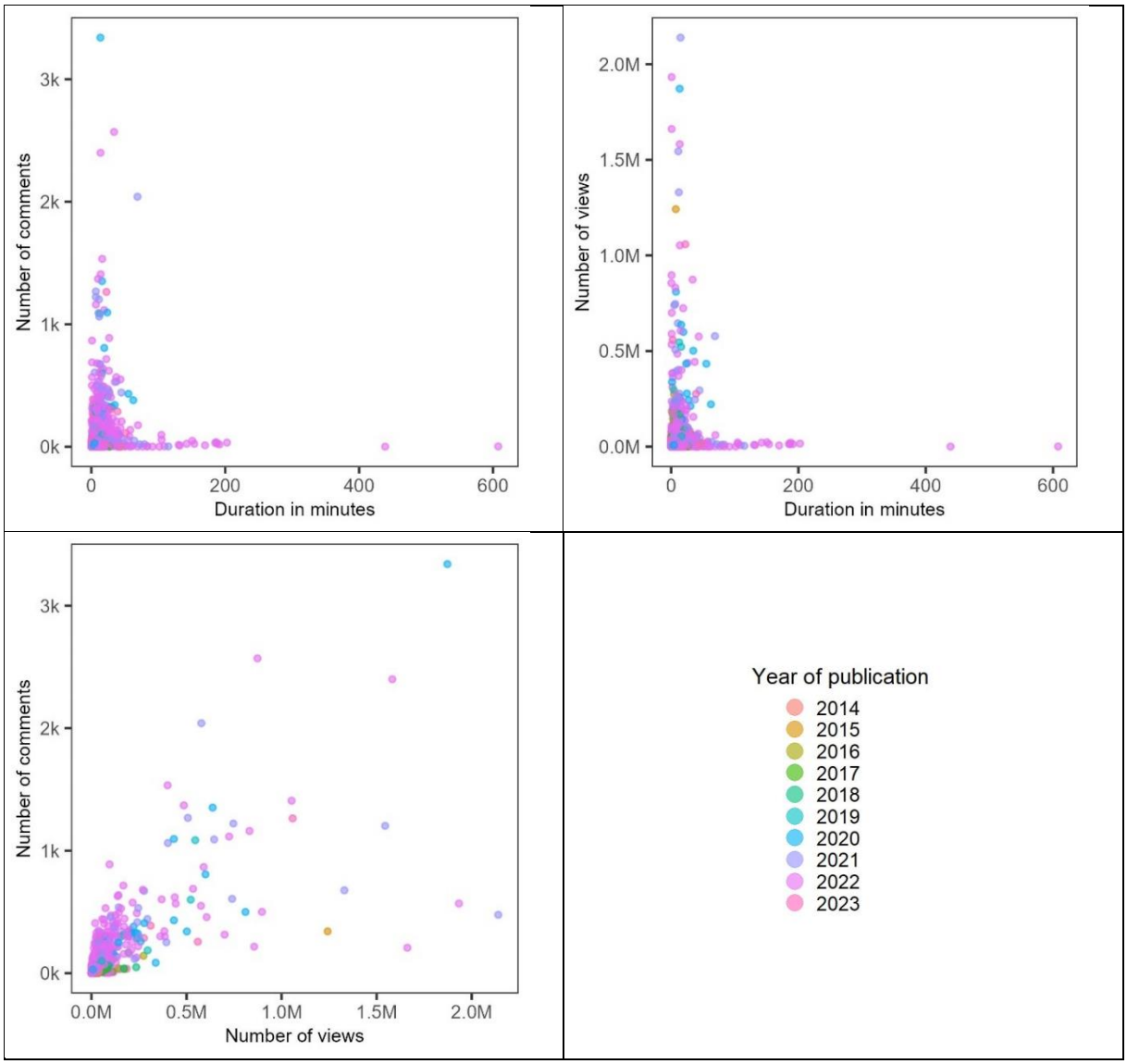

Figure 7. Relationship between duration, number of comments and views of films.

Sources: original research.

Figure 8 shows the percentage of positive, negative and neutral comments by year. We can see from it that in the year 2021 17.7% of comments had negative, 42.9% neutral and 39.4% positive sentiment. Starting in 2019, the number of positive comments decreased, while the number of neutral comments increased. The count of negative comments from 2017 to 2023 ranged between 17.7 and 21.3 per cent.

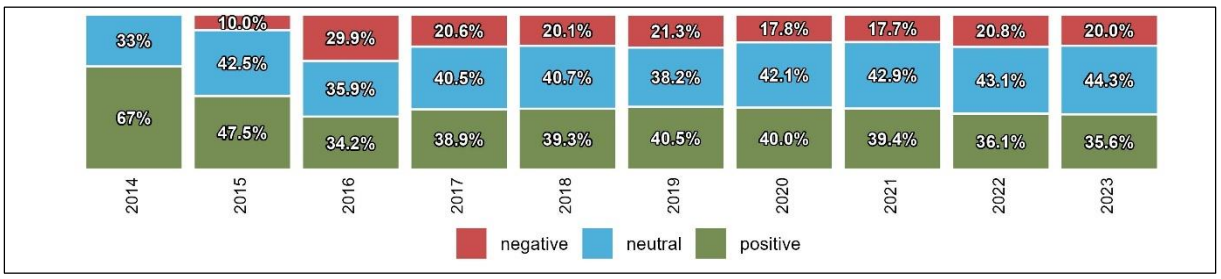

Figure 8. Percentage of positive, negative, and neutral comments.

Sources: original research.

Figure 9 presents the distribution of positive, negative, and neutral comments received by individual videos. The data is segmented by years. The distribution of comments is illustrated using box plots. Individual data points at a value of 100% for negative and neutral comments (received by videos for the year 2017) suggest that among these videos, some only received negative or neutral comments. The third quartile at approximately 25% for negative comments in 2022 indicates that 75% of the videos had a maximum of 25% negative comments.

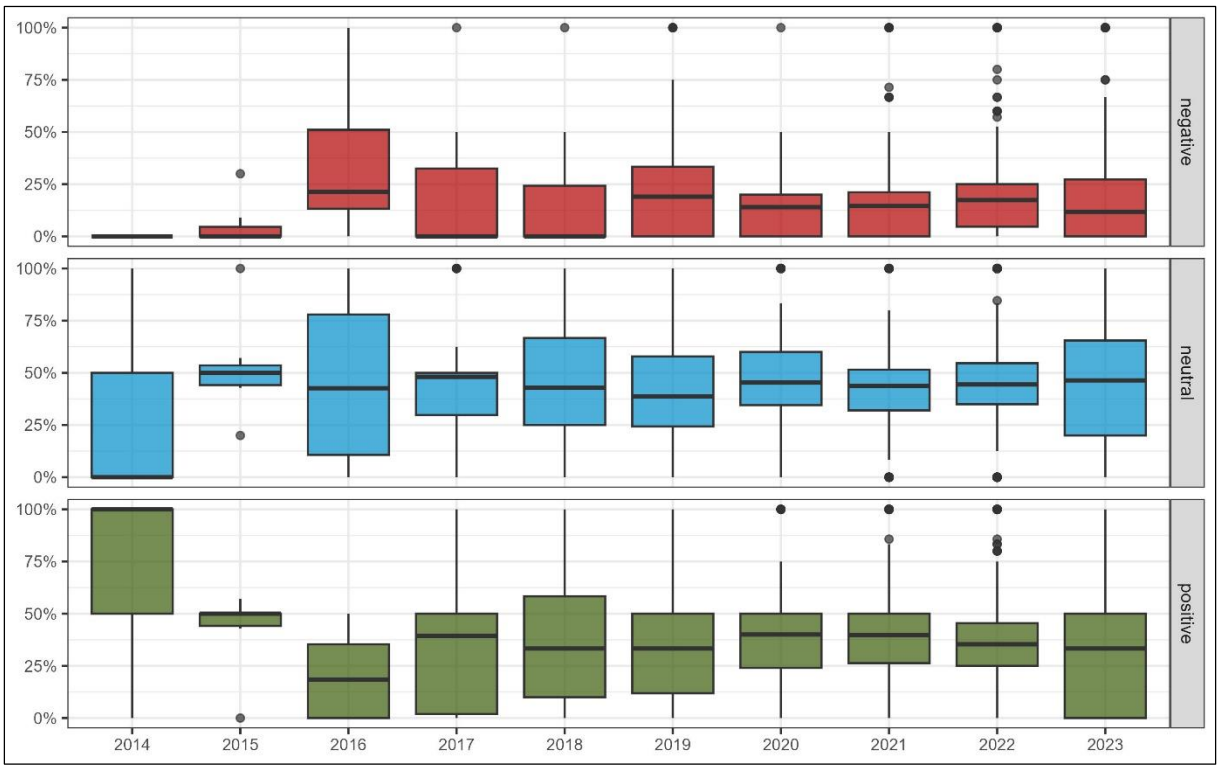

Figure 9. Distribution of the percentage of comments received by individual videos.

Sources: original research.

In Figure10, the annual distribution of words with annotated basic emotions is depicted. Positive emotions are denoted by the colour green, representing emotions like gladness, enjoying something expected, and trust. Negative emotions are indicated in red, representing emotions like disgust, fear, anger, surprise with something unpredictable, and sadness. It is evident that words associated with positive emotions had the following proportions in 2020: gladness accounted for 26.0%, enjoyment of something expected was 8.8%, and trust was 13.8%.

