

SILESIA UNIVERSITY OF TECHNOLOGY
SCIENTIFIC PAPERS

ORGANIZATION AND MANAGEMENT
Scientific paper no. 153

CONTEMPORARY MANAGEMENT

Edited by
Radosław WOLNIAK

Kolegium redakcyjne

REDAKTOR NACZELNY – Dr hab. inż. Barbara KULESZ, prof. PŚ
REDAKTOR DZIAŁU – Prof. dr hab. inż. Radosław WOLNIAK

**Druk z materiałów przygotowanych przez autorów
Redakcja Wydawnictwa nie odpowiada za stronę językową i treść artykułów**

**Wydano za zgodą
Rektora Politechniki Śląskiej**

ISSN 1641-3466

© Copyright by
Wydawnictwo Politechniki Śląskiej
Gliwice 2021

**WYDAWNICTWO POLITECHNIKI ŚLĄSKIEJ
ul. Akademicka 5, 44-100 Gliwice
tel. (32) 237-13-81, faks (32) 237-15-02
www.wydawnictwopolitechniki.pl**

**Sprzedaż i Marketing
tel. (32) 237-18-48
wydawnictwo_mark@polsl.pl**

CONTENTS

Foreword	5
1. Barbara BIAŁECKA, Mariusz KRUCZEK, Kordian RUDZIŃSKI – Assumptions for waste electrical and electronic equipment collection system evaluation	7
2. Iwona BURKA – The Lean manager as a mentor in the process of problem-solving in the A3 Thinking approach	21
3. Sergiy BUSHUYEV, Victoria BUSHUIEVA, Maryna LAZAREVA, Svitlana ONYSHCHENKO, Natalia PAVLOVA – Agile-transformation by organizational development projects	45
4. Jelena DEMENTJEVA, Rimantas STAŠYS – Organizational creativity management based on the intellectual capital	57
5. Mateusz DRUĆ, Ireneusz J. JÓŹWIAK, Alicja M. JÓŹWIAK, Wojciech M. NOWAK – Techniques of mobile application development process ...	77
6. Paweł FILIPOWICZ – Conceptualisation of using technical debt to measure the innovation level of new product – selected issues	89
7. Karolina GABRIEL – Supporting remote education in the conditions of the pandemic in Poland	103
8. Grzegorz GLISZCZYŃSKI, Filip BERKOWSKI – The role of management succession in the growth of Polish SMEs	111
9. Grzegorz GLÓD, Izabella STEINEROWSKA-STREB – Business-university collaboration in education: an example of joint teaching in entrepreneurship and management	133
10. Daniel GRICER, Ireneusz J. JÓŹWIAK, Jan SWITANA – European Union funds in infrastructure development of Polish rail transportation between 2014-2020	143
11. Beata HOZA, Adam ŻABKA – Determinants of the VAT gap – part 1	155
12. Adrian IWANIUK, Liliana HAWRYSZ, Helena BULIŃSKA-STANGRECKA, Paweł HURAS – Barriers to the effectiveness of teleworking in public administration	165
13. Robert KAMIŃSKI – Project management and employees' individual potential	179
14. Monika KIEĆ – Fit-gap analysis as introduction step to business process standardization	193
15. Arkadiusz KOLKA, Maciej KAŻMIERCZAK – Industrial twins as an effective tool for the implementation of laboratory classes	213
16. Kinga KONIECZKA – Solving problems in hoshin kanri system approach using quality management tools – case study	227
17. Piotr KORNETA – Performance management system for primary healthcare services providers	239

18. Magdalena KRACZLA – Sleep deficit and managers' functioning in stressful situations	259
19. Monika KREZYMON, Krystian STRÓŻEWSKI – Statistical analysis of the preparation of a future student during the SARS-CoV-2 pandemic (economic approach)	273
20. Anna KWIECIEŃ – The role of change in enterprises during the crisis	287
21. Alina LANGA, Ireneusz J. JÓŻWIAK, Kacper STAROŚCIAK, Jan SWITANA, Alicja M. JÓŻWIAK, Wojciech M. NOWAK – The identification of problematic software testers management areas	303
22. Hubert ŁOPUSIŃSKI, Mateusz ŁOPUSIŃSKI, Ireneusz J. JÓŻWIAK, Kacper STAROŚCIAK – A strategy for researching the performance of web applications clients	317
23. Joanna MACHNIK-SŁOMKA, Nicholas BALDACCHINO – The role of higher education institutions in shaping students' entrepreneurial attitudes – case studies from Poland and Malta	327
24. Bartosz ORZEL, Radosław WOLNIAK – Corporate social responsibility reports on Polish market over the years – comparison and analysis	343
25. Andrzej PACANA, Karolina CZERWIŃSKA, Lucia BEDNÁROVÁ – Analysis and improvement of the production system in production enterprise	357
26. Magdalena PICHLAK – Resources, dynamic capabilities, and performance: evidence from Polish green innovative companies	369
27. Adam PISARCZUK – Proposition of a method of verification occupational risk assessment	385
28. Joanna RUDAWSKA, Daniel PAVLOV, Miroslava BONEVA – Individual entrepreneurial orientation and entrepreneurial intention. Comparative research on Polish and Bulgarian students	397
29. Janusz SMOLIŁO, Andrzej CHMIELA, Aleksander LUBOSZ, Paweł WRÓBLEWSKI – Dynamics of bearing of costs in processes leading to revitalization of mine assets in SRK S.A.	409
30. Janusz SMOLIŁO, Andrzej CHMIELA – The mine liquidation processes in SRK S.A. in a cost approach	429
31. Łukasz SROKA – Comparison of jackknife and bootstrap methods in estimating confidence intervals	445
32. Lilianna STAŃCZAK – Reasons and directions for market reorientation of research institutes in Poland	457
33. Anna SVITANA – Outsourcing as a management concept in the legal plane	473
34. Katarzyna SZUPER – Innovative company profile: age, size and sources of financing	485
35. Daniel TOKARSKI, Artur SAWICKI – Risk analysis of the construction venture in the economic aspect	495
36. Rafał ZACHOROWSKI – Functioning of the medical services market in Poland: selected problems	507

FOREWORD

Presented number of Silesian University of Technology. Scientific Papers. Organization and Management Series. Contemporary management. The number is result researches of scientist from various Lithuanian, Polish, Slovak, Spanish and Ukrainian authors. The number consists of 36 papers.

The papers presented in the number concentrate on many topics connected with organization and management. The authors of paper concentrate on problems connected with: environmental management, lean management, information management, product management, SME's management, entrepreneurship, logistic, finance, public management, project management, industrial management, quality management, service management, human resource management, the COVID impact on society, change management, innovation management, Corporate Social Responsibility and risk management.

Radosław Wolniak

ASSUMPTIONS FOR WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT COLLECTION SYSTEM EVALUATION

Barbara BIAŁECKA¹, Mariusz KRUCZEK^{2*}, Kordian RUDZIŃSKI³

¹ Central Mining Institute, Katowice; bbialecka@gig.eu, ORCID: 0000-0002-6002-5475

² Central Mining Institute, Katowice; mkruczek@gig.eu, ORCID: 0000-0002-5052-3729

³ Śląskie Środowiskowe Studium Doktoranckie, Katowice; kordianrudzinski1992@gmail.com

* Correspondence author

Purpose: The main aims of the article are to analyse the waste electrical and electronic equipment management system and present a conceptual framework for evaluating the collection system for this group of waste.

Design/methodology/approach: The research methods used in the article were desk research analysis of available source data on the structure and functioning of WEEE management systems. An additional approach to the research referred to the statistical data on waste collection of the following groups of waste

Findings: WEEE management systems are widely described in the literature because this waste are source of significant and rare secondary raw materials. However, it is still a problem to create a fully efficient system for collecting this group of waste.

Research limitations/implications: The main limitation in carrying out the research is the lack of current data on the quantity and quality of electrical and electronic waste which can be used for the production

Practical implications: Further research will focus on using the approach presented to investigate the effectiveness of the different WEEE collection solutions and the possible improvement of these systems

Originality/value: The analysis carried out indicates the need to reconstruct the WEEE management system. This approach to assessing the effectiveness of the system can be used to compare different WEEE collection options.

Keywords: waste collection system, WEEE, assessment.

Category of the paper: conceptual paper.

1. Introduction

The management of electrical and electronic waste is an important problem on both a local and global scale, mainly due to the increasing amount of electro-waste generated worldwide. As production increases and the life cycle of electrical and electronic equipment shortens, it is

replaced more and more often so that it becomes a rapidly growing source of waste. Used electrical and electronic equipment is considered to be one of the fastest growing waste streams in the European Union, with an increase rate of 3-5% annually (Gurauskienė, 2008; Nowakowski, Szwarc, 2016). This is related to the consumer lifestyle, which results in a shortened life cycle of electrical and electronic equipment. Moreover, new devices with increasingly better parameters constantly appear on the market. Therefore, still working electrical and electronic devices become hazardous waste, which contains harmful substances such as lead, mercury, cadmium, bromine, etc. (Goodship, Stevels, Huisman, 2019; Góralczyk, Uzunow, 2013). Incorrect handling of WEEE leads to pollution of waters, soil and air, as well as to a number of threats to our health and wellbeing. In addition, loss of natural resources and increasingly difficult access to them can be observed. Paradoxically, waste is also one of the most important resources of raw materials and critical elements (Kruczek, 2017). In 2005, the Electrical and Electronic Equipment Waste Act came into force. It was the first document in Poland to regulate issues related to the collection and processing of WEEE. The Act implemented the provisions of the Directive on electrical and electronic equipment waste (Directive 2002/96/EC 2003, Applia 2019). Although several years have passed since the WEEE collection and handling system was introduced, the solutions currently applied in Poland are still incomplete, uncoordinated, and not very flexible. This is caused by several different barriers created by an unclear legal, organizational, and financial system related to the organization of WEEE collection and handling. The purpose of this article is to present an initial concept of a model to assess the effectiveness of electrical and electronic waste equipment collection based on literature.

2. Development of the WEEE management system

In Polish legislation, the term equipment waste first appeared in the Regulation on waste classification issued by the Minister of Environmental Protection, Natural Resources, and Forestry (Dz.U. nr 162, poz. 1135, 1997). The Regulation contains 7 types of waste that meet the currently valid definition of equipment waste (Table 1). Neither then valid the Waste Act (1997) nor the executive regulations contained a definition of the term waste equipment.

Table 1.
Selected sub-groups and types of equipment waste

No	Code	Subgroups and types of waste
1	09 01	Waste from the photographic industry
1	09 01 09	Disposable cameras with batteries
2	09 01 10	Disposable cameras without batteries
2	16 02	Used equipment and its components
3	16 02 01	Transformers and capacitors containing PCB or PCT

4	16 02 02	Other electronic and electrical waste equipment
5	16 02 03	Devices containing freon
6	16 02 04	Equipment containing free asbestos
7	16 02 05	Other used equipment

Source: (Dz.U. nr 162 poz. 1135, 1997).

The definition of equipment and waste equipment was first introduced in the Act on electrical and electronic equipment waste (Dz.U. nr 180, poz. 1495, 2005), which transposed Directive on waste electrical and electronic equipment (Directive 2002/96/EC, 2003). Article 4 of the Act dated 11th September 2015 on Waste Electrical and Electronic Equipment (Goodship, Stevels, Huisman, 2019), currently being in force, defines equipment as "a device whose correct operation depends on the supply of electric current or the presence of electromagnetic fields, as well as a device capable of generating, transmitting or measuring electric current or electromagnetic fields, designed for use with electric voltage not exceeding 1000 V for alternating current and 1500 V for direct current".

While implementing Directive 2002/96/EC, the European Union imposed on the Member States the necessity to achieve a collection level of at least 4 kilograms of WEEE per citizen per year by 31st December 2006 at the latest. However, there was no provision for the set collection rate in the WEEE Act of 2005 (Bukowski, 2018). In 2007, only 0.27 kg of WEEE per capita was collected in Poland (Cieszyńska, 2017). Figure 1 shows the volume of electrical and electronic equipment collected per capita in the years 2007 to 2017 (Figure 1).

After the amendment of the WEEE Act changes aimed at improving the functioning of WEEE management system were introduced in order to achieve the required level of collection in Poland. The minimum annual levels of WEEE collection were set in the Regulation of the Minister of Environment, and then increased in 2010 (table 2) (Nowakowski, 2015).

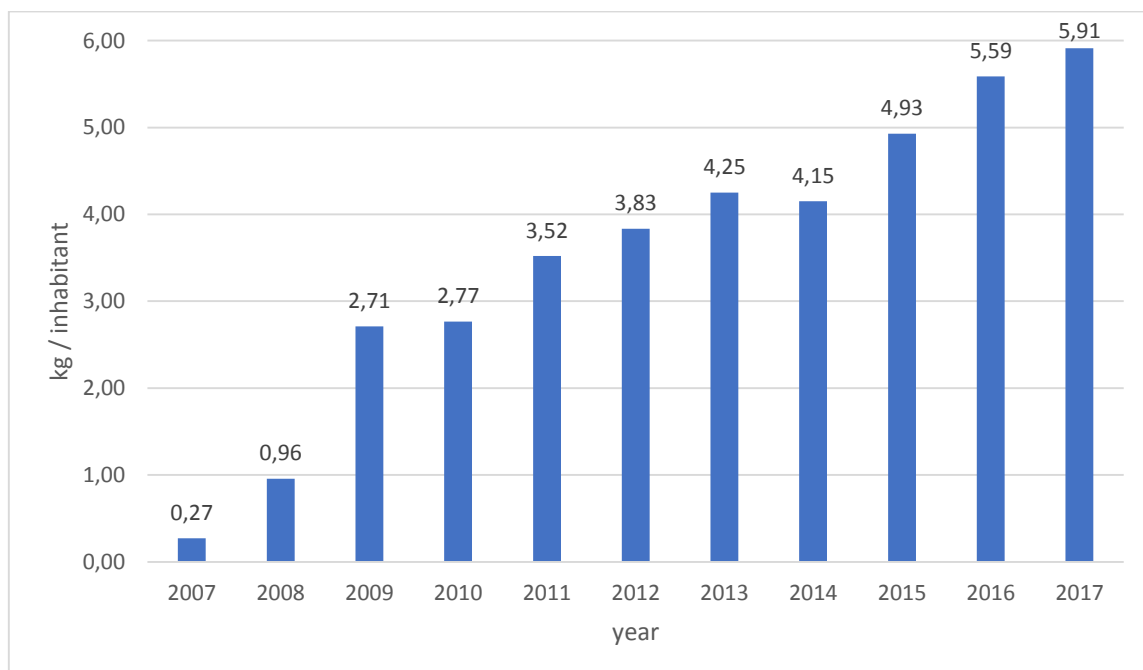


Figure 1. Weight of WEEE collected from households per capita during 2007-2017.

Source: (Eurostat, 2018).