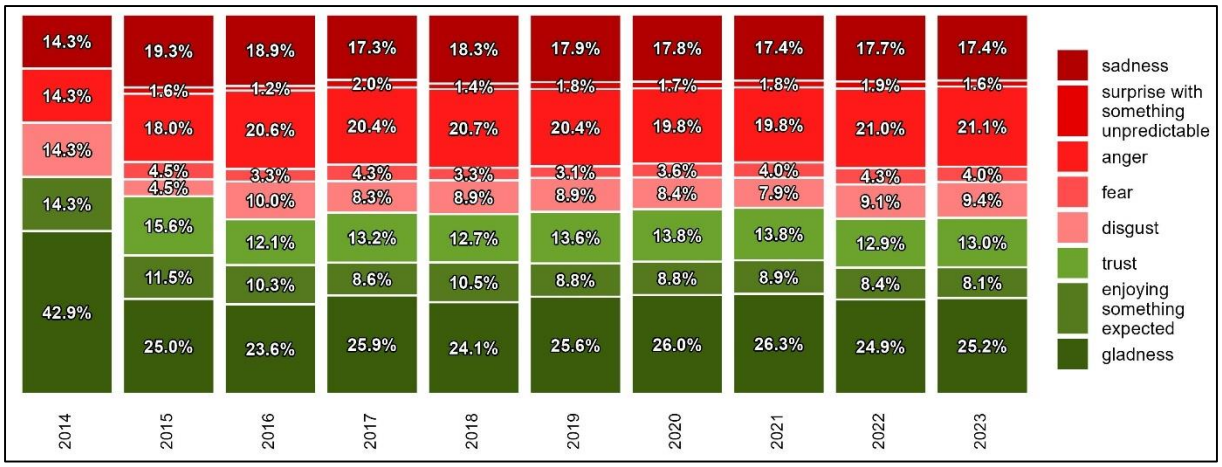

Figure 10. Percentage of words with annotated basic emotions by year.

Sources: original research.

Figure 11 presents the distribution of words with annotated fundamental human values. Positive human values are represented by the colour green (beauty, happiness, good of another man, utility, knowledge). Among the positive human values, not once did the "truth" occur. The negative human values are marked in red (unhappiness, error, harm, ignorance, uselessness, ugliness).

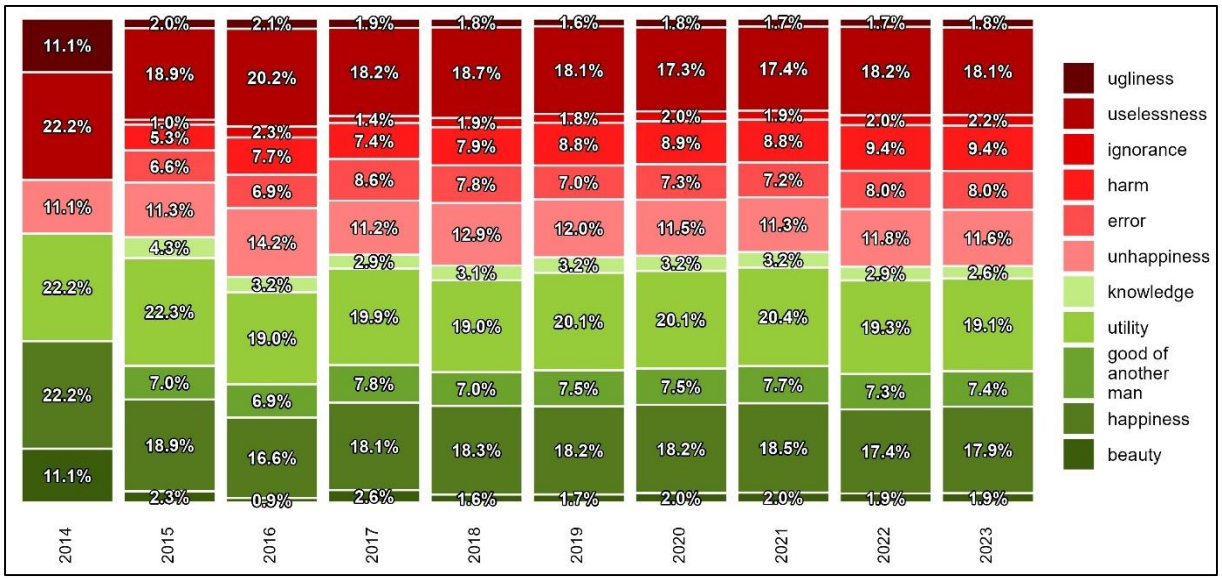

Figure 11. Percentage of words with annotated fundamental human values by year.

Sources: original research.

Figure 12 shows the most frequent words in comments. They are presented in the form of a word cloud. By analysing these words, it is possible to determine what the comments were about. The more frequently a word occurred in the comments, the bigger it is in the cloud.

Figure 12. Most frequently used words.

Sources: original research.

4. Conclusion

The analysis of data concerning videos related to photovoltaics (including the number of published videos, their view counts, the number of comments, and their sentiment) allowed for drawing the following conclusions:

- corresponding to an increasing number of videos and comments, it can be observed that interest in photovoltaics is continuously growing, particularly after the year 2018. Only 12 users (0.79 per cent) published between 17 and 112 videos;
- it's evident that there is variation in the views count of videos. Videos with comments were more frequently viewed;
- retrieved videos most commonly had one comment and a duration of one minute;
- in recent years, the number of comments with a neutral sentiment has been increasing, while the number of comments with a positive sentiment has been decreasing;
- the videos exhibit variation in the distribution of the number of positive, negative, and neutral comments, among them were those that received only negative, positive, or neutral comments;
- in 2022 and 2023, there was a slight increase in the percentage of words with annotated negative basic emotions and with annotated negative fundamental human values;
- analysing the most frequently used words, it can be assumed that comments addressed the following issues related to photovoltaics:
  - households as one of the main user groups of photovoltaics – words: “dom” (eng. house), “domowy” (eng. domestic), “budynek” (eng. building), “prosument” (eng. prosumer), “własny” (eng. own),
  - the main components of a photovoltaic installation – words: “słoneczny” (eng. solar), “ogniwo” (eng. cell), “panel”, “falownik” (eng. inverter), “moduł” (eng. module), “akumulator” (eng. battery), “bateria” (eng. battery), “magazyn” (eng. storage),
  - amount of energy produced by the photovoltaic installation over a given period – words and abbreviations like: “kwh” (kWh, eng. Kilowatt-hour), “kilowatogdzina” (eng. kilowatt-hour), “produkować” (eng. to produce), “wyprodukować” (eng. to produce), “produkcja” (eng. production), prąd (eng. “electricity”), “energia (eng. energy), “elektryczny” (eng. electric), “rocznie” (eng. annually), “roczny” (eng. annual), “rok” (eng. year), “miesiąc” (eng. month), “wynik” (“result”),
  - photovoltaic installation capacity and the factors affecting it - words: “moc” (eng. power), “kw” (eng. kW), “kilowatt” (eng. kilowatt), “k” (eng. kilo), “dach” (eng. roof), “kierunek” (eng. direction), “metr” (eng. metre), “powierzchnia” (eng. area),

- considering the purchase of an electric or plug-in hybrid car – words: “auto” (eng. car), “samochód” (eng. car), ładować (eng. to charge),
- complaints about intensive persuasion to buy photovoltaic – words: “dzwonić” (eng. to call), “telefon” (eng. phone), “sprzedać” (eng. to sell), “sprzedawać” (eng. to sell), “sprzedaż” (eng. sales),
- financial support for the purchase of photovoltaic – words: „dopłata” (eng. subsidy), “dotacja” (eng. subvention), “dostać” (eng. to get), “rząd” (eng. government), “przepis” (eng. law), “ustawa” (eng. law),
- the profitability of investment in photovoltaics – words: “koszt” (eng. cost), “kosztować” (eng. to cost), “opłacalny” (eng. worthwhile), “opłacać” (eng. to be worth), “zwrot” (eng. return on investment), “zwrócić” (eng. return on investment), “kredyt” (eng. credit),
- analysing the most frequently used words can determine that comments did not only concern photovoltaic but also in general electricity and heat production from various energy sources – “elektrownia” (eng. power plant), “eneriga” (eng. energy), “gaz” (eng. gas), “gazowy” (eng. gas), „prąd” (eng. electricity), “farma” (eng. farm), “węgiel” (eng. coal), “wiatrak” (eng. wind turbine), “wiatr” (eng. wind), “woda” (eng. water), “źródło” (eng. source), “grzać” (eng. to heat), “grzałka” (eng heater),“ciepło” (eng. heat), “pompa” (eng. pomp).

Analysis of data related to videos about photovoltaics on YouTube showed growing interest in this topic, especially after 2018, with an increase in the number of videos and comments. It is worth noting that videos with comments were viewed more often, and comments with neutral sentiment increased while those with positive sentiment decreased. Analysis of the most frequently used words shows a variety of topics, from household use to investment profitability. The conducted research confirms that comments on YouTube videos can be a source of data that can be used to understand people's thoughts, feelings, and opinions on "photovoltaics". It's worth noting that in this study, only the opinions of Polish-speaking YouTube users were identified.

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DISCOVERY SKILLS OF MICROENTREPRENEURS – DIAGNOSIS IN THE CONTEXT OF INNOVATION

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Purpose: The paper aims to assess the impact of discovery skills resulting from the concept of Innovator's DNA on the innovativeness of micro-entrepreneurs.
Design/methodology/approach: Based on the Innovator's DNA concept developed by Dyer et al. (Dyer et al., 2011) which indicates the five discovery skills of innovators, i.e. associating, questioning, observing, networking and experimenting, as well as on a broad understanding of innovation resulting from the 4th edition of the OSLO Manual (OECD and Eurostat, 2018), research was conducted into the impact of the discovery skills of micro-entrepreneurs on their innovativeness. The basis of the empirical analysis was a 2022 study of a randomly selected representative sample of 1,848 micro-entrepreneurs in Poland. Since innovation is a multidimensional phenomenon with many interrelations, a multidimensional probit model (MVP) was used for estimation.
Findings: The main conclusion is that in the case of microentrepreneurs, three out of five discovery skills positively affect all categories of implemented innovations. These discovery skills are associating, observing and networking.
Research limitations/implications: The research has some limitations. Firstly, the presented research only analyses the discovery skills indicated in the Innovator's DNA concept, ignoring delivery skills. Therefore, future research should also include these aspects. Secondly, the study is limited to Polish micro-entrepreneurs, which may affect the results, e.g., through cultural conditioning. Therefore, it would be worth geographically expanding future research.
Practical implications: Being aware that the indicated discovery skills can be further developed, it is worth using the indicated methods and techniques for their ongoing development. The results suggest that such activities should increase the probability of innovativeness among microentrepreneurs.
Originality/value: The originality of the paper's contribution is manifested in the following aspects: it explains the impact of microentrepreneurs' discovery skills on specific categories of introduced innovations, and covers a broad spectrum of microentrepreneurs' innovativeness - from product to business process innovations.

Keywords: microentrepreneurs, discovery skills, innovator's DNA, innovation.

Category of the paper: Research paper.