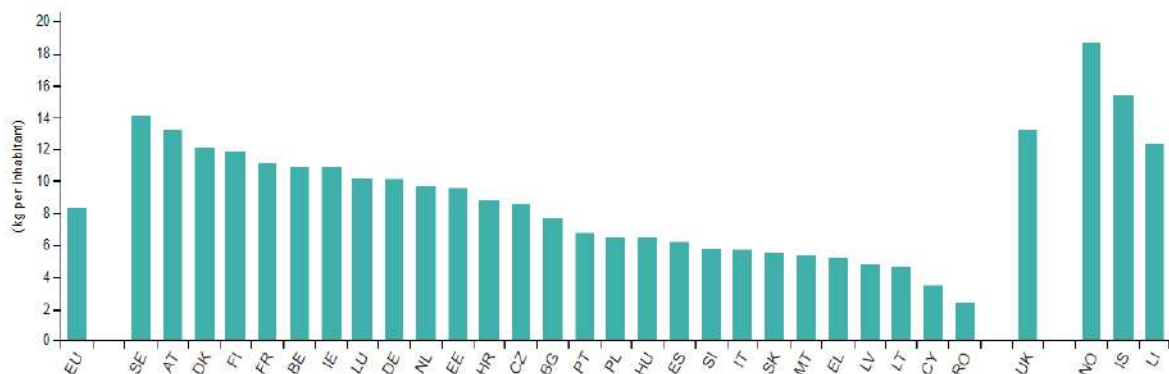
Table 2.*Minimum annual levels of WEEE collection*

No	Waste electrical and electronic equipment from households	Collection rate [%]	
		since 2009	since 2011
1	Large household equipment	24	35
2	Small household equipment	24	35
3	ICT and telecommunications equipment	24	35
4	Audiovisual equipment	24	35
5	Lighting equipment type 2-5	40	43
	Lighting equipment type 6	24	35
6	Electrical and electronic tools, except for large, stationary industrial tools	24	35
7	Toys, leisure and sports equipment	24	35
8	Medical devices, except for all implantable and contaminated products	-	35
9	Control and monitoring instruments	24	35

Source: (Nowakowski, 2015).

Directive 2012/19/EU of the European Parliament and Council on waste electrical and electronic equipment (WEEE), and later on new polish regulacy (Dz.U. poz. 1688, 2015), was another step in creating a WEEE management system. Until 31 December 2015, the WEEE collection rate amounted to 4 kilograms per citizen. From 2016, the minimum collection rate was 45%, and from 2019 onwards it grew to 65%. By way of deviation, as of 14th August 2016, Poland was obliged to achieve a collection level lower than 45% but higher than 40%. The 65% collection rate was deferred until 14th August 2021 at the latest.

The annual level of WEEE collection from households in Poland, expressed in kilograms per capita, was just over 6.5 kg in 2017. Compared to other European countries, the level of collection in Poland was low (Figure 2). The lowest level of collection was recorded in Romania. The highest collection level in 2017 was in Norway (over 18.7 kg of WEEE per capita). Average collection volume for European Union was also higher than for Poland – 8.3 kg

**Figure 2.** WEEE collection level in selected European countries 2017. Source: (Eurostat 2020).

Analysis of the data contained in the reports on the functioning of the WEEE management system for the years 2007-2017 (Eurostat 2020) indicates that the current trend in WEEE collection will not allow Poland to meet the requirements set by the European Union as regards the required levels of collection (Figure 3).

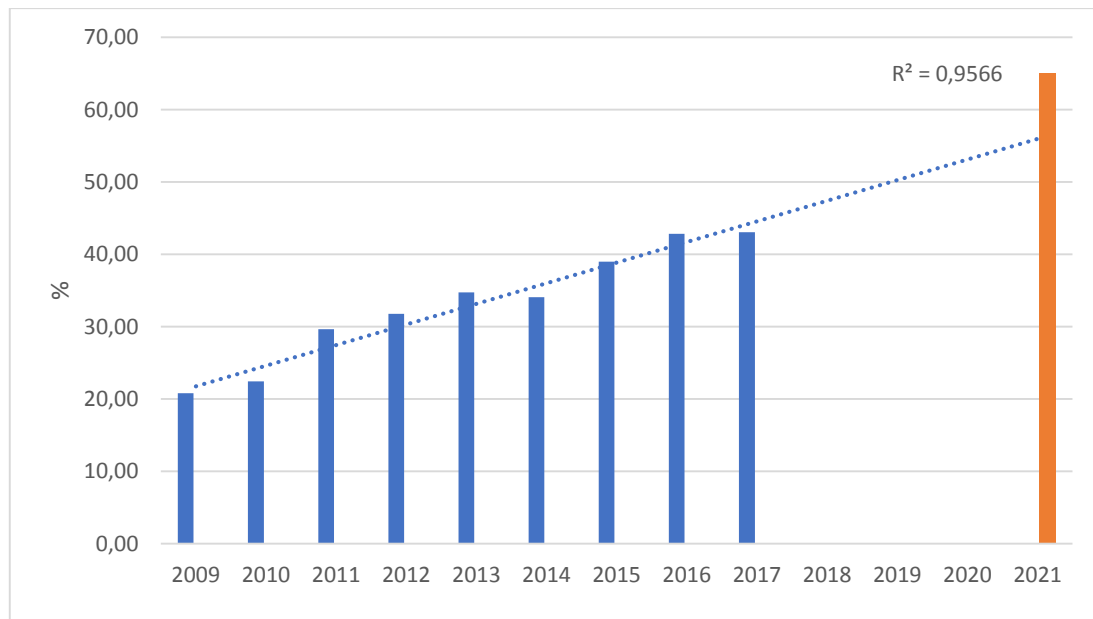


Figure 3. Level of WEEE collection in Poland in 2009-2017 with its extrapolation for 2021. Source: own calculations based on (Eurostat, 2020; Goodship, Stevels, Huisman, 2019).

The low level of WEEE collection in Poland is influenced by gaps in legislation related to the matter, for example, to the functioning of waste electrical and electronic equipment recovery organizations. Another gap is due to low awareness and poorly developed pro-environmental attitudes in the Polish society and an inefficient and ineffective waste collection system Laskowska M. (2018).

3. Waste electrical and electronic equipment collection system in Poland

Organization of the system of handling waste electrical and electronic equipment in Poland is mainly regulated by the Electrical and Electronic Equipment Waste Act. According to the principle of extended responsibility, producers are obliged to organize collection of WEEE from collectors and to handle WEEE from households. The WEEE management system is financed by consumers in the form of waste management cost (WMC) included in the price of each new piece of equipment.

Logistic approach to the WEEE management system makes it possible to identify three main streams: physical (materials), informational and financial one (Kruczek, 2017; Horodyńska, 2017). The analysis of the physical stream of WEEE flow has been carried out and established waste producers, who are also waste holders, as the first link in the chain of WEEE collection. A waste holder has many opportunities to legally transfer WEEE to the next link. When purchasing new equipment, the customer (holder) may hand over the old piece free of charge, as long as it is of the same type and has the same functionality as the purchased equipment. When delivering a new device to the customer, the retailer is obliged to take back the old one. In case of retail entities with a sales area of at least 400 m², the customer is has the

right to hand over any piece of WEEE (if none of its external dimensions exceeds 25 cm), free of charge, without the need of purchasing any new equipment. Service points are also authorized to collect WEEE. When equipment repair is technically impossible or unprofitable, the operator is obliged to accept waste equipment. Once an appropriate quantity of waste equipment is collected, it is handed over to the collection unit with which a contract has been signed. Then the equipment is transferred to the next link, which is the handling/processing plant. Entities participating in the transfer are authorized to collect waste equipment and are exempted from the obligation to obtain a waste collection permit (non-professional waste collection activities). The holder may also hand over WEEE to an entity holding a waste collection or handling/processing permit, or to a municipal waste selective collection point (MWSCP) compulsorily established by local (district) authorities (Nowakowski, 2017).

From collection points WEEE goes to treatment plants. At a handling/processing plant, hazardous substances are first removed, followed by fragmentation of parts and separation of raw materials. Hazardous substances, such as e.g. freon, are handed over to entities that deal with their disposal. In small plants, only manual disassembly is carried out. In plants operating on an industrial scale, manual dismantling is followed by mechanical dismantling, which produces raw materials such as metals or plastics. Those are, in turn, sent to recyclers or other non-recycling recovery processes. The physical flows are illustrated in the figure 4.

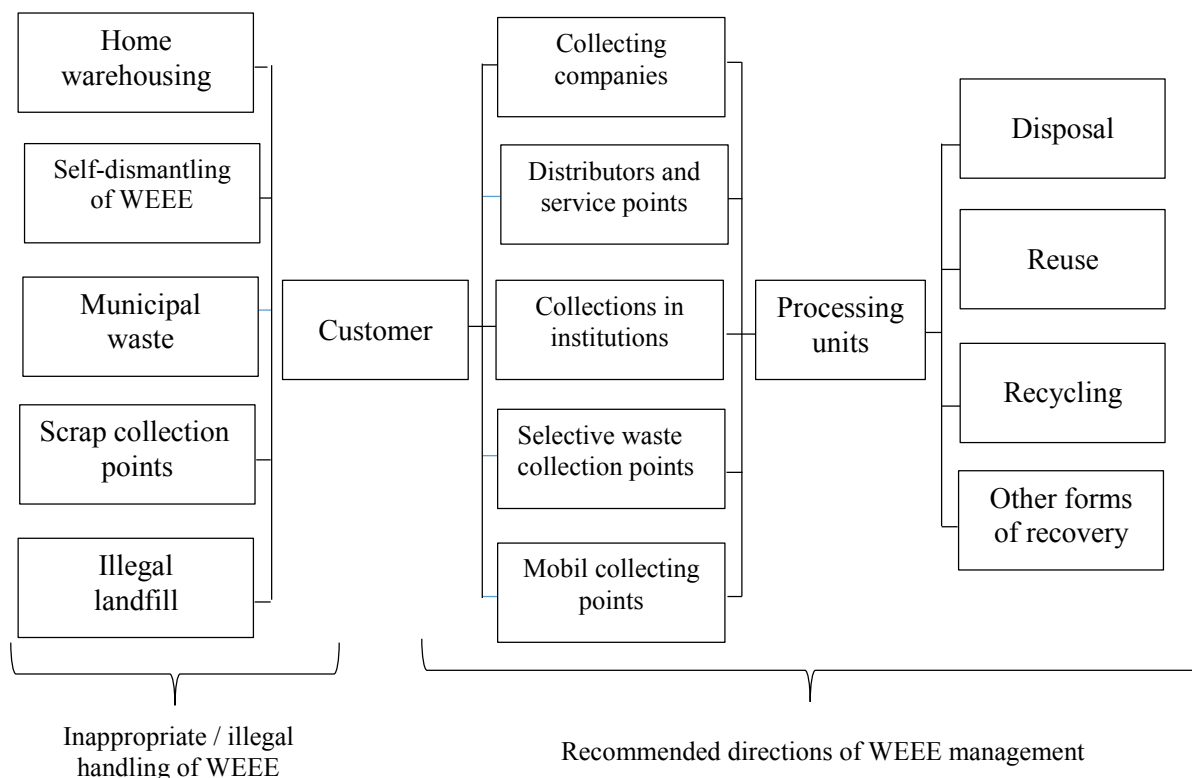


Figure 4. Overall structure of WEEE management system. Source: own elaboration.

The information flow system can distinguish between information that is necessary to perform statutory duties and information required by law, such as certificates, reports or summaries. It is also possible to divide the circulation of information into circulation between individual commercial entities and public administration, as well as between individual public administration authorities. The flow of information is shown schematically in the figure 5.

The system of WEEE management financing is based on the "polluter pays" principle, which is implemented in the form of waste management costs (WMC). WMC is a separate amount which is part of the price of each new product placed on the market. The whole cost of waste management is covered by consumers at the time of purchasing new equipment, and its amount is determined by the producer. WMC should be fully utilized to pay for the WEEE collection, treatment and recycling system. Distribution of funds from WEEE is conducted through two channels. In the first one, distributors transfer the funds to the system themselves. In the second case, the funds are distributed by intermediaries – recovery organizations, which transfer them to treatment facilities (ElektroEko, 2019).

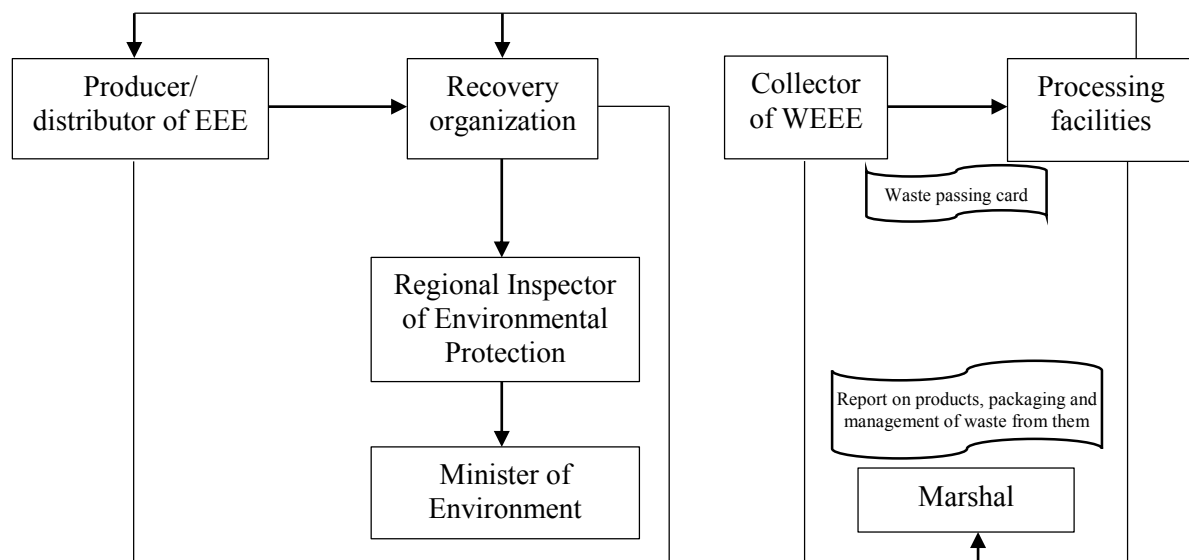


Figure 5. Information flow in the WEEE management system. Source: own elaboration.

In the presented model, a number of disturbances can be identified that affect the deterioration of system performance indicators. One of them is the transfer of WEEE to scrap yards or to municipal waste landfills, which in effect makes it impossible to indicate how much and what type of WEEE is collected and processed. Another is storage and processing of WEEE in inappropriate conditions, resulting in the release of hazardous substances to the environment, as well as high and uncompetitive costs of waste collection and processing by recovery organizations (Kruczek, 2017; Horodyńska, 2017).

4. Assumptions for the assessment of the WEEE collection system

An effectively and efficiently functioning WEEE collection system is one that is characterized by a high level of collection and which generates benefits for users. The system in Poland is assessed as not functioning correctly. P. Nowakowski (2017) pointed out the factors that affect the effectiveness of the WEEE collection system (table 3).

According to the WEEE Act, the WEEE collection system should take into account the density of population. An effective and efficient WEEE collection system requires that collection points are located in frequently visited places and open at convenient hours. However, a significant percentage of consumers are not even aware where these collection points are located (Goodship, Stevels, Huisman 2019). Disposal of WEEE together with municipal waste is a common phenomenon in Poland.

Table 3.

Factors influencing the efficiency of the WEEE return logistics chain

Factors		Characteristics
Decision	Location and availability of collection points	Collection points should be easily accessible and located in frequently visited places. Opening hours should include evening time.
	Mobile collection schedules	The mobile collection should be conducted according to a schedule. The best option is repeatability, which affects residents' memory of WEEE collection dates.
	Environmentally friendly attitude	Respecting a separate collection method results in the desire for legal and, consequently, environmentally friendly waste disposal. If there is no interest in environmental protection, WEEE is disposed of together with municipal waste or abandoned.
	Education	Educational activities should be conducted for all age groups. Educational programmes cover the young generation and there are few programmes for target groups in middle age.
	Possible benefits	For many people, the possibility of getting rid of bulky equipment (e.g. washing machine, dishwasher) is connected with the possibility of additional income, e.g. in scrap yards. This method, although run through an unofficial channel, allows for metal recycling. Mass of WEEE passing through a scrap yard avoids the register but ultimately goes to a steelworks.
Economy	Arrangement of the containers	The containers should be adapted to the equipment that is being removed. When left unattended they may facilitate the theft of stored WEEE. The person responsible for supervision must report their filling. To empty containers from multiple locations, software with optimised routes is necessary.
	Design of collection routes	It is necessary to design routes adapted to the anticipated number of WEEE to be delivered. Routes have to be designed in an optimal way – this affects the number of vehicles and staff to handle the route.
	Exchange of information between manufacturers and dismantling plants	This is a requirement for equipment manufacturers, although an effective method of large-scale information exchange has not been achieved so far.
	Choice of dismantling methods	Disassembly methods require efficient staff and efficient processing lines. Depending on labour costs and current prices on the exchanges, the so-called dismantling depth can be adapted to external market conditions.

Source: (Nowakowski, 2017; Kruczek, 2017; Horodyńska, 2017; Goodship, Stevels, Huisman, 2019).

Measurement of WEEE collection efficiency indicators requires taking into account the stream of products (SEE) on the market and the outgoing stream of collected waste generated from those products (WEEE). The basic criterion of effectiveness of a WEEE collection system is the WEEE collection rate calculated by dividing the weight of collected equipment by the weight of equipment available on the market in a given calendar year (Nowakowski, 2015). Comparison of effectiveness indicators for different countries may provide a basis for assessing the effectiveness of a WEEE collection system.

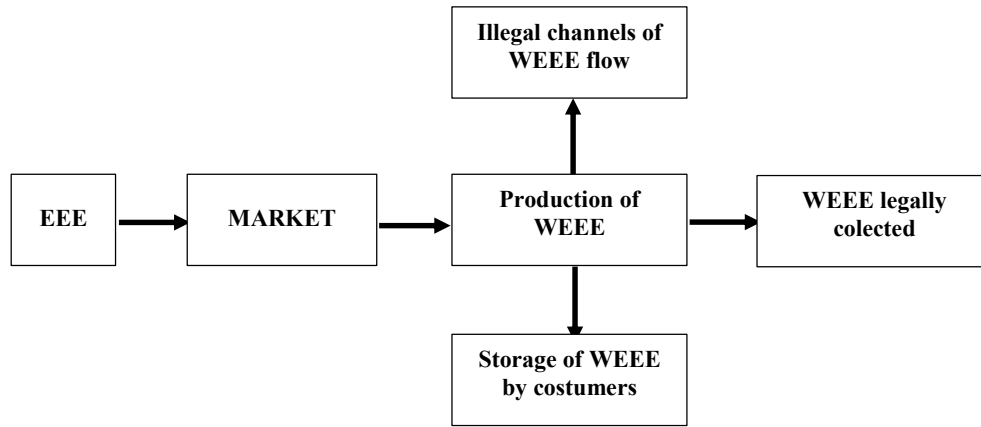


Figure 6. Product and waste streams – efficiency measurement. Source: own elaboration.

$$W_z = \frac{m_l}{m_{ur}} \cdot 100\% \quad (1)$$

where:

W_z – collection rate,

m_l – weight of WEEE collected in a legal manner,

m_{ur} – weight of equipment placed on the market.

The European Union has obliged Member States to achieve sufficiently high collection rates. The collection rate is expressed as the ratio of the weight of WEEE collected to the average annual weight of SEE available on the market during the previous three years in the Member State concerned.

$$P_z = \frac{m_l}{M_{ur}} \times 100\% \quad (2)$$

where:

P_z – collection level,

m_l – weight of WEEE legally collected,

M_{ur} – average annual weight of equipment placed on the market calculated according to the formula:

$$M_{ur} = \frac{m_{1ur} + m_{2ur} + m_{3ur}}{3} \quad (3)$$

where: m_{1ur} , m_{2ur} , m_{3ur} – weight of equipment placed on the market in each 3 years preceding the year in question.

The level of collection allows to determine the degree of achievement of the Union requirements in accordance with the formula below:

$$S_{ow} = \frac{P_z}{P_{UE}} \quad (4)$$

where:

S_{ow} – the degree of achievement of EU requirements,

P_z – collection level (in Poland), P_{UE} – collection level required by the European Union.

Improper handling of WEEE by consumers leads to a reduction in the weight of waste collected by legal means and thus affects the size of the collection rate. Results of studies concerning influence of citizens' behaviour on the effectiveness of waste electrical and electronic equipment collection published by Nowakowski (2015) make it possible to determine the total weight of generated WEEE

$$m_c = m_l + m_{nl} + m_s \quad (5)$$

$$m_l = \sum_{i=1}^n m_i \quad (6)$$

$$m_{nl} = \sum_{j=1}^k m_j \quad (7)$$

$$m_s = \sum_{p=1}^l m_p \quad (8)$$

where:

m_c – total mass of WEEE (mass of WEEE produced by consumers),

m_l – mass of WEEE legally collected,

m_{nl} – mass of WEEE removed from households illegally,

m_s – mass of WEEE stored,

n – number of waste appliances legally collected,

k – number of waste appliances removed from households,

l – number of waste appliances stored in households.

On the basis of the total weight and the weight of WEEE legally collected, an efficiency index for disposal of WEEE from households can be determined:

$$W_u = \frac{m_l}{m_c} \quad (9)$$

where:

W_u – efficiency ratio for the disposal of WEEE from households,

m_l – mass of WEEE legally collected,

m_c – total mass of WEEE.

Available literature very often uses the annual WEEE collection rate per citizen. It is calculated based on the mass of WEEE collected in a given country during the year divided by the population of that country.

$$w_z = \frac{m_l}{L} \quad (10)$$

where:

w_z – collection rate,

m_l – weight of WEEE legally collected,

L – country population.

The above-mentioned indicators make it possible to assess the WEEE collection system by individual groups of equipment and to compare collection systems operating in different regions.

5. Summary

The aim of the environmental policy of the European Union is to preserve, protect, and improve the quality of the environment and to use natural resources rationally. This policy necessitates the development of an economic concept in which products, materials and raw resources should remain in the economy for as long as possible and waste generation should be minimized as much as possible. Despite the introduction of Directive 2002/95/EC aimed at limiting the use of certain hazardous substances in electrical and electronic equipment, substances such as mercury, cadmium, lead, chromium, polychlorinated biphenyls (PCBs) and ozone depleting compounds will still be present in WEEE for many years (Nowakowski, 2015). Hazardous substances are still a major problem in waste management and insufficient recycling causes loss of valuable resources. Therefore, improvement of the efficiency and effectiveness of WEEE waste collection as well as putting the resulting materials back into circulation are a serious issue. This will significantly contribute to a more economical use of raw materials and will reduce the amount of generated waste. Against that background, the concept of circular economy is developing more and more intensively, taking into account all stages of life of products: from their design, through production, consumption, collection of waste, to their recycling. The Polish WEEE waste management system still lacks solutions aimed at closing the material flow loop. This situation is aggravated by gaps in the existing system, and therefore striving for its parameterization and ordering of flows is crucial for the elimination of disruptions and successful implementation of the new management concept.

References

1. Applia (2019). *Raport AGD 2018*. Retrieved from https://applia.pl/wp-content/uploads/2019/01/APPLiA.PL_raport-AGD-2018.pdf, 10.03.2020.
2. Bukowski, H. (2018). *W Kierunku Gospodarki Cykularnej: rekomendacje rozwoju i implementacji praktycznych rozwiązań dla biznesu*. Warszawa: Instytut Innowacyjna Gospodarka.
3. Cieszyńska, A. (2017). Odzysk platynowców ze zużytego sprzętu elektrycznego i elektronicznego (ZSEE) metodami metalurgicznymi. *Logistyka Odzysku*, Nr 1(22), pp. 52-57.
4. Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE) – Joint declaration of the European Parliament, the Council and the Commission relating to Article 9 (2003).
5. Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) (2012)
6. ElektroEko (2019). *Gospodarka elektroodpadami. Wyzwania na lata 2019-2023*. Retrieved from <https://www.teraz-srodowisko.pl/media/pdf/aktualnosci/7847-ElektroEko-raport-elektrosmieci-2019.pdf>, 12.11.2020.
7. Eurostat (2020) *Waste statistics – electrical and electronic equipment*. Available online https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics_-_electrical_and_electronic_equipment&oldid=496578, 20.08.2020.
8. Goodship, V., Stevels, A., Huisman, J. (2019). *Waste Electrical and Electronic Equipment (WEEE) Handbook*. Elsevier Ltd.
9. Góralczyk, S., Uzunow, E. (2013). The recovery of yttrium and europium compounds from waste materials. *Archives of Environmental Protection*, Vol. 39, no 3, pp. 107-114.
10. Gurauskienė, I. (2008). Behaviour of Consumers as One of the Most Important Factors in E-Waste Problem. *Environmental Research, Engineering and Management*, Vol. 4(46), pp. 56-65.
11. Horodyńska, M. (2017). *Ekologistyka i zagospodarowanie odpadów*. Gliwice: Wydawnictwo Politechniki Śląskiej.
12. Kruczek, M. (2017). Domykanie pętli łańcucha zużytego sprzętu elektrycznego i elektronicznego jako realizacja paradygmatu gospodarki cykularnej. *Logistyka Odzysku*, Nr 1(22), pp. 48-51.
13. Laskowska, M. (2018). ZSEE dwa lata po nowelizacji. Czy się udało? *Energia i Recykling: gospodarka obiegu zamkniętego*, Nr 4(4), pp. 10-12.
14. Nowakowski, P. (2015). Wyznaczanie efektywności łańcucha logistyki zwrotnej na przykładzie zużytego sprzętu elektrycznego i elektronicznego. *Logistyka*, Nr 2, pp. 655-665.

15. Nowakowski, P. (2015). *Logistyka recyklingu zużytego sprzętu elektrycznego i elektronicznego. Od projektowania po przetwarzanie*. Gliwice: Wydawnictwo Politechniki Śląskiej.
16. Nowakowski, P. (2017). Identyfikacja czynników wpływających na efektywność łańcucha logistyki zwrotnej zużytego sprzętu elektrycznego i elektronicznego. In: R. Knosala (Ed.), *Innowacje w zarządzaniu i inżynierii produkcji. T. 2.* (pp. 65-78). Opole: Oficyna Wyd. Polskiego Towarzystwa Zarządzania Produkcją.
17. Nowakowski, P., Szwarz, K. (2016). *Supporting of the mobile collection of waste electrical and electronic equipment based on a web application with the integrated database. Transport problems 2016*. VIII International scientific conference. V International symposium of young researchers. Katowice: Wydawnictwo Politechniki Śląskiej, pp. 801-810.
18. Rozporządzenie Ministra Ochrony Środowiska, Zasobów Naturalnych i Leśnictwa z dnia 24 grudnia 1997 r. w sprawie klasyfikacji odpadów. Dz.U. nr 162, poz. 1135 (1997).
19. Ustawa z dnia 11 września 2015 r. o zużytym sprzęcie elektrycznym i elektronicznym Dz.U. poz. 1688 (2015).
20. Ustawa z dnia 27 czerwca 1997 r. o odpadach, Dz.U. nr 96, poz. 592 (1997).
21. Ustawa z dnia 29 lipca 2005 r. o zużytym sprzęcie elektrycznym i elektronicznym. Dz.U. nr 180, poz. 1495 (2005).

THE LEAN MANAGER AS A MENTOR IN THE PROCESS OF PROBLEM-SOLVING IN THE A3 THINKING APPROACH

Iwona BURKA

Górnośląska Wyższa Szkoła Handlowa (Katowice Business University), Katowice;
iwonaburka@efektywnosc.net.pl, ORCID: 0000-0002-7338-8830

Purpose: The purpose of this study is to gather information on how Polish managers operating in a Lean environment, using mentoring, develop competences related to the application of the A3 Thinking approach among their employees, and how they themselves acquired the competences of mentors, what makes it difficult for them to work with their mentees and what benefits of mentoring they perceive.

Design/methodology/approach: To answer the research questions raised, the author conducted a literature review and a qualitative research – multiple-case studies. As part of the qualitative study, five in-depth interviews were conducted.

Findings: The main contribution of this study is to provide information on mentoring in the problem-solving process in the A3 Thinking approach and the experiences of mentor-managers. However, they can be used as input data for the design of training and mentoring programmes in the process of learning the A3 Thinking approach.

Research limitations/implications: Subjectivity of the analysis, owing to the application of a qualitative approach in the studies. Future research may be connected with creating a mentoring programme in the studied area.

Practical implications: The study results can be used as input data for the design of training programs and mentoring programs in the studied area. They can also act as a guidepost and motivation for Lean managers.

Originality/value: The literature review shows a small number of scientific publications that contain an approach to mentoring in the problem-solving process in the spirit of A3 Thinking. This publication may provide input data for managers wishing to improve the effectiveness of the problem-solving process.

Keywords: mentoring, A3 Thinking, problem-solving, problem owner, developing competences.

Category of the paper: Research paper.

1. Introduction

A problem is an organisational situation which causes specific difficulties or constitutes a smaller or larger divergence from the deliberate, optimised state of a system or subsystem (Perlaki, 1974, p. 21). Problem-solving is one of the most critical aspects of an organisation (Marksberry, Bustle, and Clevinger, 2011). A structured approach to this process is directly related to organisational performance and the ability to repeat successful outcomes (Perloff, and Carlton, 2004). There are many methods and approaches to problem-solving in the literature and practice of management and quality sciences. However, the A3 Report, which was derived from the Toyota Production System (TPS), is gaining more and more popularity. Whereas, A3 Thinking is Toyota's approach to using A3 Reports as a standard form of communication throughout the organisation at all levels (Loyd, Harris, and Blanchard, 2010). The A3 Report itself is used to record the thinking process and it is supposed to be flexible and adapted to the current problem (Anderson, Morgan, and Williams, 2011). The effectiveness of the problem-solving process in the A3 Thinking approach is dependent on many different factors, including: specific competences required from people responsible for solving problems, work environment, resources, standards, but also the way of learning the individual steps of A3 Thinking. Developing competences, which are necessary for effective problem-solving in the A3 Thinking approach, is most often executed with the use of training (external, internal), field studies, courses, and less often individual or group mentoring.

Mentoring means activities carried out by a mentor, an experienced person who wants to share his or her knowledge with someone who has less experience, and through his/her work and action helps the weaker to reveal their potential (Clutterbuck, 2002, p. 36). The sources of mentoring can be found in Greek mythology, in the person of Mentor who was a friend of Odysseus and guardian of his home and also tutor of his son (Marcinek et al., 2010, p. 177). A mentor is an experienced person who gives another person individual, non-linear assistance in transforming knowledge, work, or thinking. (Megginson, and Clutterbuck, 1995, p. 13). The mentor is an expert in a given field, a role model, a master who interacts with his or her mentee to support their development, achieve goals, and improve their competences. The mentor does not provide ready-made solutions, but rather gives some tips. He or she cares for, inspires, and supports the mentee.

Can mentoring be used for developing competences associated with effective problem-solving in the spirit of A3 Thinking? It seems so. In the literature, you can find studies related to mentoring or coaching in the implementation of the Lean approach (Tillmann, Ballard, and Tommelein, 2014; Liker, and Rother, 2011; Bassuk, and Washington, 2013; Tortorella, and Cauchick-Miguel, 2018). However, there is little research on being a mentor in the process of developing competencies that are necessary for effective problem-solving in the A3 Thinking approach (Shook, 2012; Alnajem, 2021).

Taking into account the importance of the effectively implemented problem-solving process (including the A3 Thinking approach) for the organisation and the benefits of mentoring, the author, during meetings with representatives of Polish organisations operating in the Lean environment, searched for information about their use of mentoring in the A3 Thinking approach. Unfortunately, cases of using such an approach were extremely rare and did not involve the creation of internal mentoring programmes, but rather only the goodwill and commitment of managers. However, people using mentoring declared numerous benefits resulting from this approach to developing the competences of employees. This was a contribution to conducting systematic research on the use of mentoring in the process of developing competences necessary for the effective implementation of individual steps of A3 Thinking. The author centred her attention on Polish business organisations operating in the Lean environment. The author's additional motivation was willingness to disseminate knowledge about the possibility of applying mentoring in teaching the A3 Thinking approach.