1. Introduction

The question of how to build innovation in contemporary economies, regions and enterprises is still highly topical. In each of these cases, it is always a question of human innovation as it is people who create the economy, region or enterprise. In other words, it is a question about what stimulates a person to be creative, i.e. to solve problems through an innovative juxtaposition of ideas or behaviours (Jirasek, Sudzina, 2020; Runco et al., 2001). This is where we find the very topical notion of so-called innovative capability. Most often, we refer to the innovative capability of an enterprise or economy, and understand it as the organisational capabilities for managing and creating innovation in the long-term (Smith et al., 2008), i.e. the ability to create new ideas or behaviours (Mendoza-Silva, 2020; Zastempowski, 2022). While the innovative capability of economies (Furman et al., 2002) and enterprises (Martínez-Román et al., 2011) is already well-researched, the innovative capability of individuals, based on management sciences, is still an interesting and relatively little-researched area. This is due to the interdisciplinarity of this issue. Its theoretical foundations can be found in many disciplines, including (a) psychology - Cattel's theory of personality (Cattell, 1950), McCrae and Costa's five-factor model (McCrae, Costa, 1987), and Guilford's theory of thinking (Guilford, 1967), (b) economics - Schumpeter's theory of creative destruction (Schumpeter, 1912, 1939), and Nelson and Winter's evolutionary theory (Nelson, Winter, 1982), (c) sociology – Weber's social action theory (Weber, 2009), and (d) management sciences – resource-based theory (Barney, 2001; Penrose, 1959; Teece et al., 1997) or the Innovator's DNA model (Dyer et al., 2008, 2011).

Therefore, it is worth asking whether it is possible to indicate certain characteristics and features that build the individual innovative capability of a human being. Looking at this question from the perspective of Schumpeter's theory, which places the individual figure of an entrepreneur at the centre of the economic development process (Schumpeter, 1912, 1939), it is worth specifying this further by enquiring about the features that create the innovative capability of a micro-entrepreneur. Innovative capability, , as Mendoza-Silva suggests, can be measured through various types of innovations (Mendoza-Silva, 2020) implemented by the micro-entrepreneur.

Based on two bibliometric databases - Scopus and Web of Science - a narrative systematic literature review indicates, among others, the role of the human personality (Ahmed, 1998; Ali, 2019; Rammstedt, John, 2007; Saatci, Ovaci, 2020; Soto, John, 2009), creativity (Altinay et al., 2022; Ferreira et al., 2018; Janssen, 2000; Jirasek, Sudzina, 2020) and divergent thinking (Basadur et al., 1999; Hausdorf et al., 2021; Runco et al., 2001) in developing innovative capabilities (or, more broadly, innovativeness). The concept that seems to connect all these threads is Dyer et al.'s idea of Innovator's DNA, emphasising the role of five discovery skills, i.e. associating, questioning, observing, networking and experimenting (Dyer et al., 2011).

Considering the above, the main purpose of this article is to assess the impact of discovery skills resulting from the concept of Innovator's DNA, on the innovativeness of micro-entrepreneurs. The basis of the empirical part is a 2022 study of a randomly selected representative sample of 1,848 micro-entrepreneurs in Poland.

The article has the following structure: part 2 presents the theoretical background, focusing on the innovation issues of micro-entrepreneurs in Poland and the Innovator's discovery skills. This section also indicates the proposed conceptual model. Part 3 discusses the empirical research, indicating the method of obtaining data and the characteristics of the research sample, the variables taken into account and the estimation model used. Part 4 presents the model estimation results, and Part 5 discusses these results. The article ends with the conclusions.

2. Theoretical framework

2.1. Innovativeness of Micro-enterprises in Poland

Although in 2021 micro-enterprises in Poland accounted for 97.2% of enterprises, created 29.5% of GDP and employed 4.34 million people (GUS, 2023), their innovativeness is omitted in most studies (e.g. in the study of innovative activity of Polish enterprises by the Central Statistical Office, or the Community Innovation Survey conducted by Eurostat). This situation is not characteristic only for Poland, because around the world, the innovativeness of micro-enterprises is treated as marginal in innovation research. This is particularly interesting in the context of the role that Schumpeter attributed to micro-entrepreneurs in economic development (Schumpeter, 1912, 1939). It is not without reason that Roper and Hewitt-Dundas pointed out that micro-enterprises are *a neglected part of Schumpeter's creative army* (Roper, Hewitt-Dundas, 2017, p. 559).

Research on the innovativeness of Polish enterprises (excluding micro-enterprises) shows that in 2019-2021, 22% of industrial enterprises and 19.7% of service enterprises introduced innovations (Statistical Office in Szczecin, 2022). These studies also show that with an increase in the size of the enterprise, its innovativeness increases.

So far, studies on the innovativeness of micro-enterprises in Poland are scarce. Żołnierski described the innovativeness of micro-enterprises in 2004, indicating that 33% of the companies studied declared that they had introduced innovations in the last two years (mainly organisational - 21%, product - 18.3% and process - 9%) (Żołnierski, 2005). Steinerowska-Streb, examining micro-enterprises in 2009, indicated that organisational innovations were introduced by 39.4% of respondents, product innovations by 57.5% and process innovations by 33.6% (Steinerowska-Streb, 2014). Rozkrut, describing the innovativeness of micro-enterprises in 2011-2013, indicated that based on a representative sample, product innovations were

introduced by 18.5% of micro-enterprises, process innovations – by 19.9%, organisational innovations – by 20.8% and marketing innovations – by 10.4% (Rozkrut, 2013). Research conducted in 2019 by the Polish Agency for Enterprise Development (PAED) showed that 29.2% of micro-enterprises undertook innovative activities (PARP, 2020). In turn, research conducted by Zastempowski on a representative sample of Kuyavian-Pomeranian micro-enterprises showed that in 2016-2018, product innovations were introduced by 17% of respondents and process innovations by 15.7% (Zastempowski, 2022; Zastempowski et al., 2020).

As can be seen, previous research shows different percentages of innovative micro-enterprises. This may be due to several issues, including the different periods of the research, the representativeness of the researched samples, the territorial scope of the research and the methodology of defining innovations (e.g., according to the 3rd or 4th edition of the Oslo Manual) (OECD & Eurostat, 2018, 2005). It also suggests the need for further research on the innovativeness of micro-enterprises.

2.2. Discovery skills

Discovery skills are a key element of the Innovator's DNA concept. Its creators, Dyer et al., indicate that discovery skills can be developed (Dyer et al., 2011, p. 21). This assumption is based on previous research on pairs of identical and fraternal twins, showing that these skills are not genetic traits endowed at birth (McCartney et al., 1990; Reznikoff et al., 1973). Therefore, if innovators can be made and not just born, Dyer et al. asked what determines the fact that some people have great new ideas. In a study conducted on a group of five hundred innovators compared to nearly five thousand managers, Dyer et al. identified five key discovery skills of disruptive innovators i.e., associating, questioning, observing, networking and experimenting (Dyer et al., 2011, pp. 22-25).

Disruptive innovators rely primarily on a cognitive skill that Dyer et al. called associational thinking (association). This is a process that occurs when the brain tries to synthesise and make sense of new information. It involves combining seemingly unrelated questions, problems or ideas, usually at the crossroads of different disciplines, which helps innovators discover completely new directions of action (Dyer et al., 2011, pp. 22-23; 41-65). From the perspective of the innovativeness of micro-entrepreneurs, this leads to the first hypothesis:

H_1: *Associating, as a discovery skill, positively affects micro-entrepreneurs' innovativeness.*

As indicated by Dyer et al., the other four discovery skills imply associational thinking because they help innovators expand the range of ideas from which innovative ideas are born. The first is questioning. Innovators are people who passionately look for solutions, asking both "what if" questions and questioning the status quo. Such questions lead innovators to new insights, connections, opportunities and directions. Interestingly, research by Dyer et al. showed that such questions are at least as highly valued as good answers (Dyer et al., 2011, pp. 23, 67-90). Therefore, the following hypothesis was proposed:

H_2: *Questioning, as a discovery skill, positively affects micro-entrepreneurs' innovativeness.*

Innovators are also keen observers. They look carefully at the world around them, especially customers, products, services, technologies and companies. Such observation allows them to gain an accurate view of the situation, and stimulates the emergence of new methods of operation. It is a kind of catalyst for new thoughts and connections (Dyer et al., 2011, pp. 23-24, 91-114). Consequently, the next hypothesis was formulated:

H_3: *Observing, as a discovery skill, positively affects micro-entrepreneurs' innovativeness.*

As the research by Dyer et al. suggests, innovators spend a lot of time and energy searching for and testing ideas among a wide range of people from different backgrounds and often with different views of the world. Instead of simply doing social networking or networking for resources, innovators actively seek out new ideas by talking to people who may hold radically different points of view (Dyer et al., 2011, pp. 24, 115-135). The above stimulated another hypothesis:

H_4: *Networking, as a discovery skill, positively affects micro-entrepreneurs' innovativeness.*

It is also worth pointing out that innovators constantly try new experiences and try testing new ideas. They tirelessly, mentally and empirically explore the surrounding world, verifying various hypotheses. They visit new places, try new things, search for new information and experiment in order to learn something new (Dyer et al., 2011, pp. 24, 136-160). Therefore, the last hypothesis was proposed:

H_5: *Experimenting, as a discovery skill, positively affects micro-entrepreneurs' innovativeness.*

Consequently, the following conceptual model was formulated (Figure 1).

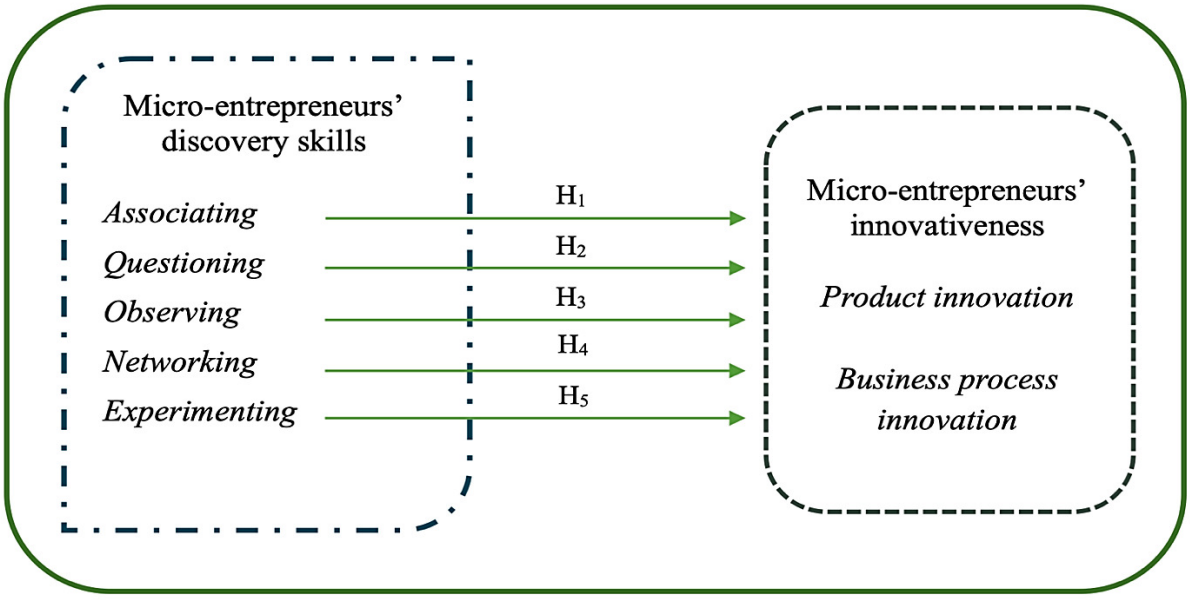

Figure 1. Conceptual model.

Source: own elaboration.

3. Materials and Method

3.1. Data collection

A representative research sample of micro-enterprises (of up to 9 employees) was drawn by the Mathematical Statistics Center of the Statistical Office in Łódź (Poland). The sampling frame was based on active micro-enterprises registered in NOREE[1]. According to data from 2022, this included 4,497,099 micro-enterprises. The sample selection was stratified according to the following criteria: PKD section[2], voivodship and legal form. The original sample consisted of 1850 records. In addition, a reserve sample was drawn (of the same cross-section), corresponding to 19 times the size of the original sample. The data was obtained between August and October 2022, and the final data set covered 1,848 micro-enterprises. This allows conclusions to be drawn at a 99% confidence level with a +/- 3% maximum error. The structure of the sample in terms of the type of activity is presented in Table 1.

Table 1.
Structure of the survey sample of micro-enterprises

Activities	**Share (%)**
A - agriculture, forestry, hunting and fishing	1.73
B - mining and quarrying	1.84
C - manufacturing	7.03
D - electricity, gas, steam, hot water and air conditioning	1.57
E - water supply; sewage and waste management and remediation activities	2.11
F - building construction	13.64
G - wholesale and retail trade; repair of motor vehicles, excluding motorcycles	19.32
H - transport and storage	5.95
I - activities related to accommodation and catering services	3.08
J - information and communication	5.84
K - finance and insurance	2.87
L - activities related to real estate	2.71
M - professional, scientific and technical activity	11.47
N - administration and support activities	3.46
P - education	3.35
Q - health care and social welfare	7.31
R - activities related to culture, entertainment and recreation	1.95
S - Other service activities	4.76

Note. Activities – A section of the Code List of Classification of Business Activities in Poland.
Source: own elaboration.

[1] NOREE - National Official Register of Economic Entities.
[2] PKD - Code List of Classification of Business Activities in Poland.

3.2. Variables

3.2.1. Dependent variable

The dependent variable was the innovativeness of micro-entrepreneurs. Its measurement was based on the guidelines resulting from the fourth edition of the OSLO Manual that divides innovations into two types - product innovation and business process innovation (OECD & Eurostat, 2018).

The micro-entrepreneurs were asked whether, in the last three years (2019-2021), they had introduced a product innovation and/or business process innovation. Taking into account the possible categories of innovations within each type, the following dummy variables were created referring to the introduction of new or improved products or processes (OECD & Eurostat, 2018, pp. 70-74):

- within product innovations:
  - y_1 – goods,
  - y_2 – services,
- within business process innovations:
  - y_3 – methods for producing goods or providing services (including methods for developing goods or services),
  - y_4 – logistics, delivery or distribution methods,
  - y_5 – methods for information processing or communication,
  - y_6 – methods for accounting or other administrative operations,
  - y_7 – business practices for organising procedures or external relations,
  - y_8 – methods of organising work responsibility, decision making or human resource management,
  - y_9 – marketing methods for promotion, packaging, pricing, product placement or after-sales services.

3.2.2. Independent variables

The independent variables describing the discovery skills of micro-entrepreneurs were constructed using the Innovator's DNA concept, based on the odd-numbered statements in the 20-item "Delivery and Discovery Skills Quiz" presented by Dyer et al. (in the quiz, the even-numbered statements referred to performance skills, which were not tested) (Dyer et al., 2011). The micro-entrepreneurs answered on a 5-point Likert scale from 1 - "I strongly disagree" to 5 - "I strongly agree". A list of these is presented in the Appendix.

Consequently, the different types of discovery skills were coded as follows:

- x_1 – associating (statements 7 and 15),
- x_2 – questioning (statements 17 and 3),
- x_3 – observing (statements 5 and 19),
- x_4 – networking (statements 9 and 1),
- x_5 – experimenting (statements 11 and 13).

Additionally, as recommended in the literature (Guan et al., 2006; Martinez-Roman, Romero, 2017), the following two control variables were used:

- x_6 – enterprise age – micro-enterprise age measured by the number of years since the business was founded – this variable was numerical, and a logarithm was applied to the calculations,
- x_7 – enterprise size – micro-enterprise size measured by the number of employees (numerical).

The descriptive statistics of all the variables are displayed in Table 2.

Table 2.
Descriptive statistics of variables

Variable	% - yes	Mean	S.E.	M	D	S.D.	SD^2	Min.	Max.
y_1	4.654	0.047	0.005	0.000	0.000	0.211	0.044	0.000	1.000
y_2	8.496	0.085	0.006	0.000	0.000	0.279	0.078	0.000	1.000
y_3	10.335	0.103	0.007	0.000	0.000	0.305	0.093	0.000	1.000
y_4	5.303	0.053	0.005	0.000	0.000	0.224	0.050	0.000	1.000
y_5	10.335	0.103	0.007	0.000	0.000	0.305	0.093	0.000	1.000
y_6	8.820	0.088	0.007	0.000	0.000	0.284	0.080	0.000	1.000
y_7	9.416	0.094	0.007	0.000	0.000	0.292	0.085	0.000	1.000
y_8	9.037	0.090	0.007	0.000	0.000	0.287	0.082	0.000	1.000
y_9	8.063	0.081	0.006	0.000	0.000	0.272	0.074	0.000	1.000
x_1	-	3.404	0.018	3.500	3.000	0.7774	0,604	1.000	5.000
x_2	-	3.369	0.024	3.000	4.000	1.0682	1.141	1.000	5.000
x_3	-	3.490	0.021	3.500	4.000	0.9240	0.854	1.000	5.000
x_4	-	3.160	0.018	3.000	3.000	0.7896	0.623	1.000	5.000
x_5	-	3.631	0.024	4.000	4.000	1.0349	1.071	1.000	5.000
x_6	-	0.969	0.008	1.000	0.602	0.354	0.125	0.000	2.021
x_7	-	2.692	0.068	2.000	0.000	2.937	8.628	0.000	9.000

Source: own elaboration.

3.3. Method

Innovation is a multi-dimensional phenomenon in which many mutual relations take place. Previous research has shown that introducing one type of innovation leads to other types. In other words, they are not independent of each other (Zastempowski, 2023). Consequently, a multivariate probit model (MVP) was used considering the correlation of error terms (Maietta, 2015; Wainaina et al., 2016). Its specificity lies in the fact that it examines the influence of independent variables on dependent variables (each type of introduced innovation) while allowing for the correlation of unobserved and immeasurable factors (error terms).

The MVP model used consists of nine binary choice equations concerning the introduction of various categories of product innovations (y_1 and y_2) and business process innovations (y_3 - y_9). The MVP model can be written as (Wainaina et al., 2016):

$$y_{ijm}^{*} = X_{ijm}'\beta_m + \varepsilon_{ijm}\ m = 1, 2 \ldots 9 \tag{1}$$

$$y_{ijm} = \begin{pmatrix} 1\ if\ y_{ijm}^{*}>0 \\ 0\ otherwise \end{pmatrix}, \tag{2}$$

where:

y_{ijm}^{*} is a latent variable that captures the degree to which a micro-entrepreneur treats innovation m as worth introducing,

X_{ijm}^{*} is a latent variable that is a linear combination of discovery skills,

ε_{ijm} is the unobserved characteristics captured by the stochastic error term,

β_m – is the estimated vector of the parameters. Considering the latent nature of y_{ijm}^{*}, the estimation is based on the observable binary y_{ijm}, indicating whether a micro-entrepreneur introduced a particular innovation in the previous three years (2019-2021).

Estimating all models was based on the simulated maximum likelihood method (Cappellari, Jenkins, 2003) using STATA.16.1 software.

4. Results

In the first step, the Cronbach's alpha, Kaiser-Meyer-Olkin and Bartlett tests were conducted. The results presented in Table 3 confirm the reliability of the measurement scale. The test values obtained are acceptable for this type of analysis (Hair et al., 2010).

Table 3.
Properties of the measurement scale

Variable	Cronbach's alpha	Kaiser-Meyer-Olkin	Bartlett
Discovery skills	0.727	0.573	2098.719*

Note. * p-Value ≤ 0.01.

Source: own elaboration.

The correlation analysis, the results of which are presented in Table 4, constituted the second stage. Its analysis allows for the formulation of a few conclusions. Firstly, statistically significant correlations between the analysed categories of innovation were observed. They are all positive, and their values range from 0.239 to 0.751. This gives a strong argument for using the chosen MVP estimation method. Secondly, there is a correlation between the independent and dependent variables, but their values (below 0.227) indicate a very poor relationship. Thirdly, there are several significant correlations between the independent variables. However, their value is always below 0.435, and the variance inflation factors (VIF) are below 10 (the highest observed VIF is 2.11), indicating that collinearity is not an issue.