In her work, the author posed the following research questions:

- RQ1. What paths of developing mentoring competences have Polish Lean managers chosen, and which competences of a mentor do they consider to be crucial in their work?
- RQ2. How do Polish managers working in the Lean environment implement mentoring in the problem-solving process in the A3 Thinking approach?
- RQ3. What difficulties do managers encounter most often when mentoring problem owners and what benefits of mentoring in the analysed area they perceive?

Problem owners should be understood as persons who have been indicated by the organisation management to solve a specific problem and are responsible for solving it.

In order to answer the research questions, the author conducted a literature search and an empirical study, a multiple case study, among Polish managers operating in the Lean environment, conducting five partially structured in-depth interviews with mentor-managers. The study results made it possible to collect information on: the development paths of Polish managers-mentors operating in the Lean environment, conducting mentoring under A3 Thinking; their way of working with their mentees; opinions on mentor competences which they consider relevant for mentoring in A3 Thinking; the difficulties they encounter in this process and the benefits of using mentoring to teach the aforementioned problem-solving approach.

The information obtained can be a guidepost and motivation for Lean managers to deal with the topic of mentoring. They can also be used as input data to the development of a mentoring programme in the A3 Thinking approach teaching process.

2. Mentoring in the problem-solving process using the A3 Thinking method

Problem-solving is a complex activity that requires continuous development of competences while the implementation of A3 Thinking in an organisation is associated with many difficulties, as indicated by the authors of the publication (Saad et al., 2013; Tortorella, Viana, and Fettermann, 2015; Tortorella, Cauchick-Miguel, and Gaiardelli, 2018; Oliveira, and Nodari, 2010; Arantes, and Giacaglia, 2013; Silva Filho, and Calado, 2013; Sobek II, and Jimmerson, 2004; Sobek, and Smalley 2011; Shook, 2012). In order to solve problems effectively, theoretical knowledge should be combined with knowledge about the organisation and responsibilities. To do this, it is not sufficient enough to complete studies, a course or participate in training. Many years of experience are needed, a change in the way of thinking about problems and the ongoing filling of gaps in knowledge that appear in specific situations. In this way, the employee becomes an expert in a given field. Inexperienced employees willingly use expert advice. This helps them speed up the learning process, be more effective and more productive and become full-fledged employees quicker. An expert can become a good teacher if he or she takes the time to do so and develops competences that allow him or her to teach effectively. Unfortunately, in organisations you often work under the pressure of time. Instead of letting employees discover, under the watchful eye of the master, the emerging clues, they are overwhelmed with ready-made solutions. Their role is reduced to mechanically, thoughtlessly filling out the A3 Report. Do such activities allow for effective teaching?

What can improve the effectiveness of educating employees, especially problem owners? How to make them become masters of the A3 Thinking approach?

2.1. Mentoring

One of the methods of effective competency development which is widely described in the literature is mentoring. Mentoring in the organisation has developed as a response to the need to support employees in their pursuit of development and achievement of the assumed goals (Myjak, 2016, p. 137). It is a relationship of master and apprentice in which the entrant draws from the master's experience, and the master transfers knowledge to the entrant over a longer period of time. This relationship is based on full voluntariness, constant contact, relationship dynamism, and focuses on inspiring. Mentoring has been studied extensively, but as Clutterbuck says, the "father" of modern mentoring, intensively does not mean well. Clutterbuck believes that the problem is the errors in structure and definition (Clutterbuck, 2013). So there are as many definitions of mentoring as there are researchers.

According to the authors, mentoring is: a process in which learning and development are stimulated and supported (Parsloe, and Wray, 2002, p. 81); a method of supporting young people in their development by the care of a more experienced and older person over a younger and less experienced one (Karwala, 2007, p. 27); it is voluntary help which is independent of

the official hierarchy, given by one person to another, owing to which he or she can make progress in their knowledge, work, or way of thinking (Clutterbuck, 2002).

Mentoring can take the form of either an informal relationship or a formal programme (Czekaj, 2007; Wanberg, Welsh, and Hezlett, 2003). Regardless of the degree of formalisation of this relationship, we can talk about patronage and development mentoring. In the patronage model, the mentor is more influential, usually takes a higher position in the hierarchy, actively advocates for the mentee, promotes them, guides them in gaining experience and gathering resources. The development model, on the other hand, is focused on joint development, the mentor helps the student enrich their knowledge and act independently, has more experience in a given area, helps the student to make small discoveries, owing to which the student can direct his/her own development (Megginson et al., 2008, p. 30).

Mentoring, apart from the individual form (student-master; one-on-one), can also take the form of group mentoring. There are also specific advantages and disadvantages of both approaches (Myjak, 2016).

Implementing mentoring in an organisation gives a number of benefits for the organisation, the mentored employees as well as the mentors themselves. According to Sidor-Rządkowska, mentoring is a valuable supplement to the organisation's training policy, it allows for supporting knowledge and diversity of the management processes, supports the idea of life-long learning, influences the development of managerial competences and it is a kind of prevention of the so-called "burnout". It also allows you to build alternative career paths (Sidor-Rządkowska, 2016). In addition, the benefits include accelerated promotion rates, greater job mobility, higher overall salaries and remuneration packages, greater personal and professional satisfaction, increased professional confidence, increased self-esteem, reduced stress related to the implementation of new tasks, reduction of work-family conflicts, or a sense of greater agency in the organisation (Burke, 1984; Chao, Walz, and Gardner, 1992; Dreher, and Ash, 1990; Wright, and Wright, 1987; Johnson, 2003). Mentoring supports management processes by increasing the value of human and social capital, supports an individual in increasing his or her independence, and prepares them to take responsibility for themselves (Krzyszminiewska, 2016). The mentors themselves also benefit. Mentoring allows for the constant development of a mentor, gaining greater respect among employees, and increasing job satisfaction. Ayoobzadeh and Boies also indicate that in the case of mentor-managers, if they themselves provide their mentees with a higher level of mentoring, they experience an improvement in the leader's identity and feeling of self-efficacy (2020). Ślęzak-Gładzik (2016), among others, writes about the benefits as well.

The implementation of the mentoring process is associated with many difficulties that mentors face. Research shows mentors' doubts about their initial role and tasks, anxiety connected with uncertainty about their skills, difficulties in understanding what the expectations of the mentees, frustration related to the mentees not showing up to the arranged meetings, limited time to support the mentees, fear that they are doing too little or that they do not have the competences to teach and conduct meetings (Gonçalves, and Bellodi, 2012). The threats

resulting from the implementation of a mentoring programme in an organisation stem from many aspects. On the one hand, the direct superiors of mentored people may feel threatened as regards developing the competences of their subordinates, which, moreover, is related to the opinion that the immediate supervisor should not be a mentor. Other threats include: improper selection of the candidates for mentors, lack of training support, improper selection of mentor-mentee pairs, insufficient, poorly planned or organised information campaign, or maladjustment of the mentoring programme to the organisation's specificity (Sidor-Rządkowska, 2016).

According to Gambade, the mentor's tasks include: providing feedback, sharing knowledge, opinions and feelings, encouraging discovery, defining barriers, indicating methods of action, supporting, encouraging, and observing (2013, pp. 16-17). At this point, it is worth adding active listening and asking the right questions. Rowley believes that a good mentor is committed to the role of mentoring, accepting of the beginner mentee, skilled at providing instructional support, effective in different interpersonal contexts, is a model of continuous learner, who communicates hope and optimism (Rowley, 1999).

What competencies are required of a good mentor? The most frequently mentioned competences include: knowledge and skills in the field of work, knowledge of the principles and techniques of mentoring, attitude towards one's own professional work and towards the mentee, self-awareness (understanding oneself), behavioural awareness (understanding others), sense of proportion/humour, communicativeness, conceptualisation (understood as the ability to analyse and evaluate information, giving information the right structure), uninterrupted self-education, interest in the development of others, managing a mentoring relationship, clarity of the goals, the ability to delegate work to others, maintaining confidentiality, the ability to communicate empathy, respect, compassion to the mentees, observation and feedback skills (Sidor-Rządkowska, 2014; Ślęzak-Gładzik, 2016; Clutterbuck, 2002; Johnson, 2003; Orth, Wilkinson, and Benfari, 1987). The virtues highlighted are integrity (personal honesty to develop trust in a relationship), protectiveness, care, and prudence (Johnson, 2003). The mentor should also present some manifestations of creative thinking to be able to show unconventional paths to the mentee. Pietroń-Pyszczyk and Golej (2018) writes about the necessity to develop creative thinking in the mentees under their care, and to have critical and analytical thinking skills (Gantz, 2010; Orth, Wilkinson, and Benfari, 1987).

The essence of mentoring today does not only come down to personal development, but it covers a wider scope, a broader perspective (Flaszewska, Lewicka, 2020). One of the directions of development is to provide support while learning specific methods, tools, or approaches to management, including problem-solving in the A3 Thinking approach.

2.2. A3 problem-solving

A3 Thinking reflects the PDCA (Plan, Do, Check, Act) cycle and it is based on a scientific approach to creating knowledge in an organisation (Marksberry, Bustle, and Clevinger, 2011).

It is a kind of scientific storytelling about a problem, supported by a detective flair, rationality of action, as well as critical, holistic, visual, and creative thinking. The result of the work is entered in the individual fields of the A3 Report. The report is usually completed by the problem owner, i.e. the person responsible for solving it. The work, on the other hand, takes place in teams. The A3 report is a worksheet containing several sections that complement each other when solving a specific problem. It is recommended to include data and information in graphic form. Its layout and the way of completing the sections allows it to be placed among visual management instruments (Simons et al., 2014). An A3 report typically includes the following sections (Sobek II, and Jimmerson, 2004; Shook, 2012; Sobek, and Smalley, 2008; Dennis, 2015; Liker, and Meier, 2011; Koskela et al., 2020): Theme – problem definition; Background – relevant background information that is necessary to understand the scope and severity of the problem; how the problem was detected; what is the business context of the problem; Current Condition – information about the current results of the process; facts collected at source, resulting from observations and measurements, quantified and presented graphically; Target Statement/Future Goal – determining what results are desired and what results are to be achieved; Root Cause Analysis – identifying the causes of the problem, determining what is the essence of the problem, asking more and more questions ("5 Why's"), looking for cause-effect relationships, developing a set of causes; Countermeasures/Target Condition – proposed solutions, methods of counteracting the problem, improvement proposals, graphic presentation of the target state; Implementation Plan - defining the steps to be taken in order to achieve the target state, their order, identification of responsible persons, implementation deadlines, scheduling activities, supervising the status of activities; Follow-up Action – information on how actions will be reviewed in order to make sure that the problem has been eliminated; the last stage is drawing conclusions and knowledge sharing.

In order to efficiently and effectively solve problems applying the A3 Thinking approach, it is necessary to develop specific competences. The authors indicate the following competences necessary for effective problem-solving using the A3 Thinking approach (Shook, 2012; Sobek, and Smalley, 2008): the ability to apply various ways of thinking and reject opinions and use facts; the ability to analyse data, investigate the situation, detective work; ability to define problems; the ability to observe, ask questions, listen and draw conclusions, reflect; ability to think independently, initiative; responsibility; the ability to see opportunities in emerging problems, openness to various possibilities, the ability to generate unconventional solutions; the ability to tell stories; the ability to think contextually, identify and analyse coexisting factors related to something; ability to set standards; the ability to reach consensus and agreement; the ability to admit mistakes and ignorance; the ability to involve other people in activities; the ability to look to the future; teamwork skills; the ability to graphically present data and information.

A mentor in the problem-solving process should be an expert who possesses a high level of the above-mentioned competences in order to be able to teach them. At the same time, he/she should develop the competences necessary for effective mentoring.

3. Methods

Although the A3 Thinking approach to the problem-solving process seems to be intuitive and thoroughly described in the literature, in practice it turns out to cause many difficulties for organisations. These can include: bias in data collection, bias, rigid approach to problems, basic attribution errors and other cognitive errors, making decisions based on opinions rather than evidence, tendency to skip the steps of problem analysis, misidentification of the problem to be solved, inadequate information gathering connected to the situation in which the problem occurs, difficulties in generating innovative ideas (Shook, 2012; Saad et al., 2013; Tortorella, Viana, and Fettermann, 2015; Tortorella, Cauchick-Miguel, and Gaiardelli, 2018; Oliveira, and Nodari, 2010). Introducing mentoring for problem owners can help to overcome them. However, this is not a common practice in Polish enterprises operating in the Lean environment.

The author conducted systematic research on the use of mentoring in the process of developing employees' competences necessary for the effective implementation of individual steps of A3 Thinking.

In order to answer the research questions posed by the author, a literature study and an empirical study were carried out. Since the research questions begin with the question: "how?" and "what?" the author chose qualitative research, multiple case studies with the use of in-depth interviews as the most appropriate research method. Thanks to case analysis, it is possible to confront one's own reasoning with the conduct of real participants of events and processes (Sławińska, and Witczak, 2008, p. 121). The case study is empirical in nature, it is reliable collection and processing of data that can be compared with each other (Yin, 1994, p. 23).

The research method adopted by the author is made up of three stages: stage I – a literature query according to previously established criteria, correlated with research questions and goals (the information obtained was used, *inter alia*, to construct an interview sheet); stage II – empirical research (multiple case studies with the use of partially structured in-depth interviews to maintain data consistency); stage III is the preparation of results, drawing conclusions, and giving proposals for further research.

The objectives of the empirical study were:

- to indicate which paths for the development of mentoring competences were chosen by Polish Lean managers, and which mentor competences they consider to be crucial in their work,
- to indicate how Polish managers working in the Lean environment implement mentoring in the problem-solving process in the A3 Thinking approach,
- to indicate what difficulties managers encounter when mentoring problem owners most often and what benefits they perceive from mentoring in the analysed area.

Information connected with in-depth interviews:

- the author conducted 5 in-depth interviews, based on partially structured interview questionnaires, where the respondents were Polish managers working in the Lean environment, in three different industries,
- the interview questionnaire consisted of 80 questions (open and closed-ended ones), divided into five groups of questions,
- the participants of the study were managers (men) with many years of experience in problem-solving using the A3 Thinking method (from 3 to 9 years),
- the call to participate in the study was posted on 30 March, 2021 on LinkedIn, and the study was conducted in April 2021 (telephone interviews and video calls using Internet connection); the interviews lasted from 1.5 hours to 2.5 hours,
- 6 people expressed their willingness to participate in the study, of whom 5 met the initial assumptions (at least two years of experience in problem-solving with the A3 Thinking method and experience in mentoring in the A3 Thinking method).

One of the limitations of the study is the possibility of reporting the willingness to participate in the study only of people for whom sharing knowledge and supporting others in their development is a passion.

4. Results

The study presents the results of research on the use of mentoring in the process of developing the competences of problem owners employed in organisations operating in a Lean environment, in the context of problem-solving in the A3 Thinking approach. Five mentor-managers replied to the interview questionnaire. The study participants were coded with a number from 1 to 5, resulting from the order of the interviews. The interview questionnaire included 80 questions, both open and closed-ended ones, divided into five groups: introduction and general information; mentoring the competence development pathway and mentor's key competences; the way of implementing the mentoring process in the A3 Thinking approach;

difficulties and benefits; additional notes. The respondents defined the mentored person as a protégé, student, mentee, or intern. For the purposes of this study, in order to standardise the terminology, the term "mentee" was adopted. The mentee is a person responsible for problem-solving in the organisation, also known as the problem owner, who is in the process of developing his/her competences in problem-solving. In each of the organisations represented by the study participants, problem owners are appointed, and the mentored mentees are people with higher education, short work experience, working in white-collar positions.