In the next step, the MVP models were estimated (Table 5). It is worth noting that the results of the correlation between error terms showed in several cases that it is strong (greater than 0.7). In three cases, namely rho32, i.e. between innovations in the field of methods for producing goods or providing services and innovations in services, rho93 - innovation in marketing methods for promotion, packaging, pricing, product placement or after-sales services

and in methods for producing goods or providing services, and rho87 - innovation in methods of organising work responsibility, decision making or human resource management and in business practices for organising procedures or external relations, the correlation coefficients even exceeded 0.8. Other strong correlations were also observed for rho92, rho43, rho53, rho83, rho94, rho65, rho75, rho85, rho95, rho76, rho86 and rho98. These results clearly confirm the legitimacy of using the MVP method.

Table 4.
Correlation matrix

	y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	y_9
y_1	1.000								
y_2	0.532**	1.000							
y_3	0.431**	0.751**	1.000						
y_4	0.429**	0.448**	0.523**	1.000					
y_5	0.313**	0.438**	0.550**	0.491**	1.000				
y_6	0.239**	0.295**	0.415**	0.412**	0.647**	1.000			
y_7	0.316**	0.354**	0.493**	0.420**	0.548**	0.514**	1.000		
y_8	0.271**	0.344**	0.470**	0.439**	0.556**	0.528**	0.687**	1.000	
y_9	0.454**	0.580**	0.631**	0.506**	0.526**	0.405**	0.463**	0.406**	1.000
x_1	0.137**	0.178**	0.197**	0.129**	0.227**	0.191**	0.231**	0.257**	0.144**
x_2	0.039	-0,012	-0,020	0,031	-0,034	-0.045*	-0,014	-0.064**	0,027
x_3	0.106**	0.171**	0.166**	0.131**	0.204**	0.170**	0.203**	0.224**	0.145**
x_4	0.112**	0.166**	0.176**	0.134**	0.196**	0.174**	0.206**	0.207**	0.160**
x_5	0.041*	0.084**	0.106**	0.060**	0.141**	0.106**	0.154**	0.179**	0.043*
x_6	0.032	0.030	0.020	0.021	-0.007	-0.003	0.003	-0.005	0.028
x_7	0.075**	-0.022	-0.024	0.097**	-0.008	0.018	0.015	0.015	0.044*

	x_1	x_2	x_3	x_4	x_5	x_6	x_7
x_1	1.000						
x_2	0.096**	1.000					
x_3	0.378**	-0,015	1.000				
x_4	0.367**	-0.049**	0.394**	1.000			
x_5	0.435**	0.318**	0.110**	0,033	1.000		
x_6	-0.019	-0.029	-0.039*	-0.015	-0.029	1.000	
x_7	0.070**	0.065**	0.051**	0.044*	-0.059**	-0.031	1.000

Note. * p-Value ≤ 0.05, ** p-Value ≤ 0.01.

Source: own elaboration.

Only three out of the five discovery skills are significant determinants explaining all categories of micro-entrepreneurs' innovations (y_1-y_9). These discovery skills are associating (x_1), observing (x_3) and networking (x_4). The other skills affect only some categories of the innovations, with questioning (x_2) for 6 (negative) and experimenting (x_5) for 3.

An interesting result was also observed in terms of the control variables. In many earlier studies, their impact on innovation was confirmed (Guan et al., 2006; Martinez-Roman, Romero, 2017). Our results for micro-entrepreneurs showed that both the enterprise age and size have a small impact. The age of micro-enterprises (x_6) has a positive effect only on innovations in marketing methods for promotion, packaging, pricing, product placement or after-sales services (y_9), while the size of micro-enterprises (x_7) has an effect on innovations in goods (y_1) and in logistics, delivery or distribution methods (y_4).

5. Discussion

When assessing the level of innovativeness of Polish micro-entrepreneurs, it should be emphasised that it is not as high as suggested by previous research, e.g. by PAED – 29.2% (PARP, 2020). The results presented in Table 2 and Figure 2 show that, on average, 8.3% of micro-enterprises introduced innovations in 2019-2021. The smallest share was for goods innovations (4.7%), and the largest, 10.3% each, for methods for producing goods or providing services (including methods for developing goods or services) and methods for information processing or communication.

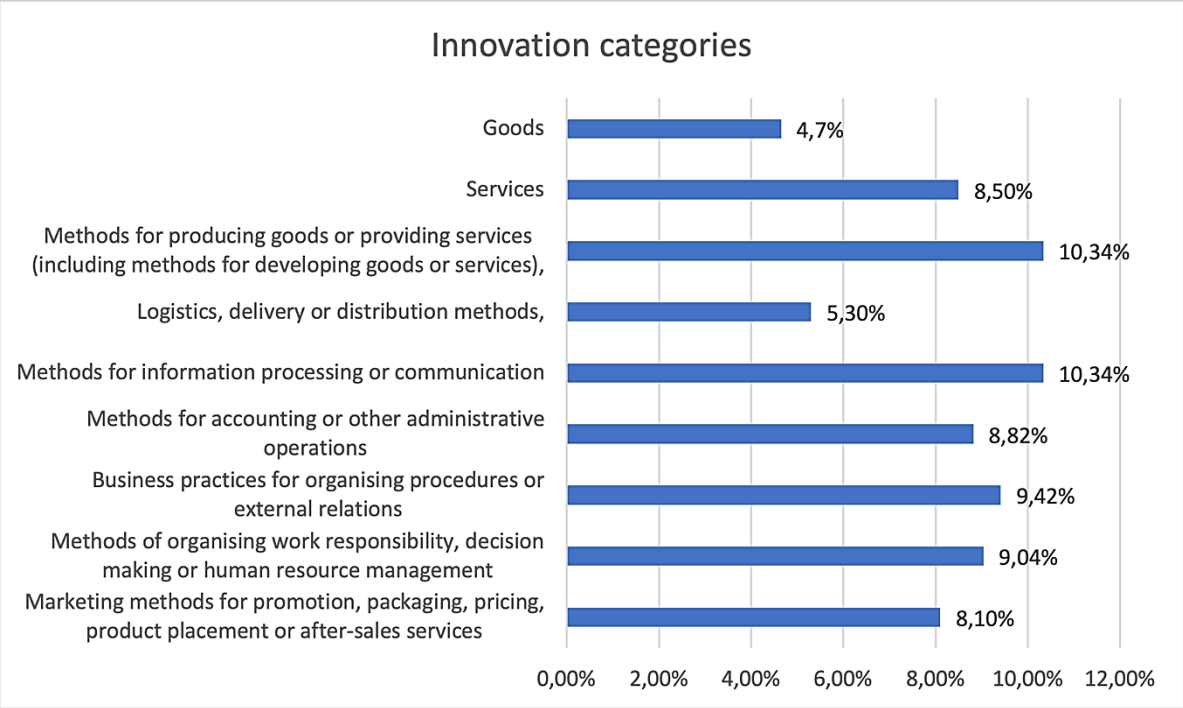

Figure 2. Micro-entrepreneurs' innovativeness.

Source: own elaboration.

Referring to the assessment of the impact of discovery skills resulting from the Innovator's DNA concept on the innovativeness of micro-entrepreneurs, it can be stated that three of them, namely associating, observing and networking, have a positive impact on all categories of innovation. This means that only in the case of hypotheses H_1, H_3 and H_4 are there no reasons to reject them ($p \leq 0.05$). In the case of questioning and experimenting, there are reasons to reject hypotheses H_2 and H_5.

Table 5.

Multivariate probit model results

	Model 1 (y_1)		**Model 2 (y_2)**		**Model 3 (y_3)**		**Model 4 (y_4)**		**Model 5 (y_5)**		**Model 6 (y_6)**		**Model 7 (y_7)**		**Model 8 (y_8)**		**Model 9 (y_9)**	
	β	**dF/dx**	***β***	**dF/dx**	***β***	**dF/dx**	***β***	**dF/dx**	***β***	**dF/dx**	***β***	**dF/dx**	***β***	**dF/dx**	***β***	**dF/dx**	***β***	**dF/dx**
x_1	0.399**	0.024**	0.297**	0.031**	0.288**	0.036**	0.169*	0.011*	0.293**	0.035**	0.255**	0.033**	0.291**	0.033**	0.319**	0.029**	0.252**	0.028**
x_2	0.040	0.005	-0.110*	-0.008*	-0.139**	-0.014**	-0.064	0.000	-0.188**	-0.019**	-0.179**	-0.018**	-0.172**	-0.013**	-0.310**	-0.020**	-0.009	0.005
x_3	0.094*	0.005*	0.189**	0.022**	0.140**	0.020**	0.206**	0.011**	0.222**	0.027**	0.190**	0.020**	0.199**	0.020**	0.258**	0.020**	0.190**	0.016**
x_4	0.155*	0.011*	0.228**	0.025**	0.233**	0.033**	0.295**	0.019**	0.274**	0.030**	0.262**	0.027**	0.317**	0.031**	0.328**	0.024**	0.275**	0.029**
x_5	-0.129	-0.006	0.015	0.005	0.091	0.015	0.040	0.003	0.175**	0.022**	0.098	0.012	0.186**	0.020**	0.281**	0.023**	-0.082	-0.007
x_6	0.216	0.020	0.228	0.029	0.099	0.021	0.178	0.018	-0.005	0.000	0.055	-0.001	0.045	0.003	0.017	-0.003	0.263*	0.030*
x_7	0.039*	0.004*	-0.006	0.001	-0.006	0.002	0.035*	0.005*	0.001	0.002	-0.001	0.002	0.004	0.003	0.017	0.003	0.009	0.004
_cons	-4.009**		-3.813**		-3.555**		-4.206**		-4.130**		-3.665**		-4.382**		-4.754**		-3.857**	
Log likelihood			-2774.289															
Wald chi^2 (63)			474.44															
Prob > chi^2			0.0000															

rho	**rho21**	**rho31**	**rho41**	**rho51**	**rho61**	**rho71**	**rho81**	**rho91**	**rho32**	**rho42**	**rho52**	**rho62**
Coef.	0.573**	0.534**	0.539**	0.434**	0.319**	0.414**	0.390**	0.487**	0.818**	0.633**	0.591**	0.456**
Std. Err.	0.043	0.042	0.046	0.047	0.053	0.045	0.048	0.045	0.022	0.039	0.036	0.043
rho	**rho72**	**rho82**	**rho92**	**rho43**	**rho53**	**rho63**	**rho73**	**rho83**	**rho93**	**rho54**	**rho64**	**rho74**
Coef.	0.504**	0.501**	0.706**	0.763**	0.721**	0.605**	0.699**	0.707**	0.804**	0.697**	0.620**	0.664**
Std. Err.	0.042	0.041	0.031	0.032	0.030	0.039	0.032	0.030	0.025	0.036	0.040	0.038
rho	**rho84**	**rho94**	**rho65**	**rho75**	**rho85**	**rho95**	**rho76**	**rho86**	**rho96**	**rho87**	**rho97**	**rho98**
Coef.	0.691**	0.735**	0.771**	0.740**	0.742**	0.755**	0.713**	0.742**	0.646**	0.845**	0.694**	0.704**
Std. Err.	0.036	0.035	0.025	0.030	0.030	0.030	0.032	0.031	0.039	0.022	0.036	0.034

Notes: * p-Value ≤ 0.05, ** p-Value ≤ 0.01. N = 1848; Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho61 = rho71 = rho81 = rho91 = rho32 = rho42 = rho52 = rho62 = rho72 = rho82 = rho92 = rho43 = rho53 = rho63 = rho73 = rho83 = rho93 = rho54 = rho64 = rho74 = rho84 = rho94 = rho65 = rho 75 = rho85 = rho95 = rho76 = rho86 = rho96 = rho87 = rho97 = rho98 = 0: chi^2 (36) = 2604.77, Prob chi^2 = 0.0000.

Associating - the first of the discovery skills - involves connecting seemingly unrelated ideas, concepts or experiences to generate innovative insights (Dyer et al., 2011, pp. 22-23). Micro-entrepreneurs who excel in associating can draw from diverse sources of inspiration, and combine them in novel ways. This skill helps them identify unique market opportunities, develop creative solutions, and differentiate their offerings from competitors. Our research clearly confirms this. The higher micro-entrepreneurs assess this feature in themselves, the more likely they are to implement all types of innovations (the probability is greater, between 0.011 and 0.036). Therefore, it is worth encouraging micro-entrepreneurs to develop their associating skills. This can be stimulated by various methods, e.g., by forcing new associations (combining things that do not naturally connect), trying to empathise with the role of another company's employees, creating metaphors and using the SCAMPER method (Michalko, 1991).

Observing - the second of the discovery skills that affect the implementation of all categories of innovations by micro-entrepreneurs - involves keenly observing the world around, paying attention to details, and recognising patterns (Dyer et al., 2011, pp. 22-23). Micro-entrepreneurs who are adept at observing can identify emerging trends, customer behaviours and changing preferences. As our research shows, these insights enable them to create products and services that align with evolving market demands. The greater the observing skill, the higher the probability of implementing all innovations (from 0.005 to 0.027). Among the possible methods of developing the ability to observe, the following can be indicated: regular observation of customers (e.g., how they use the product or service offered by a micro-entrepreneur), observation of the activities of a specific company (e.g. an industry leader), observation of everything that is popular at a given moment, and the use of all the senses for observation.

Networking - the last of the discovery skills that affect the innovativeness of Polish micro-entrepreneurs - involves building a diverse network of people with different backgrounds, expertise and perspectives (Dyer et al., 2011, p. 24) who can expose micro-entrepreneurs to a wide range of ideas and insights. Effective networking helps with access to information from various industries and disciplines, leading to cross-pollination of ideas and innovative solutions. If micro-entrepreneurs assess this skill better, the probability of implementing innovations increases from 0.011 to 0.033. Methods that can serve the development of this skill can also be indicated here. For example, it is worth striving to increase the diversity of the network of contacts, increase the frequency of participation in conferences and fairs, and invite people from outside the company to visit more often.

Although experimenting does not affect all types of innovations introduced by micro-entrepreneurs, it should be emphasised that where this impact has been observed, it is negative. In other words, the higher the assessment of micro-entrepreneurs' ability to experiment, the lower the probability of them implementing innovation. This is probably because experimentation involves trying out new ideas, prototypes and approaches that can lead to both successes and failures, and the results of our research seem to suggest that negative outcomes are in the majority.

6. Conclusions

The article aimed to assess the impact of discovery skills on the innovativeness of micro-entrepreneurs. Based on the Innovator's DNA idea (Dyer et al., 2011) and a broad understanding of innovations (OECD & Eurostat, 2018), the main conclusion is that in the case of micro-entrepreneurs, three of five discovery skills positively affect innovativeness. These skills are associating, observing and networking.

Bearing in mind that these skills can be improved, it is worth using the indicated methods and techniques for their development. The research results suggest that such activities should increase the probability of micro-entrepreneurs being innovative.

It is also worth emphasising that developing the skills of associating, observing and networking should contribute to increasing the generation of ideas, improving adaptability, increasing resilience, building a competitive advantage and making micro-entrepreneurs more customer-oriented.

Finally, it is worth underlining that this research has some limitations. Firstly, the presented research analyses only those discovery skills indicated in the concept of the Innovator's DNA, ignoring delivery skills. Therefore, it would be worth including these aspects in future research. Secondly, the research is limited to Polish micro-entrepreneurs, which may affect the results, for example due to cultural conditioning. Therefore, it would be worth expanding future research geographically.

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INTENTIONS OF ELECTRIC CAR USE – VALIDATION OF SCALES BASED ON TECHNOLOGY ACCEPTANCE THEORY

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Purpose: The aim of this paper is to answer the following research questions: 1) What observable variables can create constructs stemming from technology acceptance theory, where the technology under study is electric cars? 2) Do the observable variables creating constructs such as economic utility, environmental utility, social pressure, perceived ease/difficulty of use, attitudes, promotions and regulations, intentions to use electric cars form scales with acceptable validity and reliability? 3) Which of the studied constructs significantly affect the intention to use electric cars?
Design/methodology/approach: In order to achieve the stated purpose, literature research and empirical studies were conducted. The literature research was based on technology acceptance theory, which provided the theoretical basis for the questions for the survey, which was then conducted on a sample of 147 people. The obtained survey data were analyzed and used to: 1) validate the questionnaire scales that represent electric car acceptance factors and consist of observable variables; 2) model the factors affecting the acceptance of electric car technology. Structural Equation Modeling (pls-SEM) was used.
Findings: We found sets of statements, or observable variables building scales based on technology acceptance theory, where the technology under study was electric cars. Not all of these scales are of acceptable accuracy and reliability. Scales for the constructs of attitudes and promotions proved problematic. Therefore, these scales must be reexamined in another study. The remaining scales, after removing or recoding some variables, can be considered acceptable. We built a model in which the construct of attitudes toward electric cars was not included, while all other constructs except social pressure and promotion of electric cars were found to significantly affect intentions to use electric cars.
Research limitations / implications: The study sample was quite small, so we assume that our research will be repeated on a larger number of respondents.
Practical implications: Nevertheless, we consider our results on the validation of the scales of economic and environmental utility, social pressure and perceived difficulty of using electric cars to be valid. The scales we have proposed may prove useful for studying the acceptance of electric cars.
Originality/value: The originality of our article comes from a set of observable variables measuring constructs derived from Technology Acceptance Theory, where the technology under study is electric car technology.

Keywords: electric cars, questionnaire validation, pls-SEM.
Category of the paper: Research paper.

Introduction

With the advent of the 21st century, interest in green lifestyles has grown, along with the necessity to reduce greenhouse gas emissions and combat climate change. This, in turn, contributed to the popularization of electric cars. There is now strong pressure, especially in the European Union, to use electric cars for the sake of environmental goals and reducing CO_2 emissions. The European Union is aiming for climate neutrality by 2050, which requires a sharp reduction in emissions. As such, various incentives and regulations for electric cars are being pursued, such as subsidies, tax exemptions, investments in charging infrastructure, etc. However, despite the growing interest in electric cars, there are still some barriers and challenges that affect the acceptance and widespread use of this technology. Analyzing these factors and understanding the intentions of electric car use is key to the development of the electro-mobility market. These factors include, but are not limited to, economic, environmental, infrastructural or attitudes toward technology.

The main research problem of the paper is to determine how the factors influencing the intention to use electric cars are formed. Solving this problem became the main purpose of the paper.

To flesh out the research problem, the following research questions were raised:

1. What observable variables can create constructs stemming from technology acceptance theory, where the technology under study is electric cars?
2. Do the observable variables creating constructs such as economic utility, environmental utility, social pressure, perceived ease/difficulty of use, attitudes, promotions and regulations, intentions to use electric cars form scales with acceptable validity and reliability?
3. Which of the studied constructs significantly affect the intention to use electric cars?

In order to achieve the stated purpose, literature research and empirical studies were conducted. The literature research was based on technology acceptance theory, which provided the theoretical basis for the questions for the survey, which was then conducted on a sample of 147 people. The goal of the surveys was to find quantitative data on the variables driving acceptance of electric car technology. The obtained survey data were analyzed and used to:

1. validate the questionnaire scales, which are factors of electric car acceptance and consist of observable variables,
2. model the factors affecting the acceptance of electric car technology.

We used Structural Equation Modeling (pls-SEM) to analyze the survey data.

The paper consists of five chapters. The first chapter serves as an introduction to electric cars. It also covers the Technology Acceptance Model (TAM) theory complemented by the Theory of Planned Behavior (TPB). With these theories mentioned, the factors that can shape the acceptance of electric car technology are presented. Thus, the following constructs were included in the research model: economic and environmental utility of electric cars, social pressure to own them, promotion and regulation of electric cars, attitudes toward electric cars, and intentions to use them. The construct of intention to use became the dependent variable (target variable), and the other constructs became predictors. Chapter two deals with the methodological aspects of the empirical study. The research methods used to analyze the survey data are discussed therein. It also outlines the questionnaire, the research model and describes the research sample. Chapter three presents the results of the empirical study, and chapter four provides the main conclusions.

1. Electric cars in the context of technology acceptance theory

To answer the first research question, a literature review in the field of electric cars was conducted, which was aligned with the technology acceptance theory. Technology Acceptance Model (TAM) theory provides the theoretical basis for the research presented in the paper. The basic constructs in this theory are: perceived utility, perceived effort, attitudes toward the technology, intentions to use the technology, and actual use (Davis, 1985).