The research participants implement development, informal, spontaneous, direct mentoring (it happens that they use instant messaging or phones in their contacts). Only Mentor No. 5 carries out formal mentoring, based on a mentoring programme introduced in the organisation half a year ago. Mentor No. 5, however, declared that he had already mentored one of the mentees (before the formal programme was introduced). Mentors do not plan and carry out mentoring sessions, but focus on supporting the mentees at the next stages of the problem-solving process, depending on the needs.

All organisations represented by managers participating in the survey use the A3 Thinking approach to problem-solving, and the survey participants are experienced Lean managers and have been using the A3 Thinking approach for years. They also declare that they are mentors, although not always for their subordinates. Therefore, they meet the author's initial assumptions and could participate in the study.

Table 1 presents the basic information on the study participants.

Table 1.

Basic information on the study participants

	Mentor No. 1	Mentor No. 2	Mentor No. 3	Mentor No. 4	Mentor No. 5
Age	45 years old	38 years old	49 years old	52 years old	45 years old
Sex	male	male	male	male	male
Industry represented	automotive	food	automotive	automotive	manufacturing, household appliances
Organisation size (number of employees)	from 51 to 250	from 51 to 250	above 251	from 51 to 250	from 51 to 250
Seniority	22 years	13 years	27 years	29 years	21 years
Seniority in Lean	7 years	8 years	10 years	11 years	8 years
How many years has the respondent been using the A3 Thinking approach in the problem-solving process?	5 years	8 years	9 years	6 years	3 years
For how many years has the respondent been using mentoring in the A3 Thinking problem-solving process?	0.5 a year	one year	one year	one year	1.5 years

Cont. table 1.

Mentoring scope	only in the A3 Thinking approach	only in the A3 Thinking approach	not only in the A3 Thinking approach	only in the A3 Thinking approach	only in the A3 Thinking approach
Number of mentees	1	1	4	1	2
Are the mentees functionally dependent on the mentor?	no	yes, immediate superior	yes and no	yes, immediate superior	no
Which party proposed mentoring?	mentor	mentee	mentor	mentor	mentor
How long has the mentor study the A3 Thinking approach?	2 years	2 years	one year (with the support of a mentor)	2 years	one year
Did the mentor have a mentor's support?	no	no	yes	no	no
How long has the process of teaching the mentee the A3 Thinking approach been going?	from half a year to one year	from half a year to one year	from four months to even a year	from half a year to one year	from half a year to one year
Does the respondent create development programmes for the mentees?	no, but I will prepare them	I have a general concept	no	no	yes
Has the respondent created his own programme of developing mentor competences?	no, but I have now understood that it is important	yes, I like to have everything planned	no	no	no, but we have programmes in the organisation

Note. own study.

The following subsections contain brief descriptions of individual cases. The sections correspond to the order of the research questions asked. Descriptions concern the examined scope of mentoring, i.e., support in solving problems in the A3 Thinking approach.

4.1. Mentor No. 1

The path of developing mentoring competences and the mentor's key competences

"Mentoring for me is a process of developing the competences of my mentees". The respondent declares that he developed his mentoring competences on his own. He himself had not had a mentor before, but he came across an interesting article about mentoring and that made him interested in the topic. In the literature, he fumbles around in the dark, rather haphazardly. He did not identify competences that he should develop. He does not rate the available materials very well. He believes that most of them are connected with mentoring personal development. A study on the competences that he should develop among the mentees, along with tips on how to do it best would be valuable to him. He does not feel like a real mentor, but tries to develop continuously. During mentoring, he learns to be patient,

and the mentor's key competences are in his opinion: knowledge about work and the ability to apply it, communicativeness, knowledge of the principles and techniques of mentoring, the ability to listen and show respect. He has never created a development programme for himself, but during an interview he decided to create one. The mentoring goal for him will be to crystallise the development path and develop creative thinking. He is motivated well enough to pursue it.

The way of implementing the mentoring process in the A3 Thinking approach

He believes that it is easier to mentor someone for whom you are not a direct supervisor. He lacks the support of his superiors and the development of mentoring among other managers. Knowledge and experiences could be shared. He practices mentoring irregularly, depending on the mentee's needs. The other managers are a bit sceptical about his actions. The immediate supervisor of the mentee is not satisfied. The respondent does not define the goals, expectations and boundaries, but as he stated, he will probably start to do so, because it is a good idea. Periodically, as part of reflection, he analyses the results of his work with the mentee and tries to improve his technique. His support usually concerns specific problems, but if he finds that one of the competences of the mentee needs to be worked on, he returns to it. He believes that mentoring helps him in being a better manager for his subordinates. Meetings with the mentee take place at *gemba* or the mentor's office. There is no possibility to observe the mentee at work, but he places importance on asking questions and is always eager to listen. He has no problem with establishing relationships, he is open to people.

Difficulties and additional remarks

- lack of support from the company's management (resources, time) and the ward's immediate superior, unfavourable organisational culture,
- he was informed that the management was wondering why he wanted to learn so much about other people's problems, but he was not discouraged yet,
- a lot of incomprehensible literature,
- A3 Thinking notices the most difficulties in implementing the steps at the stage of collecting data and looking for root causes,
- his suggestions regarding the inclusion in the training plan in the context of specific competences of the mentee/ward are not taken into account; believes that emphasis should be placed on developing critical and holistic thinking among problem owners; it is difficult for the mentee to concentrate and listen carefully; during each meeting, discusses with him exercises to improve these competences.

4.2. Mentor No. 2

The path of developing mentoring competences and the mentor's key competences

"Mentoring for me means supporting the development of mentees in the agreed scope". He is self-taught in the field of mentoring. He searches for materials on the Internet and buys

books. He makes development plans. He likes to have everything planned. He evaluates the available literature as average. Usually, he finds something that does not fall within his scope and wastes his time on reading it. He became interested in mentoring when his mentee, a subordinate employee, came to ask for help. They had a good discussion, and they worked together well, they even stayed behind after working hours. In the end that employee told him that he could be a mentor. He likes helping others, he builds relationships easily, so he became interested in it. He believes that the key competences and qualities of a mentor are: willingness to learn, knowledge, providing feedback, listening skills, understanding, good knowledge of the organisation, the ability to create lasting relationships based on respect and trust. His mentoring goal is to deepen his knowledge about effective education techniques. He has no problems with motivation. He is driven by the mentee's enthusiasm.

The way of implementing the mentoring process in the A3 Thinking approach

A formal mentoring programme does not exist in the organisation. Being the immediate supervisor of the mentee does not make his job easier. He fears that other employees may feel treated in an unequal way. He tries to lead his mentee by the hand through all the steps of A3 Thinking and constantly improve his competences at each stage of work. He believes that he feels good enough with A3 Thinking that he can help others. During mentoring, he constantly learns something new. He is often forced to look for hints in the literature. He likes to be in *gemba* the most, and this is where he most often conducts mentoring. He tries to meet his mentee regularly, although they do not plan meetings in advance. He never leaves questions posed unanswered. He does not evaluate progress because he does not define expectations. He declares that he will start doing it.

Difficulties and additional remarks

- lack of support from superiors, including in terms of finding time for mentoring,
- supervisors do not understand the value of mentoring,
- he notices the most difficulties in implementing the steps of A3 Thinking at the stage of searching for root causes,
- the least developed competences of problem owners are: the ability to select, analyse and interpret data, especially relating them to the context, a holistic view of the problem, objectivity, and the ability to reflect.

4.3. Mentor No. 3

The path of developing mentoring competences and the mentor's key competences

"Mentoring for me is developing the skills of my mentees". He himself experienced mentoring many years ago. As he claims, it was not named that way back then. He maintains close contact with his mentor to this day. It was his mentor who made him start helping others. He tries to continuously develop. He participated in a mentoring training once and the employer covered the costs of this training. He believes it was a good investment. However, he obtains

most of his knowledge himself. He believes that there is too much literature and sometimes he does not know what to choose. Sometimes, he made wrong choices. He feels like a real mentor. He believes that he is predisposed to it, he understands people, he can read their emotions. In his opinion, the most important competences of a mentor are: of course, knowledge of a given topic, communication skills, sense of humour, interest in the development of other people and oneself, empathy, understanding, and patience. His goal is to learn foreign languages. Maybe he could become a mentor without borders.

The way of implementing the mentoring process in the A3 Thinking approach

There is no formal mentoring programme in the organisation. He does not force anyone to cooperate, but the employees come to him themselves. Maybe that is why he says that he likes to joke. Since the employees started to turn to him for support, he had begun to help others develop in a more organised way. His wife is not happy because he sometimes answers phone calls from his mentees at home, also about personal matters. He considered setting boundaries, expectations. He is pleased that, according to the employees, their motivation to work has increased since his mentoring started. However, he believes that if he does not "feel chemistry with someone", he does not declare that he will help that person in the long run. He treats them a little like his own children. As he says: "they feel taken care of". Maybe also because they see his commitment, passion, and it drives them. It happens that they themselves ask what they can help him with, because they see that he is unable to do everything in a timely manner. He is an advocate of creating a mentoring standard for the A3 Thinking approach. The immediate superiors of his mentees do not mind the mentoring activities at all. And when he is the manager, mentoring has had a positive impact on his relationship with the employee. He said: "One of my charges got a better job offer and left the company, but he still talks to me and he still, gives him advice". He believes that the mentee has already outgrown him. He believes that mentoring is more effective than mass training, but it is more time-consuming.

Difficulties and additional remarks

- he compensates the lack of possible bonuses for activities with the joy of continuous development,
- no time; it is an additional, time-consuming activity,
- no training in mentoring in the present organisation,
- he notices the most difficulties in implementing the steps of A3 Thinking at the stage of collecting data and generating ideas for improvement, as he claims, unconventional,
- the mentees are the worst at being objective, with long-term planning and generally dealing with more data and information; they focus too much on statistical data and have a hard time interpreting them, it would also be useful to develop their creativity.

4.4. Mentor No. 4

The path of developing mentoring competences and the mentor's key competences

"Mentoring for me means supporting my mentees in gaining new knowledge and skills". The respondent's adventure with mentoring began with the words of an employee: "Boss, you can explain it in a nice way." He learns to be a good master for others himself. He lacks support and thinks good, concise material is difficult to come by. He wishes he had had a mentor earlier. Since he "plays" in mentoring, he has jumped out of the routine associated with his professional work. He points to the following key competences of a mentor: mastery in the base field, the ability to cooperate and understand others, knowledge of mentoring and effective teaching of others, the joy of constantly learning something new, and communicativeness. The mentoring goal is to be the best teacher possible.

The way of implementing the mentoring process in the A3 Thinking approach

The organisation lacks a formal mentoring programme. He regrets that he has little time and mentoring is quite irregular. However, he tries to devote every free moment to his mentee. They meet in his office or in the hall. Being a direct supervisor does not bother him. He even thinks that he is a better boss because of that. He is already watching over another mentee. Mentoring improved communication with the employee and developed a common style of communication. The respondent does not create programmes, does not set limits, and does not define goals. He claims that he prefers to act spontaneously, it gives him joy, fun, and satisfaction. The mentee calls him "my guide". The mentee appreciates an individual approach, and you can see that he is trying harder, as if he wanted to prove something. The mentor does relieve him, he only guides him. He also does not analyse the results of mentoring. He claims to feel if there is progress.

Difficulties and additional remarks

- lack of management's interest in extending the scope of mentoring and possibly remunerating for additional work,
- little time and no support (e.g., reimbursement of the cost of books or training),
- he notices the most difficulties in implementing the steps of A3 Thinking at the stage of data collecting and searching for root causes,
- the mentees are the worst at interpreting data in relation to a given situation, at being objective; they fall into the trap of looking for data confirming their assumptions.

4.5. Mentor No. 5

The path of developing mentoring competences and the mentor's key competences

"Mentoring for me means participation and support in developing the required competences in my mentees". First, he developed his passion himself, because helping others is his passion. A year ago, his organisation conducted a series of mentoring training sessions. He evaluates them very well and much better than the available literature. During the first month of reading on the Internet, he was unable to define what mentoring was. While searching for materials, he came across several interesting publication titles, but they were unavailable to him. He has not purchased access to the publication databases. He said it would be good if the scientific studies were available to the general public. He is waiting for someone to publish something simple and clear in the message, as was discussed during the training. He points to the following key competences of a mentor: knowledge, the ability to cooperate and communicativeness. His mentoring goal is to think outside the box and teach the same to his mentees.

The way of implementing the mentoring process in the A3 Thinking approach

There is a formal mentoring programme in the organisation, but its activities are only just getting started. The respondent determines the expectations, boundaries, cooperation rules, since the system is formalised. He has not yet managed to assess in accordance with the system's assumptions. He meets his mentees quite regularly, mainly in the hall or in the conference room. He teaches his mentees how to be detectives and have fun at the same time. His favourite question during meetings is: "What if?" He tries to follow the A3 Thinking process step by step with his mentees. When necessary, they stop and come back. They often work in a team. They have endless discussions and the mentor loves to ask questions. However, this results in a backlog in the mentor's base work. So far, his proposals for training for mentees developing specific competences have not been accepted. He does not understand the whole system a bit.

Difficulties and additional remarks

- despite the mentoring programme, there are no financial benefits so far,
- the programme is quite formal and the expectations assessment system seems to discourage mentoring, there is a lot of bureaucracy,
- he devotes a lot of his private time,
- he notices the most difficulties in implementing the steps of A3 Thinking at the stage of data collecting and looking for root causes; claims that coming up with interesting and wise solutions flounders as well,
- the mentees are worst at dealing with statistics, but also with creative thinking, two different poles of thinking.

Table 2 lists the benefits of mentoring most frequently indicated by the respondents, broken down into benefits for the mentor, mentee, and organization.

Table 2.

Selected benefits of using mentoring in the A3 Thinking approach indicated by the respondents

For the mentor	For the mentee	For the organisation
<ul style="list-style-type: none"> - fun, pleasure - better mood - greater job satisfaction - change of mindset - more respect from colleagues - distinction (if someone chooses us to be mentors) - continuous development and they modify their approaches to the matter - consolidation of knowledge - structuring knowledge - in order to learn something, it must first be organised - developing knowledge about learning processes - participation in the idea of lifelong learning - continuous development of competences, often resulting from unconventional questions of the mentees 	<ul style="list-style-type: none"> - more efficient problem-solving - increase in motivation to work - greater self-confidence when working on solving a problem in a given team, - greater commitment and willingness to speak in the forum - developing the way of thinking about problems characteristic of the A3 Thinking approach - developing knowledge about problems and ways of solving them - developing knowledge about the processes implemented in the organisation - a broader view of problems and processes - seeing interactions in processes and the impact of the problem-solving process on the company's development - developing a detective talent or a talent for finding out-of-the-box solutions - opportunity to be promoted - better relationships 	<ul style="list-style-type: none"> - efficient problem-solving process - shorter time for people responsible for solving problems to gain experience - easier and wisely aided adaptation of new employees responsible for solving problems - improving communication in the organisation in the problem-solving process - the employee feels more connected with the organisation, which affects employee rotation - revealing tacit knowledge in the use of A3 Thinking, resulting from experience (support for knowledge management processes) - increases loyalty to the organisation and job satisfaction - better relations among employees - supporting the employee training policy

Note. own study.

The mentors also emphasised that before starting helping others, it is good to first get to know yourself, your strengths and weaknesses, and the methods of work. They also claim that mentoring in the A3 Thinking approach is based on believing by yourself that problems create opportunities, are an opportunity for development and improvement. Otherwise, the mentor will be unreliable.