The *perceived utility* of electric cars consists of economic, environmental and social issues, among others. *Economic* issues include range and equipment of electric cars. They offer extensive modern equipment, are dynamic and quiet thanks to electric propulsion, often have two trunks and are safer, since they do not have fuel tanks. One can easily see that electric cars are more expensive than internal combustion ones by reviewing the offerings of various brands. The main contributor to higher prices is the cost of the battery, which accounts for half or more of the electric car's value. The high price of batteries is due to expensive raw materials and a complicated manufacturing process. The results of the study indicate that the current average price of an electric car is about € 33,000, compared to € 19,000 for a car with an internal combustion engine. Forecasters say that by 2026 the prices of both models should level off at € 19,000, and in 2030 the electric car should be several thousand euros cheaper than its combustion counterpart (Auruszkiewicz, 2022). In Poland, there is also the "Mój elektryk" program, which subsidizes the purchase of an electric car for individuals as of July 12, 2021, and for entrepreneurs and companies as of November 22, 2021. Subsidies apply to either purchases, leases or rentals (Rychlewicz, 2022). The maximum subsidy is PLN 18,750, while for Large Family Card holders it is PLN 27,000. It is crucial that the price of the car does not exceed the amount of PLN 225 thousand (Gov.pl, 2023). More rights on the roadway include:

the possibility to drive electric vehicles on bus lanes in Poland until 2026, free parking in paid zones or free charging (Grabek, 2022).

Also related to perceived utility are issues of *environmentalism*. Sustainability is the most important and most talked about aspect in the context of electric cars. It is true that electric vehicles (EVs) are carbon-zero; however, the issue of contention is the production of electricity and batteries needed to use them. The ideal scenario would be to produce energy from renewable sources, but unfortunately not all countries are well developed in this regard (Chłopek, 2013). In Poland, the production of electricity for electric cars is not environmentally friendly, as electricity in Poland comes mainly from fossil fuels. Unfortunately, the emissions from energy production for EVs is 0.29 due to NO_x emissions, which means it only meets the EURO III standard. However, a life-cycle comparison model between a turbocharged gasoline vehicle and an EV shows that electric cars allow a greater chance of reducing climate change impacts. The chances increase as the use of renewable energy sources increases. On the other hand, electric cars produce more pollution than combustion cars during production. One additional problem is the greater wear and tear on the tires, as electric cars weigh more due to their batteries and rechargeable batteries (Pero et al., 2018). The production of batteries for electric cars requires the consumption of a large amount of energy, and since production is mainly carried out in countries where electricity generation is based on the intensive use of fossil fuels (mostly China), this has a detrimental impact on the environment (Sendek-Matysiak, 2019). With the growing trend toward environmentalism and the various restrictions on reducing pollution or the benefits of using green equipment and products, it can be said that social pressure to be "eco-friendly" has emerged. This is well illustrated by the previously mentioned topic of restrictions that will be introduced by 2035 in the European Union.

The perceived *ease of use* in the context of electric cars is mainly a matter of the availability of car chargers. As of January 21, 2023, there were 2,565 electric chargers (Forum Energii…, 2023). Unfortunately, one of the problems of electric chargers is their uneven distribution, the Automotive Market Research Institute SAMAR found, based on data from the European Automobile Manufacturers Association (ACEA). This problem can be mainly seen in Europe, where the number of electric chargers in the Netherlands is more than 90 thousand, while in Romania, which is six times larger, there are about 500 (Krzyczkowska, 2021). Long distance travel through Europe can be problematic in this regard. A similar aspect of the ease of use of an electric car may be its charging time as well as its associated cost. It all depends on the size of the car's battery and the type of charger. The cheapest, albeit slowest, way to charge an electric car is to plug it into an outlet at home. Assuming an average rate of PLN 0.8/kWh, the cost of driving 100 km will be PLN 14. However, one has to expect a long charging time, which can take up to a dozen or more hours. It is possible to reduce this time by purchasing a wall charger plugged into a home outlet. It will charge the car 3 times faster (CORAB, 2022). The car can also be recharged in the city. Unfortunately, one must then expect a cost in the range of PLN 2 per kWh, but then the car will recharge in about an hour (Rychlewicz, 2022).

A concern for potential buyers of electric cars is the qualifications of mechanics. Electric cars are built with fewer parts, cheaper to run and may require less frequent repairs than internal combustion cars (costs such as changing oil, replacing plugs, clutch, air and fuel filters, are gone). Mechanics would have to get additional training in electrics as well as in the use of the diagnostic computer (AutoŚwiat, 2020).

The general public shows different mindsets, or *attitudes*, toward electric cars. Some see them as the future and love them, others sincerely hate them. Car shows are beginning to increasingly portray electric cars in a good light and present this technology as a good alternative with room for growth. In Poland, there are 31,249 electric cars (as of December 2022) and they outnumber hybrid cars. In comparison, in 2020 there were only 7231 electric cars in Poland. The (Klamut, 2018) paper conducted a survey of *purchase intentions* toward electric cars on a group of technical college students. The level of interest in electric cars was 80%. 78% of respondents would buy an electric drive vehicle if they had the financial capacity and only 10% of respondents would not consider buying an electric car despite meeting their requirements (Klamut, 2018).

2. Methodological aspects of the study

2.1. Research model

Based on the literature analysis, a research model was created for use in empirical studies. The model is presented in Fig. 1. Perceived utility was divided into two constructs, i.e. economic utility and environmental utility. Perceived ease/difficulty of use was incorporated into the research model as directly derived from the TAM (Technology Acceptance Model). Both the perceived economic and environmental utility, as well as the ease of use of electric cars, affect attitudes toward these cars. Social pressure (a construct derived from the theory of planned behavior) was also included as an important construct shaping attitudes. According to the TAM model, attitudes significantly influence intentions to purchase electric cars. It was also assumed that purchase intentions are also influenced by promoting and regulations. The aim of the empirical study is to examine each construct in terms of relevance and reliability, and then to model the impact of the constructs on intentions to use electric cars. Structural Equation Modeling (pls-SEM) was used to achieve this.

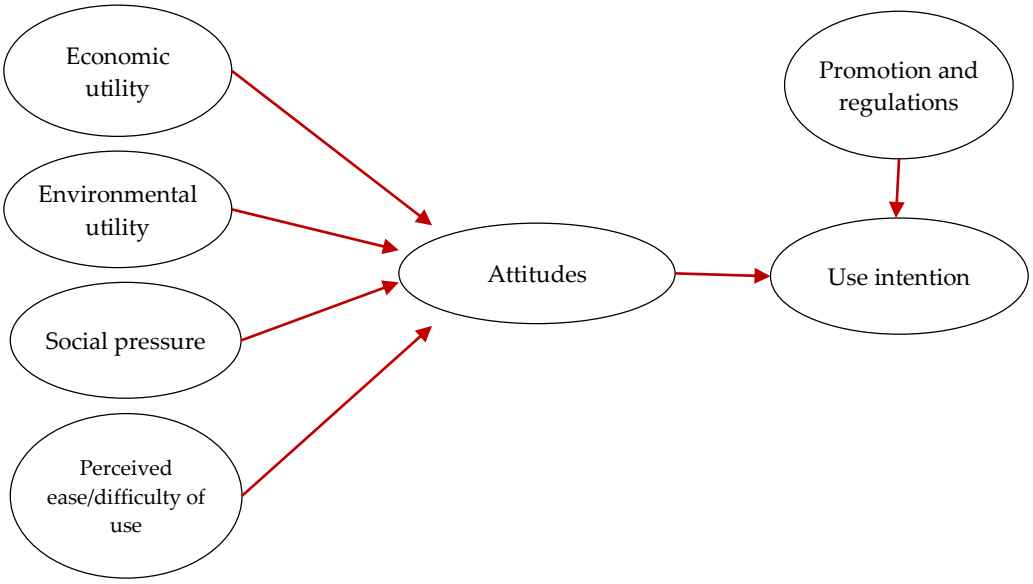

Figure 1. Research model.

Source: own study.

2.2. Measurement tool

Each construct in the research model was treated as a hidden (latent) variable. Therefore, a set of observable variables was developed to measure the listed constructs. These variables took the form of statements that were given to survey respondents. Respondents were asked to respond to these statements on a 7-point Likert scale. The observable and latent variables are shown in Table 1.

Table 1.
Questionnaire structure

Construct	Variable symbol	Questionnaire questions
Environmental utility (ECOL)	Ekol 1	Electric cars are environmentally friendly
	Ekol 2	Electric cars help reduce CO_2 emissions
	Ekol 3	Disposal of electric car batteries is not eco-friendly
	Ekol 4	Electric car production is not eco-friendly
	Ekol 5	Generating electricity in Poland for electric cars is not eco-friendly
Economic utility (ECON)	Ekon 1	Electric cars have low running costs
	Ekon 2	The cost of driving an electric car is lower than the cost of driving an internal combustion car
	Ekon 3	The cost of maintaining an electric car is lower than the cost of maintaining an internal combustion car
	Ekon 4	Electric cars require less frequent repairs than internal combustion cars
	Ekon 5	Electric cars are expensive
Social pressure (SN)	Spol 1	My family expects me to have an electric car
	Spol 2	My employer would like me to have an electric car
	Spol 3	My friends and acquaintances expect me to have an electric car
Perceived ease/difficulty of use (POU)	PoU 1	I am concerned about general mechanics' lack of skills in repairing electric cars
	PoU 2	The charging time discourages me from using an electric car
	PoU 3	The charging infrastructure discourages me from using an electric car
	PoU 4	Electric cars are safe
	PoU 5	Electric cars offer high driving comfort

Cont. table 1.

Attitudes (POST)	Post 1	Electric cars will dominate the market in the future
	Post 2	I am concerned that electric cars are not reliable
	Post 3	I am concerned that electric cars do not deliver the expected benefits
	Post 4	We should strive to reduce CO_2 emissions in transportation
Promotion and regulations (PRM)	Promo 1	Nowadays, you can see the State and the European Union support purchasing electric cars
	Promo 2	I agree with the ban on the sale of new internal combustion engine cars in the EU from 2035
	Promo 3	Automotive TV shows encourage people to buy electric cars
	Promo 4	In the future, electric cars will have more rights on the road than combustion cars
Use intentions (INT)	Int 1	I'm thinking of buying an electric car in the future
	Int 2	I'm thinking of using an electric car in the future (e.g. renting)

Source: own study.