5. Discussion

“No problems, that's a problem” (Shook, 2012, p. 2). Problems have always been and will always be. An appropriate approach to solving them is therefore crucial in the process organisation improvement. A mentor-manager, trying to teach his mentees to effectively solve problems in the A3 Thinking approach, should try to understand the process of achieving results used by the mentee, the problem owner. This will allow him/ her to manage the learning process. One of Toyota's principles is that the right process, a process that is well designed and controlled, leads to good results. (Liker, 2005). Mentoring is a long-lasting process. Therefore,

it requires good preparation and planning. In addition to knowledge about processes, work, and responsibility that is gained through experience while working in a given organisation, a manager-mentor must also, as Shook emphasises, "learn to learn" (2012, p. 4). He or she has to lay out the entire A3 path, be able to read the A3 Report, but also find out if the process owner himself understands what he has described. Therefore, it is important to ask questions skilfully, actively listen, be able to think logically, but also to go beyond the patterns of reasoning, thinking outside the box and thinking visually.

Each of the managers surveyed defines mentoring in a similar way as a process, the path of developing human competences and supporting him/her during this journey. Comparing this with the definitions from the literature, one can conclude that each study participant understands what mentoring is and what is the essence of this approach to sharing knowledge and developing skills. The paths of developing the mentoring competences of the research participants were similar. They are self-taught. They search for knowledge and develop skills themselves. They are distinguished by their passion, enthusiasm, commitment, and willingness to help others. Certainly, these features are conducive to building good relationships with the mentees. Motivations to start searching for knowledge about mentoring are the impulse caused by the appreciation of their "natural" way of working with people or an interesting article. In the case of Mentor No. 3, it was his own mentor who influenced his willingness to help others. The survey participants regret that in their organisations mentoring is not an element of organisational culture, is not taken more seriously, and mentoring is not used. In the organisation represented by Mentor No. 5, a formal mentoring program was introduced half a year ago. Mentor No. 5 does not assess it very well, considering that it has introduced too much bureaucracy. On the other hand, the training conducted before the introduction of the programme is assessed very well by him.

The mentors rate the materials available on the Internet rather poorly. They notice the terminological chaos and find it difficult for them to navigate in the knowledge maze, much of which, as they emphasise, is worthless. They had no one to advise them on what to read. All of the respondents agree as to the fact that a good mentor should know well the scope of the work he is teaching. The aims in the context of mentoring, however, vary. These are: crystallising the path of development, expanding knowledge about effective learning techniques, learning foreign languages, or developing creative, out-of-the-box thinking skills. How many mentors, so many different individual goals. Contrastingly, they showed greater compliance with the key competences of the mentor-manager, pointing primarily to the knowledge of work and responsibility as well as: communication skills, knowledge of the principles and techniques of mentoring, the ability to listen, provide feedback, understanding, the ability to create lasting relationships based on respect and trust, sense of humour, interest in the development of other people and oneself, empathy, patience, the ability to cooperate and understand others, knowledge of effective learning of others, the joy of learning something else.

The research participants follow the mentoring process in a similar way. In four out of five cases, it is developmental, informal, and spontaneous mentoring. Only Mentor No. 5 conducts formal mentoring, based on a mentoring programme that has been in place for six months. Previously, however, his form of work was exactly the same as in the case of the other mentors. The mentors rather do not plan, define goals, and implement mentoring sessions, but focus on supporting their mentees at the next stages of the problem-solving process, depending on the needs. They act rather irregularly, intuitively, and do not assess progress. However, they found that it would be good to think about defining expectations and boundaries, or assessing progress. Mentor 2 has an overview of what he would like to achieve with the mentee, while Mentor 5 is obliged to formalise the work. The mentors first of all try to actively listen, observe, ask questions and work in the *gemba*. They encourage reflection, direct, teach a holistic view of the problem, try to develop detective skills in their mentees, especially valuable at the stage of evaluating the current situation and looking for problem sources. They also pay attention to developing critical thinking skills, as the problem, in their opinion, is the lack of objectivity and patterns of reasoning. They develop creative thinking in their mentees, which is important at the stage of generating solutions, as well as visual and holistic thinking, applicable throughout the problem-solving process. They try to teach long-term planning, analysing, interpreting data and relating them to the context, active listening and methods of focusing better. The respondents believe that the mentor should also "feel the chemistry" with the mentee.

The mentors also agree on the difficulties that have an impact on the quality of their mentoring work. These mainly include the following: lack of time, no bonuses for additional work, lack of interest in mentoring among top management, failure to provide training in mentoring and learning materials by the organisation, lack of support from the direct superiors of mentored persons. The most difficult problems for their mentees in the process of problem-solving in the A3 Thinking approach are the stages of data collection, searching for root causes and generating solutions.

The benefits of implementing the mentoring process indicated by the respondents can be divided into benefits for the mentors, mentees, and organisation. Table 2 shows selected benefits of mentoring in the A3 Thinking approach indicated by the respondents.

Mentor-managers believe that mentoring makes them better managers. They believe that every manager should teach how to be a mentor. Mentoring a direct subordinate is something valuable, it improves communication and relationships, however it can lead to a situation where other subordinate employees may feel they are treated unequally.

To sum up, the task of the mentor-managers is to develop employees. Quoting the sentence from the TWI (Training Within Industry) card: "If the employee has not learned, it means that the instructor has not taught them" (Graupp, and Wrona, 2010, p. 13). The mentor-manager must therefore continuously develop his or her own competences.

6. Summary

The practice of management is associated with continuous problem solving. Therefore, the quality of the improvement activities in the organisation depends on the quality of the problem-solving process. Regardless of which path or method of problem-solving a given organisation chooses, its effectiveness will depend on the knowledge and skills of people who implement it. The A3 Thinking approach focuses on changing the way of thinking about problems and acting according to strictly defined steps. However, the effective implementation of each of the steps requires the development of specific competences, and the A3 Thinking approach itself is also a set of knowledge about problem-solving. Therefore, emphasis should be placed on effective processes of developing competences among problem owners, i.e., people responsible for solving them. What can improve the effectiveness of educating employees, especially problem owners? How to make them become masters of the A3 Thinking approach? In the literature of management and quality sciences, the use of mentoring is suggested more and more often and boldly.

The author, as part of a qualitative research, multiple case study, preceded by a literature query, conducted in-depth interviews with five Polish mentor-managers operating in a Lean environment to obtain answers to the research questions posed. This made it possible to achieve the objectives of the study, including obtaining answers to questions about: paths of developing mentoring competences of Polish Lean managers and mentor competences indicated by them as key; ways of implementing the mentoring process in the A3 Thinking approach; difficulties in mentoring problem owners and the benefits of mentoring in the area studied. The obtained data and information are described in detail in sections 4 and 5 of this study.

This study provides information on mentoring in the problem-solving process in the A3 Thinking approach and the experiences of Polish mentor-managers. Due to its nature, the results of the study cannot be used as a basis for generalisation. However, they can be used as input data for designing problem solving/Lean Management training programme and for creating mentoring programmes in the process of learning the A3 Thinking approach. They can also be a signpost and motivation for Lean managers to deal with the subject of mentoring. This will educate and develop effective problem owners.

References

1. Alnajem, M. (2021), Learning by doing: an undergraduate lean A3 project in a Kuwaiti bank". *The TQM Journal*, 33(1), pp. 71-94. doi: 10.1108/TQM-01-2020-0010.
2. Anderson, J.S., Morgan, J.N., and Williams, S.K. (2011). Using Toyota's A3 Thinking for Analyzing MBA Business Cases. *Decision Sciences Journal of Innovative Education*, 9(2), pp. 275-285. doi: 10.1111/j.1540-4609.2011.00308.x.
3. Arantes, A., and Giacaglia, G. (2013). *Melhoria de resultados de confiabilidade dos equipamentos, pela aplicação do Hoshin Kanri, associado ao Relatório A3*. IX Congresso Nacional de Excelência em Gestão, Rio de Janeiro: Universidade Federal Fluminense, pp. 1-22. Retrieved from https://www.inovarse.org/artigos-por-edicoes/IX-CNEG-2013/T13_0628_3463.pdf, 8 Jan. 2021.
4. Ayoobzadeh, M., and Boies, K. (2020). From mentors to leaders: leader development outcomes for mentors. *Journal of Managerial Psychology*, 35(6), pp. 497-511. doi: 10.1108/JMP-10-2019-0591.
5. Bassuk, J.A., and Washington, I.M. (2013). The A3 problem solving report: a 10-step scientific method to execute performance improvements in an academic research vivarium. *PLOS ONE*, 8(10), p. e76833. doi: 10.1371/journal.pone.0076833.
6. Burke, R.J. (1984). Mentors in Organizations. *Group & Organization Management*, 9(3), pp. 353–372. doi:10.1177/105960118400900304.
7. Chao, G.T., Walz, P.M., and Gardner, P.D. (1992). Formal and informal mentorships: A comparison on mentoring functions and contrast with nonmentored counterparts. *Personnel Psychology*, 45(3), pp. 619-636. doi: 10.1111/j.1744-6570.1992.tb00863.x.
8. Clutterbuck, D. (2002). *Każdy potrzebuje mentora. Jak kierować talentami*. Warszawa: Petit.
9. Clutterbuck, D. (2013). *The problems with research in mentoring*. Retrieved from <https://coachingandmentoringinternational.org/wp-content/uploads/CMI-Article-The-problems-with-research-in-mentoring.pdf>, 7 Apr. 2021.
10. Czekaj, J. (2007), *Metody organizacji i zarządzania*. Kraków: Wydawnictwo Akademii Ekonomicznej.
11. Dennis, P. (2015). *Lean Production Simplified: A Plain-Language Guide to The World's Most Powerful Production System*. 3rd ed. New York: Productivity Press. doi: 10.1201/b18961.
12. Dreher, G.F., and Ash, R.A. (1990). A comparative study of mentoring among men and women in managerial, professional, and technical positions. *Journal of Applied Psychology*, 75(5), pp. 539-546. doi: 10.1037/0021-9010.75.5.539.
13. Flaszevska, S., and Lewicka, D. (2020). Mentoring w procesie dzielenia się wiedzą w przedsiębiorstwie. In: Cewińska, J., Krejner-Nowecka, A., and Winch, S. (Eds.),

- Zarządzanie kapitałem ludzkim – wyzwania* (pp. 151-159). Warszawa: Szkoła Główna Handlowa.
14. Gambade, G. (2013). Mentoring – tajniki skutecznej realizacji. *Personel plus*, 9, pp. 16-17.
 15. Gantz, N. (2010). *101 Global Leadership Lessons for Nurses*. Canada: Renee Wilmeth.
 16. Gonçalves Mde C., and Bellodi P.L. (2012). Mentors also need support: a study on their difficulties and resources in medical schools. *Sao Paulo Medical Journal*, 130(4), pp. 252-258. doi:10.1590/s1516-31802012000400009.
 17. Graupp, P., and Wrona, R.J. (2010). *Podręcznik TWI. Doskonalenie niezbędnych umiejętności przełożonych*. Wrocław: Wydawnictwo Lean Enterprise Institute Polska.
 18. Johnson, W.B. (2003). A Framework for Conceptualizing Competence to Mentor. *Ethics & Behavior*, 13(2), pp. 127-151, doi: 10.1207/S15327019EB1302_02.
 19. Karwala, S. (2007). *Model mentoringu we współczesnej szkole wyższej*. Retrieved from <http://www.repozytorium.wsb-nlu.edu.pl/handle/11199/8339>, 4 Apr. 2021.
 20. Koskela, L., Broft, R.D., Pikas, E., and Tezel, A. (2020). *Comparing the Methods of A3 and Canvas*. In: Tommelein, I.D. and Daniel, E. (eds.). Proc. 28th Annual Conference of the International Group for Lean Construction (IGLC28) [online]. Berkeley: IGLC28, pp. 13-24. Retrieved from <https://iglc.net/Papers/Details/1838>, 11 Jan. 2021. doi.org/10.24928/2020/0136.
 21. Krzyminiewska, G. (2016). Mentoring w podmiotach ekonomii społecznej. *Studia i Prace WNEIZ US*, 44(3), pp. 23-31, doi: 10.18276/sip.2016.44/3-0.
 22. Liker, J.K. (2005). *Droga Toyoty. 14 zasad zarządzania wiodącej firmy produkcyjnej świata*. Warszawa: MT Biznes.
 23. Liker, J.K., and Meier, D.P. (2011). *Droga Toyoty. Fieldbook*. Warszawa: MT Biznes.
 24. Liker, J.K., and Rother, M. (2011). *Why lean programs fail*. Lean Enterprise Institute. Retrieved from <https://www.lean.org/Search/Documents/352.pdf>, 25 Jan. 2021.
 25. Loyd, N., Harris, G.A., and Blanchard L. (2010). *Integration of A3 Thinking as an Academic Communication Standard*. In: A. Johnson and J. Miller (eds.). Proc. the 2010 Industrial Engineering Research Conference. The University of Alabama, pp. 1-6. Retrieved from: <https://uahcmer.com/wp-content/uploads/2010/11/FINAL-Integration-of-A3-Thinking-as-an-Academic-Communication-Standard.pdf>, 10 Jan. 2021.
 26. Marcinek, J. et al. (2010). *Ilustrowana Encyklopedia Powszechna. Tom III*. Kraków: Wydawnictwo Zielona Sowa.
 27. Marksberry, P., Bustle, J., and Clevinger, J. (2011). Problem solving for managers: a mathematical investigation of Toyota's 8-step process. *Journal of Manufacturing Technology Management*, 22(7), pp. 837-852. doi: 10.1108/17410381111160924.
 28. Megginson, D., and Clutterbuck, D. (1995). *Mentoring in Action*, London: Kogan Page.
 29. Megginson, D., Clutterbuck, D., Garvey, D., Stokes, P., and Garret-Harris, R. (2008) *Mentoring w działaniu. Przewodnik praktyczny*, Poznań: Rebis.

30. Myjak, T. (2016) Developing the Potential of Employees Through Mentoring in Organizations Based on Knowledge. *Roczniki Ekonomii i Zarządzania/Towarzystwo Naukowe Katolickiego Uniwersytetu Lubelskiego Jana Pawła II*, 8(2), pp. 137-149. doi: 10.18290/reiz.2016.8(44).2-8.
31. Oliveira, N., and Nodari, C. (2010). *Metodologia do Relatório A3 para solução de problemas*. Universidade Federal do Rio Grande do Sul, Porto Alegre. Retrieved from <https://www.lume.ufrgs.br/handle/10183/32228>, 8 Feb. 2021.
32. Orth, Ch.D. Wilkinson, H.E., and Benfari, R.C. (1987). The manager's role as coach and mentor. *Organizational Dynamics*, 15(4), pp. 66-74. doi:10.1016/0090-2616(87)90045-3.
33. Parsloe, E., Wray, M. (2002). *Trener i mentor. Udział coaching i mentoring w doskonaleniu procesu uczenia się*. Kraków: Oficyna Wydawnicza.
34. Perlaki, I. (1974). Metody i etapy rozwiązywania problemów w praktyce zarządzania. *Organizacja i Kierownictwo*, 12, p. 21.
35. Perloff, J., and Carlton, D. (2004). *Modern Industrial Organization*. Englewood Cliffs: Prentice-Hall.
36. Pietroń-Pyszczyk, A., and Golej, R. (2018). Mentoring z perspektywy rozwoju kompetencji twórczych. *Studia i Prace WNEiZ US*, 51(2), pp. 77-86. doi: 10.18276/sip.2018.51/2-07.
37. Rowley, J.B. (1999). The Good Mentor. *Educational Leadership*, 56(8), pp. 20-22.
38. Saad, N., Al-Ashaab, A., Maksimovic, M., Zhu, L., Shehab, E., Ewers, O., and Kassam, A. (2013). A3 thinking approach to support knowledge-driven design. *The International Journal of Advanced Manufacturing Technology*. 68(5-8), pp. 1371-1386. doi: 10.1007/s00170-013-4928-7.
39. Shook, J. (2012). *Zarządzać znaczy uczyć. Rozwiązywanie problemów i rozwój pracowników z wykorzystaniem metody A3*. 2nd ed. Wrocław: Wydawnictwo Lean Enterprise Institute Polska.
40. Sidor-Rządkowska, M. (2014). *Mentoring. Teoria, praktyka, studia przypadków*. Kraków: Wolters Kluwer.
41. Sidor-Rządkowska, M. (2016). Wdrażanie programu mentoringu w przedsiębiorstwie – korzyści i zagrożenia. *Kwartalnik Nauk o Przedsiębiorstwie*, 40(3), pp. 62-71.
42. Silva Filho, O., and Calado, R. (2013). Learning supply chain management by PBL with A3 report support. In: *6th IFAC Conference on Management and Control of Production and Logistics*, Fortaleza: IFAC Proceedings Volumes, 46(24), pp. 471-477. doi:10.3182/20130911-3-br-3021.00115.
43. Simons, F.E., Aij, K.H., Widdershoven, G.A.M., and Visse M. (2014). Patient safety in the operating theatre: How A3 thinking can help reduce door movement. *International Journal for Quality in Health Care*, 26(4), pp. 366-371. doi:10.1093/intqhc/mzu033.
44. Sławińska, M., and Witczak, H. (2008). *Methodological basis of doctoral theses in economic sciences*. Warsaw: PWE.

45. Sobek, D.K., and Smalley, A. (2008). *Understanding A3 Thinking: A Critical Component of Toyota's PDCA Management System*. New York: CRC Press. doi: 10.4324/9781439814055.
46. Sobek, D.K., and Smalley, A. (2011). *Common Mistakes in A3 Report Writing*. [Blog] A3 Thinking. Retrieved from <http://a3thinking.com/blog/?p=153>, 12 Dec. 2020.
47. Sobek, D.K. II, and Jimmerson, C. (2004). *A3 reports: tool for process improvement*. Proceedings of the Industrial Engineering Research Conference. Houston, pp. 1-6. Retrieved from <https://www.lean.org/Search/Documents/133.pdf>, 10 Feb. 2021.
48. Ślęzak-Gładzik, I. (2016). Mentoring jako metoda wspierająca rozwój potencjału pracowników. *Coaching Review*, 1(8), pp. 177-194. doi: 10.7206/cr.2081-7029.41.
49. Tillmann, P., Ballard, G., and Tommelein, I. (2014). *A Mentoring Approach to Implement Lean Construction*. Proc. 22nd Ann. Conf. International Group for Lean Construction, Oslo, Norway, 25-27 June, pp. 1283-1293. Retrieved from <https://iglcstorage.blob.core.windows.net/papers/attachment-43bb28a1-8ec4-466a-987c-eab2db17abb3.pdf>, 10 Jan. 2021.
50. Tortorella, G., and Cauchick-Miguel, P.A. (2018), Teaching lean manufacturing at a postgraduate level: Integrating traditional teaching methods and problem-based learning approach, *International Journal of Lean Six Sigma*, Vol. 9 No. 3, pp. 301-323. doi: 10.1108/IJLSS-08-2017-0101.
51. Tortorella, G., Cauchick-Miguel, P.A., and Gaiardelli, P. (2018). Hoshin Kanri and A3: a proposal for integrating variability into the policy deployment proces. *The TQM Journal*, 31(2), pp. 118-135. doi:10.1108/TQM-06-2018-0076.
52. Tortorella, G., Viana, S., and Fettermann, D. (2015). Learning cycles and focus groups: A complementary approach to the A3 thinking methodology. *The Learning Organization*, 22(4), pp. 229-240. doi:10.1108/TLO-02-2015-0008.
53. Wanberg, C.R., Welsh, E.T., and Hezlett, S.A. (2003). Mentoring research: a review and dynamic process model. *Research in Personnel and Human Resources Management*, 22, pp. 39-124. doi:10.1016/s0742-7301(03)22002-8.
54. Wright, C.A., and Wright, S.D. (1987). The role of mentors in the career development of young professionals. *Family Relations: An Interdisciplinary Journal of Applied Family Studies*, 36(2), pp. 204-208. doi: org/10.2307/583955.
55. Yin, R.K. (1994), *Case Study Research. Design and Methods*. Newbury Park: Sage Publication.

AGILE-TRANSFORMATION BY ORGANIZATIONAL DEVELOPMENT PROJECTS

Sergiy BUSHUYEV^{1*}, Victoria BUSHUIEVA², Maryna LAZAREVA³,
Svitlana ONYSHCHENKO⁴, Natalia PAVLOVA⁵

¹ Kyiv National University of Construction and Architecture, Kyiv, Ukraine; sbushuyev@ukr.net,
ORCID: 0000-0002-7815-8129

² Kyiv National University of Construction and Architecture, Kyiv, Ukraine; ORCID: 0000-0001-7298-4369

³ Kyiv National University of Construction and Architecture, Kyiv, Ukraine; ORCID: 0000-0002-7573-1268

⁴ Odesa National Maritime University, Odesa, Ukraine; ORCID: 0000-0002-728-4939

⁵ Odesa National Maritime University, Odesa, Ukraine; ORCID: 0000-0001-7528-2370

* Correspondence author

Purpose: Agile transformation is a necessary process for companies in various fields of activity to ensure their competitiveness in modern business conditions, when the uniformity of production processes and the growth of the level of customer (client) demands reduce the impact of traditional ones that remain competitive.

Design/methodology/approach: Modern business is a "customer-oriented" business, in which instead or in addition to technological or marketing advantages comes the highest value of human resources and teamwork. That means Agile transformation provides companies with a transition to another level, and those who have not moved to this level remain outside of competitiveness, if not in the near term, then in a strategic perspective.

Findings: Agile transformation is comparable to the need to introduce new technologies into production processes to replace obsolete ones, since without new technological solutions, the products created do not meet modern quality requirements or do not have a competitive cost price. Thus, Agile transformation ensures the introduction of new technology not only into the production process, but into the management system and product creation processes within the framework of project or project-oriented activities.

Originality/value Mathematical model of managing project portfolio for Agile transformation is new.

Keywords: Modelling, Agile, Transformation, Project Portfolio, Organizational Development.

Category of the paper: Research paper.

1. Introduction

Within the framework of Agile as Scaled Agile Framework (SAFe®) transformation, such a restructuring of the work of enterprises is carried out, in which the receipt of project

products is accelerated on the one hand, on the other hand, the most complete coordination of the project team is ensured both with the customer, and between team members, and with other project teams of the enterprise. Created by Dean Leffingwell (Scaled Agile Framework, 2018), SAFe (Scaled Agile Framework) is an interactive software framework that enables you to apply Lean-Agile and Scrum practices at large enterprises. SAFe Full Configuration consists of four levels: Team, Program, Large Solution and Portfolio. It is constantly being improved.

Agile transformation takes time and resources (for example, to develop and implement appropriate information platforms and decision support systems, create business process procedures, etc.) (Pavlova, Onyshchenko, Obronova, Chebanova, Andriievskaya, 2021, pp. 51-59; Bondar, Onyshchenko, 2020, pp. 21-30). Thus, this transformation is carried out through a number of relevant development projects, which must be organically coordinated with other areas of enterprise development projects. That is, the task arises of forming a portfolio of projects that meet both the traditional development goals and the goals of Agile transformation (Bondar, Bushuyeva, Bushuyev, Onyshchenko, 2020, pp. 141-145; Bondar, Onyshchenko, 2019, pp. 11-18).

2. Analysis of recent publications and problem statement

According to the existing approaches, described above, a portfolio of company development projects should meet strategic goals, taking into account their priority. Each goal is characterized by a specific quantitative indicator, for example, market share, profit level, production cost, etc. (Onyshchenko, Bondar, Andriievskaya, Sudnyk, Lohinov, 2019, pp. 33-42; Bondar, Bushuyev, Bushuieva, Bushuyeva, Onyshchenko, 2020, pp. 890-903). Let the company consider n priority strategic goals, for each of which a target indicator $V_i, i = \overline{1, n}$ is determined, the priority of the goals is characterized by their "weights" $\alpha_i, i = \overline{1, n}$, for which the following is fulfilled:

$$\sum_{i=1}^n \alpha_i = 1. \quad (1)$$

Development goals are determined by the state of the company itself, the competitive environment, marketing priorities, changing consumer demands, etc. What does the priority of goals affect? The opinions of experts on this matter, basically, boil down to the fact that projects that do not "cover" all the strategic goals, but only the most priority ones can be selected in the project portfolio. This is influenced, first of all, by the limited resources of companies. Thus, in this study, let us assume that the higher the priority goal, the more its corresponding target indicators should be achieved by the set of projects that are selected for implementation in the near future. Low priority goals may not be "met" by projects at all, or their targets are

only marginally met. This approach is adopted for subsequent modeling (Bondar, Bushuyev, Onyshchenko, Hiroshi, 2020, pp. 233-243; Bondar, Bushuyeva, Bushuyev, Onyshchenko, 2020, pp. 141-145).

Agile transformation is also an option for the development of companies, but this development is implemented through a whole set of specific projects, which in fact represent an Agile transformation program. Earlier it was noted that the main result of Agile transformation of companies is the acceleration of project completion times, obtaining project products, including on the basis of organizational, information and communication technologies, aimed at the implementation and use of various types of Agile tools (frameworks).

Thus, each company, depending on its vision of the final results of Agile transformation, can set by decomposition a set of corresponding local goals m , for each of which a target can also be set $A_j, j = \overline{1, m}$. Since Agile transformation is a kind of development program, the main goal for it is considered achieved when all local goals are achieved (Bondar, Bushuyev, Bushuieva, Bushuyeva, Onyshchenko, 2021). Therefore, it is not advisable to rank them in any way, since not achieving any of them leads to not achieving the results of the entire Agile transformation.

A conceptual model for forming a portfolio of company development projects taking into account its Agile transformation is shown in Fig. 1. Portfolio projects must, on the one hand, meet development goals, and on the other, meet the goals of Agile transformation.

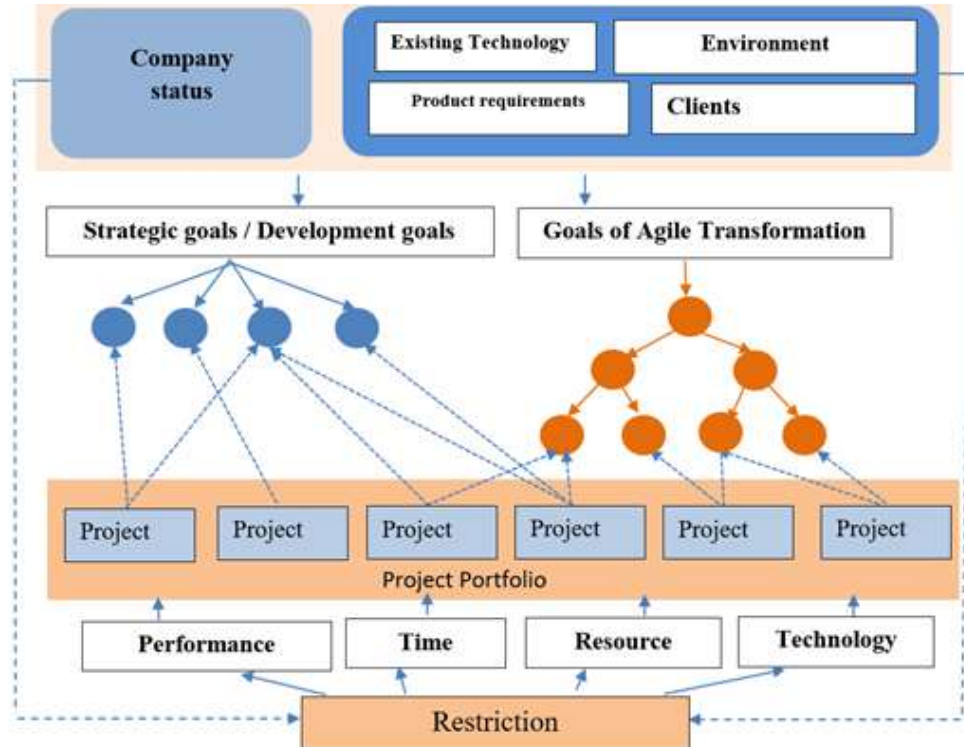


Figure 1. Conceptual model of the formation of a portfolio of development projects of the company, taking into account its Agile transformation.

Moreover, each project can contribute both to the achievement of one development goal, or several (the applied aspect of such compliance is demonstrated by the example of the technical development program in (Bondar, Bushuyev, Bushuieva, Bushuyeva, Onyshchenko, 2021; Onyshchenko, Leontieva, 2018, pp. 36-41)). In addition, the project can provide both the achievement of the development goal (s) and one or more goals of Agile transformation – for example, when it comes to a project for the implementation of a new information platform or a project for staff development. For the latter, the acquired new skills of the staff can be aimed both at mastering certain procedures of Agile frameworks and at improving the quality of service, stress resistance, etc. Thus, projects can be “multifaceted” from the point of view of both “traditional” strategic goals of the company development, and from the point of view of Agile transformation.

Naturally, a portfolio of projects is formed under objective constraints associated with both the company's capabilities (for example, in terms of resources) and the availability of certain resources and technologies on the market. Technologies also impose restrictions on the time of project implementation and their fundamental implementation. Efficiency in the traditional sense of individual projects or the portfolio as a whole should also be set in the form of the minimum acceptable frontier in accordance with the interests of the company. And, of course, time – if the results of projects and the portfolio as a whole are received in the wrong timeframe, which is expedient, then this does not, in fact, ensure the achievement of the set goals in terms of time. Thus, to ensure the success of development projects and Agile transformation, the portfolio as a whole, it is necessary that the products and project results are achieved on time. In (Bondar, Onyshchenko, 2019), in particular, it is indicated that in some situations it is required to invest with greater intensity to ensure the timely implementation of the project and the receipt of its product, this will allow timely and more efficient use of the result (for example, when launching a new product, or opening a new branch, etc.). If we are talking about Agile transformation projects, then the transition to a new level in this context later than all competitors will not give the necessary effect and result of this transformation. Thus, resources, time, efficiency and technology are the main constraints on a portfolio of development projects.