2.3. Research sample

The survey was conducted in March and April 2023 and a total of 147 responses were collected via an electronic survey. The survey included 93 women and 53 men; one person did not define their gender. In order to ascertain the age of respondents, they were divided into six age groups. The most numerous of these is the 18–25 age group (82 individuals), followed by the 45–55 age group (26 individuals). The survey was most frequently taken by people with secondary education (71 individuals), and higher education (65 individuals). Almost half of the respondents were interested in motor vehicles (72 individuals). Only 27 respondents used an electric powered car, and the prevailing number of respondents did not own an electric car (142 individuals).

3. Results

3.1. Questionnaire validation

To validate the scales used in the questionnaire, their relevance and reliability were examined. To do so, for each scale the following were calculated: 1) factor loadings derived from conformational factor analysis, 2) Cronbach's alpha coefficient (alpha), 3) rhoA and rhoC coefficients and average, variance extracted (AVE) coefficient. The R environment and the seminr package were used for this. To be considered an accurate and reliable scale, the alpha, rhoA and rho C should exceed a threshold value of 0.7, and AVE a value of 0.5 (Hair et al., 2011, 2014, 2019). The obtained results are shown in Fig. 2.

	alpha	rhoC	AVE	rhoA
ECON	0.661	0.782	0.486	0.799
ECOL	0.036	0.228	0.594	0.851
SN	0.879	0.818	0.614	-0.209
POU	0.449	0.016	0.390	0.654
POST	0.082	0.000	0.399	0.592
PRM	0.308	0.626	0.327	0.376
INT	0.839	0.925	0.861	0.841

Figure 2. Measures of relevance and reliability of scales with original selection of variables

Source: own study.

As the results obtained were not satisfactory, we decided to remove or recode the observable variables within each construct. First, variables with unsatisfactory values of factor loadings (i.e., smaller than |0.5|) were removed. Deletions were made in the following constructs: economic utility, perceived ease/difficulty of use, attitudes, and promotion. It should be noted that for the construct of perceived ease/difficulty of using electric cars, of the five statements, only two describe the latent variable well. These statements read as follows: "The charging time discourages me from buying an electric car" and "The charging infrastructure discourages me from using an electric car." Therefore, these are statements that negatively describe the ease of use of electric cars. Hence, the construct has been renamed "perceived difficulty of using electric cars." Moreover, in the case of two constructs (attitudes, promotion) it was not possible to create a scale, and ultimately these constructs were defined by a single observable variable for modeling. Recoding of variables was also done during the examination of scales for some constructs. Such was the case with the construct of environmental utility. Recoding consisted of swapping answers 7 for 1, 6 for 2, 5 for 3, while 4 was left unchanged. Recoding was done for the variables ekol, 3, ekol 4, and ekol 5. The necessity of recoding was due to the fact that in the questionnaire, environmental utility was presented to respondents as environmental advantages and drawbacks of electric cars. It was therefore necessary to establish a single direction, which was achieved by recoding the variables describing the drawbacks. The final result was the model presented in Fig. 3 of which tested measures (Cronbach's alpha, rhoA, rhoC and AVE) met the preset thresholds of relevance and reliability.

	alpha	rhoC	AVE	rhoA
ECON	0.784	0.860	0.607	0.834
ECOL	0.831	0.878	0.590	0.844
SN	0.879	0.882	0.716	0.279
POU	0.772	0.895	0.811	0.831
PRM	1.000	1.000	1.000	1.000
POST	1.000	1.000	1.000	1.000
INT	0.839	0.925	0.861	0.841

Figure 3. Measures of relevance and reliability of scales with modified selection of variables.

Source: own study.

To test discriminant accuracy, the HTMT criterion was used. The results are shown in Fig. 4. It shows that none of the values exceeds the preset threshold value of 0.9 (Hair et al., 2011, 2014, 2019), which indicates satisfactory values.

	ECON	ECOL	SN	POU	PRM	POST	INT
ECON	.	.	.	.	.	.	.
ECOL	0.344	.	.	.	.	.	.
SN	0.149	0.111	.	.	.	.	.
POU	0.329	0.330	0.065	.	.	.	.
PRM	0.405	0.133	0.047	0.231	.	.	.
POST	0.107	0.389	0.066	0.119	0.048	.	.
INT	0.486	0.478	0.070	0.442	0.290	0.263	.

Figure 4. The HTMT criterion representing discriminant accuracy for scales with modified variable selection.

Source: own study.

3.2. Factors determining intentions of electric car use

Once the questionnaire is validated, a model can be built to explain the intentions of car use. During the research process, we built a number of models, which showed that attitudes strongly influence intentions of use, but also cause the relevance of other constructs to decline. This development is characteristic of the mediating variable, which in the light of technology acceptance theory is the attitude construct. Ultimately, due to the fact that attitudes were represented by only one observable variable, we created a model without this construct. Such a model is presented in the following figure (Fig. 5). It explains 32% of the variation in intentions to use electric cars. The model indicates that use intentions are most strongly influenced by the construct of environmental utility ($\beta = 0.279$) and this influence is positive. The second most influential construct is the economic utility ($\beta = 0.240$) and its influence is positive. Perceived difficulty of use negatively affects intentions to use electric cars ($\beta = -0.199$). Whereas social pressure proved statistically insignificant, as did the promotion of electric cars.

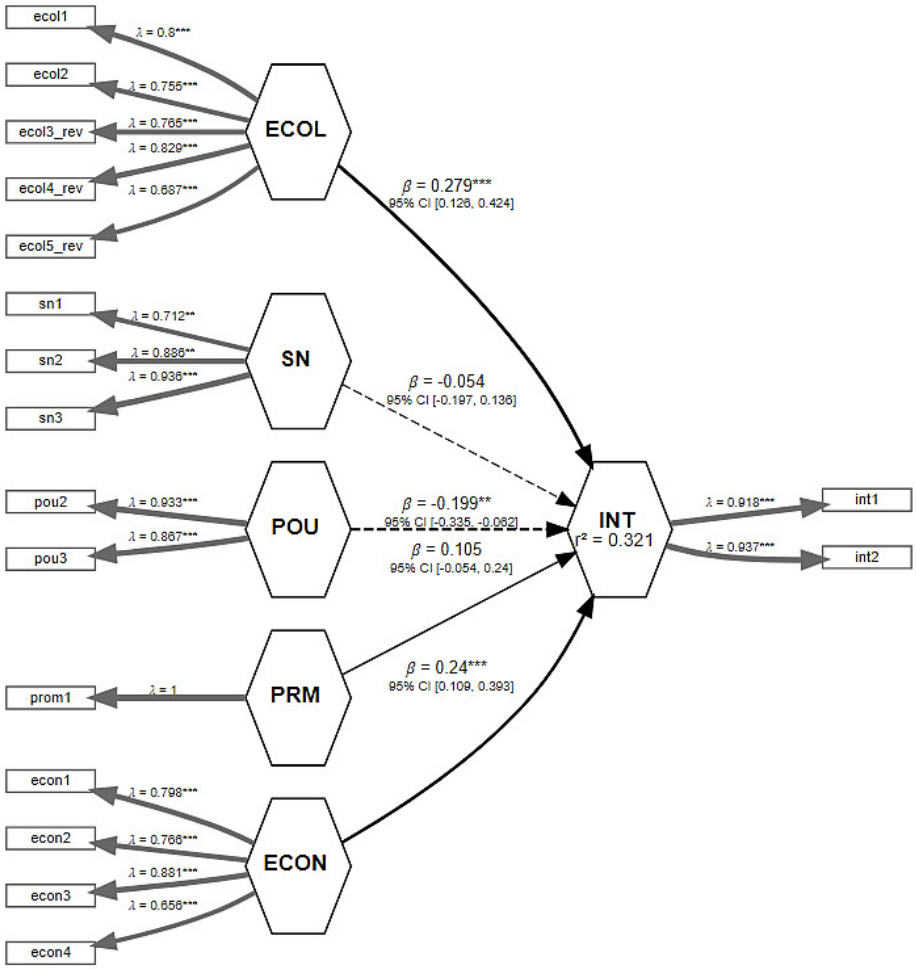

Figure 5. A model of the determinants of intentions of electric car use.
Source: own study.

4. Conclusion

The paper presented here poses three research questions, and then answers them on the basis of literature research and surveys. As to the first research question, we have found sets of statements, or observable variables that build scales based on technology acceptance theory, where the technology under study was electric cars. The answer to the second research question, however, has shown that not all of these scales have acceptable accuracy and reliability. Scales for the constructs of attitudes and promotions proved problematic. Therefore, these scales must be reexamined in another study. The remaining scales, after removing or recoding some variables, can be considered acceptable. To answer the third research question, we have built a model in which the construct of attitudes toward electric cars was not included, while all other constructs except social pressure and promotion of electric cars were found to significantly affect intentions to use electric cars.

Therefore, the first statistically significant factor for the intention to use electric cars turned out to be the ecological factor. Research has shown a positive impact of this factor on usage intentions. This proves the growing ecological awareness in Polish society. This is probably related to the perception of the problems of polluted air and climate change. The importance of ecological factors is undoubtedly a positive result of the research conducted. The second important factor turned out to be the economic factor. Research has shown a positive impact of this factor on usage intentions. This result is not surprising, as it is one of the most important factors motivating the acceptance of innovations (Mularczyk et al., 2022; Zdonek et al., 2022). The third important factor turned out to be the factor related to the perceived difficulty of use. Its impact on usage intentions turned out to be negative. It points to the problematic situation of infrastructure for servicing electric cars in Poland, which discourages the use of this type of cars. Social pressure and the promotion of electric cars turned out to be statistically insignificant factors. The lack of significance of social pressure can be explained by the fact that the use of electric cars in Poland is in the early phase of popularization. Therefore, the respondents did not feel any significant social pressure to use this type of car. Similar conclusions were also observed in other types of innovations in research (Mularczyk et al., 2022). The respondents also did not feel significantly motivated by the promotion of electric cars in the media. This factor turned out to be statistically insignificant. Therefore, in order to improve the intentions to use electric cars in Poland, the promotion of these cars should be strengthened. Promotional activities would also require influencing the respondents' closer and more distant social environment in order to influence the factor of subjective norms.

However, we would like to stress that the study sample was quite small, so we assume that our research will be repeated on a larger number of respondents. Nevertheless, we consider our results on the validation of the scales of economic and environmental utility, social pressure and perceived difficulty of using electric cars to be valid. The scales we have proposed may prove useful for studying the acceptance of electric cars.

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