2.1. Identification of multiple characteristics of projects

According to modern project management methodology, the result of the project implementation can be defined as “value”. In (Bondar, Bushuyeva, Bushuyev, Onyshchenko, 2020; Bondar, Bushuyev, Bushuieva, Bushuyeva, Onyshchenko, 2021), it was proposed to use the degree of “contribution” to the achievement of company goals as the value of projects. Thus, taking this approach as a basis, we will take the following value for the value of each project:

$$PV_k = \sum_{i=1}^n \alpha_i \frac{V_i^k}{V_i} + \sum_{j=1}^m \frac{A_j^k}{A_j}, k = \overline{1, K}, \quad (2)$$

where:

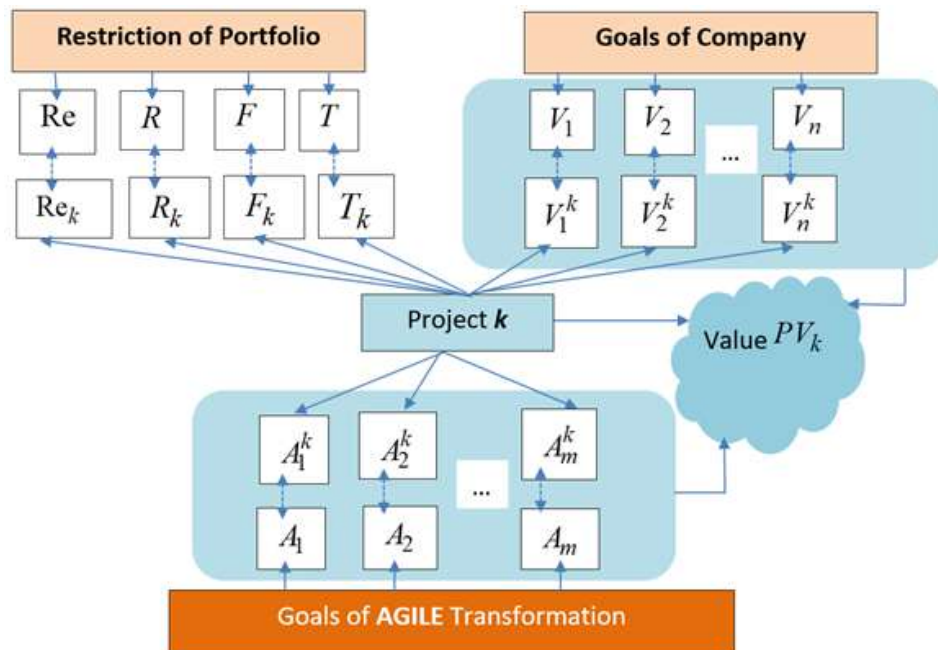
PV_k is the value of the k -th project for the company,

K is the total number of projects under consideration, is the contribution V_i^k of the k -th project to the achievement of the i -th development goal, is the contribution of the k -th project to the achievement of the j -th goal of Agile transformation.

So, each project can be described by a whole set of characteristics reflecting what is necessary for its implementation, and what is expected as a result of its implementation, including its value in terms of achieving the company's goals, both development in the traditional sense and Agile transformation as a specific development program.

In addition to the above values – the contributions of projects to the achievement of goals, the traditional set of characteristics for the k -th project includes (Fig. 2):

- Re_k – the required resources in financial terms,
- F_k – economic efficiency,
- R_k – risks in monetary terms (for example, possible deviation ΔF_k , or increased costs ΔRe_k),
- T_k – time of project realization.



Re – available resources, F – economic efficiency, R – risks, T – the time of realization of this portfolio of projects in terms of achieving its goals.

Figure 2. A set of project characteristics used for the model of forming a portfolio of company development projects in the process of its Agile transformation.

Note that a portfolio of projects in the general case is a dynamic structure to which projects can be added, taking into account the emergence of new goals. Therefore, we believe that the implementation period is T the period for the established composition of projects, taking into account the established goals of the company.

Naturally, the set of project characteristics can be expanded taking into account the specifics of the company's field of activity and approaches to the formation of a project portfolio. In this study, the main task is to form a generalized model that establishes a balance between the necessary development (achievement of strategic goals) and the goals of Agile transformation. Thus, individual aspects of the set of development projects can be introduced into the model as characteristics of projects and portfolio constraints.

Note that the proposed value estimate (2) can be used in the processes of selecting projects outside the model, for example, if there are few alternative projects, or, conversely, with a sufficiently large number of alternative projects for their primary "filtering".

2.2. The model for forming the optimal composition of the project portfolio

The characteristics of projects highlighted above correspond to the main characteristics of the project portfolio, which are the basis for establishing the criterion and limitations of the portfolio. So, the integral achievement of a set of goals (strategic/development and Agile transformation) is taken in this study as the main criterion for forming a portfolio of projects. Resources, time, efficiency and risks are the main characteristics of the portfolio, which are set as the constraints of the model.

So, let a set of alternative projects be formed, with a total of $K + L$ both to ensure development goals (K projects) and to ensure Agile transformation (L projects). Analysis of projects allows us to establish their characteristics in terms of achieving the considered integral set of goals, as well as those that correspond to the main limitations of the portfolio (see Fig. 2).

Let's introduce the variables $x_k = \{0;1\}, k = \overline{1, K}$ that are responsible for the selection of a particular development project $y_l = \{0;1\}, l = \overline{1, L}$ in the portfolio – for the selection of projects related to Agile transformation. To ensure the achievement of the integral set of goals, we introduce a criterion of the following form:

$$Z = \sum_{i=1}^n \alpha_i \left(\sum_{k=1}^K \frac{V_i^k}{V_i} \cdot x_k + \sum_{l=1}^L \frac{V_i^l}{V_i} \cdot y_l - 1 \right)^2 + \sum_{j=1}^m \left(\sum_{l=1}^L \frac{A_j^l}{A_j} \cdot y_l + \sum_{k=1}^K \frac{A_j^k}{A_j} \cdot x_k - 1 \right)^2 \rightarrow \min. \quad (3)$$

The values $\frac{V_i^k}{V_i}, \frac{V_i^l}{V_i}, \frac{A_j^l}{A_j}, \frac{A_j^k}{A_j}$ are relative values characterizing the achievement of each

goal of the company, thanks to the implementation of a specific project. The use of relative values eliminates the problem of target heterogeneity. Ideally, the achievement of the

company's goals by a portfolio of projects should be 100% ensured, that is, it should be completed

$$\sum_{k=1}^K \frac{V_i^k}{V_i} \cdot x_k + \sum_{l=1}^L \frac{V_i^l}{V_i} \cdot y_l = 1, \quad (4)$$

$$\sum_{l=1}^L \frac{A_j^l}{A_j} \cdot y_l + \sum_{k=1}^K \frac{A_j^k}{A_j} \cdot x_k = 1. \quad (5)$$

Therefore, in (3), the distance between the actual indicators of $\left(\sum_{k=1}^K \frac{V_i^k}{V_i} \cdot x_k + \sum_{l=1}^L \frac{V_i^l}{V_i} \cdot y_l - 1 \right)$

achieving goals as a result of the implementation of portfolio projects and ideal ones is used. Note that in (3) the “largest” elimination of inconsistencies is carried out for the goals with the highest weights. The quadratic form of this criterion minimizes the “distance” between the portfolio results and the integral set of goals. At the same time, in (3) it is taken into account that Agile transformation projects can contribute to the achievement of strategic goals, as well as the opposite, development projects can ensure the achievement of Agile transformation goals. Thus, the “versatility” of the project results is taken into account. That is why, in accordance with (2), the most valuable is a project that either “covers” a significant number of goals, or “covers” one goal as much as possible, and the most priority one when it comes to strategic/development goals. Note that the value of projects is used in a somewhat implicit form in (3), the criterion ensures the selection of those projects that, in aggregate, have the maximum value for the company, taking into account both the current strategic/development goals and the goals of Agile transformation.

The value:

$$\sum_{i=1}^n \alpha_i \left(\sum_{k=1}^K \frac{V_i^k}{V_i} \cdot x_k + \sum_{l=1}^L \frac{V_i^l}{V_i} \cdot y_l \right) + \sum_{j=1}^m \left(\sum_{l=1}^L \frac{A_j^l}{A_j} \cdot y_l + \sum_{k=1}^K \frac{A_j^k}{A_j} \cdot x_k \right) \quad (6)$$

can be interpreted as the value of a portfolio of projects, thus (3) maximizes the value of a portfolio of projects for the company by minimizing the discrepancy between its results and goals.

It should be noted that in some cases, individual goals may not simply have a higher priority set by the aid (for goals not directly related to Agile transformation). The need to ensure a certain minimum degree of goal achievement can be specified in the form of constraints of the form:

$$\sum_{k=1}^K \frac{V_i^k}{V_i} \cdot x_k + \sum_{l=1}^L \frac{V_i^l}{V_i} \cdot y_l \geq S_i, i = \overline{1, n}, \quad (7)$$

where $0 \leq S_i \leq 1$ is the minimum permissible degree of achievement of the i -th goal.

Similar constraints can be formed for the purposes of Agile transformation:

$$\sum_{l=1}^L \frac{A_j^l}{A_j} \cdot y_l + \sum_{k=1}^K \frac{A_j^k}{A_j} \cdot x_k \geq S_j^a, j = \overline{1, m}, \quad (8)$$

where $0 \leq S_j^a \leq 1$ is the minimum permissible degree of achievement of the j -th goal of Agile transformation.

Thus, taking into account conditions (7), (8), the model will ensure not only the maximization of the value of the project portfolio, but also its minimum allowable boundary, taking into account each aspect of the value reflected by a specific goal from the considered integral set.

So, having decided on the criterion for the formation of a portfolio, we will establish the main limitations of the model. The first and foremost is the limitation on available resources (in monetary terms):

$$\sum_{k=1}^K Re_k \cdot x_k + \sum_{l=1}^L Re_l \cdot y_l \leq Re, \quad (9)$$

at the same time, a restriction can be introduced separately for projects related to Agile transformation:

$$\sum_{l=1}^L Re_l \cdot y_l \leq Re^a, \quad (10)$$

Where Re^a – is the limiting amount of resources that the company is ready to spend on the transition to another qualitative level from the point of view of Agile.

Portfolio risk limit:

$$\sum_{k=1}^K R_k \cdot x_k + \sum_{l=1}^L R_l \cdot y_l \leq R. \quad (11)$$

We will assume that the risks are assessed in monetary terms, as a possible increase in costs or a shortfall in profit from commercial projects. Since in this study the issues related to various aspects of the portfolio, with the exception of Agile transformation, are not the main ones, we will restrict ourselves to an introduction to the consideration and consideration of risks without delving into their essence and assessment methods.

Achievement of the set goals must be carried out within a certain time frame, therefore we will introduce a time limit:

$$\begin{aligned} T_k \cdot x_k &\leq T, k = \overline{1, K}, \\ T_l \cdot y_l &\leq T, l = \overline{1, L}. \end{aligned} \quad (12)$$

Note that projects may not start at the same time, and, most often, in practice, this happens in order to equalize the use of resources, first of all. In (Bondar, Onyshchenko, 2020), a model was proposed that took into account the options for the possible distribution of projects over time. But we consider it expedient, within the framework of the problem being solved,

not to take into account the different beginnings of projects. The task of forming a set of projects is aimed at their selection according to their compliance with the criterion, and the time distribution for optimizing resources should be carried out within the framework of a separate task – implementation planning. Thus, (12), in principle, allows for consideration projects, the term of which does not exceed a certain established one.

If a specific deadline is set for Agile transformation, then it is ensured by the fulfillment of the constraint:

$$T_l \cdot y_l \leq T^a, l = \overline{1, L} \quad (13)$$

for the case of absence of technological dependence of projects. If it is available, it is advisable to use the approach and form alternative options for the Agile transformation program, and make a choice within the model not of individual projects, but of the whole program. The use of this approach practically does not change the structure of the model, but changes meaningfully y_l , defining it as a variant of the Agile transformation program, while it becomes necessary to introduce a restriction that ensures the choice of only one such program:

$$\sum_{l=1}^L y_l = 1. \quad (14)$$

By the way, the number of projects in the portfolio can also be limited if there are certain reasons for this. In such a situation, a constraint of one of the following types can be introduced into the model:

$$\sum_{k=1}^K x_k \leq N, \quad (15)$$

$$\sum_{k=1}^K x_k + \sum_{l=1}^L y_l \leq N, \quad (16)$$

where N is the allowed number of projects in the portfolio.

The use of (15) or (16) is determined by both the scale of alternative projects and the vision of the company's management.

With regard to efficiency. For commercial projects, efficiency is the main attribute and, as a rule, determines the value of these projects. The portfolio includes both commercial projects and projects, the value of which is not associated with obtaining a clear economic effect, but affects its receipt in the future. For example, Agile transformation allows you to increase the number of orders (customers), which can be estimated as an increase in profits. But, as a rule, this effect "customer growth – profit growth" is laid down in the form of the target indicator of Agile transformation, that is, it is the essence of one of the $A_j, j = \overline{1, m}$.

In addition, profit growth, an increase in the company's assets, etc. can also be used as strategic goals/development goals (and this is most often the case in practice). Therefore, it makes practical sense to introduce into the model additional restrictions related to economic efficiency, such as:

$$\sum_{k=1}^K F_k \cdot x_k + \sum_{l=1}^L F_l \cdot y_l \geq F, \quad (17)$$

which provides the total minimum permissible efficiency frontier for the portfolio. It should be noted that it is advisable to set the lower limit of efficiency for each project only for commercial, investment projects, and this should be done before solving the problem of forming a portfolio of projects. Thus, projects that are related to purely commercial purposes, and that do not meet the necessary performance requirements, are not considered as alternatives. For those projects that are related to both commercial goals and other strategic goals, a minimum acceptable boundary $F_{g, g=\overline{1, G}}$ should be established, taking into account the specifics of the project, that is, compliance with one of the G selected categories:

$$F_k \cdot x_k, F_l \cdot y_l \geq F_g, k, l \in U_g, \quad (18)$$

where is the set of projects belonging to the category $g = \overline{1, G}$.

Thus, (3), (7)-(13), (15) (or (16)), (17), (18) constitute a model for the formation of a company's project portfolio in the process of its Agile transformation and allow us to establish such a set of projects, that aligns with both strategic/development goals and Agile transformation goals within a single limited budget.

Conclusion

Unlike existing approaches to the formation of a portfolio of projects, in this study, the value of each alternative project is determined both in terms of the company's strategic goals and in terms of the goals of Agile transformation. Thus, as the value of each project and portfolio as a whole, an integral indicator of their compliance with both the strategic goals and the goals of Agile transformation is taken. Setting time limits and the degree of achievement of each goal associated with the company's transition to a new level from the point of view of the Agile methodology, ensures maximum compliance (within the available budget) with the projected results of this transformation – the established values.

Further development of the proposed results is the concretization of the target indicators of Agile transformation at the substantive level, taking into account the specifics of the areas of activity of companies, which will allow the generalized model in a meaningful sense to be adapted and turned into applied ones, which will ensure their high practical value.

References

1. Scaled Agile Framework (SAFe®) (2018). <https://www.agilest.org/what-is-agile-knowledge-base/#agile-terms>.
2. Pavlova, N., Onyshchenko, S., Obronova, A., Chebanova, T., & Andriiievskia, V. (2021). Creating the agile-model to manage the activities of project-oriented transport companies. *Eastern-European Journal of Enterprise Technologies*, 1(3(109)), pp. 51-59. <https://doi.org/10.15587/1729-4061.2021.225529>.
3. Bondar, A., & Onyshchenko, S. (2020). Experimental studies of a model for optimizing the portfolio of a project-oriented organization based on the entropy concept. *Innovative Technologies and Scientific Solutions for Industries*, 4(14), pp. 21-30. <https://doi.org/10.30837/ITSSI.2020.14.021>.
4. Bondar, A., Bushuyeva, N., Bushuyev, S., & Onyshchenko, S. (2020). *Modelling of Creation Organisational Energy-Entropy*. 2020 IEEE 15th International Conference on Computer Sciences and Information Technologies (CSIT), Zbarazh, Ukraine, pp. 141-145, <https://doi.org/10.1109/CSIT49958.2020.9321997>.
5. Bondar, A.V., Onyshchenko, S.P. (2019). Optimization of project time parameters. *Management of Development of Complex Systems*, 39, pp. 11-18, <https://doi.org/10.6084/M9.FIGSHARE.11340629.V1>.
6. Onyshchenko, S., Bondar, A., Andriievskia, V., Sudnyk, N., Lohinov, O. (2019). Constructing and exploring the model to form the road map of enterprise development. *Eastern-European Journal of Enterprise Technologies*, Vol. 5/3(101), pp. 33-42, <https://doi.org/10.15587/1729-4061.2019.179185>.
7. Bondar, A., Bushuyev, S., Bushuieva, V., Bushuyeva, N., & Onyshchenko, S. (2020, September). *Action-Entropy Approach to Modeling of 'Infodemic-Pandemic' System on the COVID-19 Cases*. Conference on Computer Science and Information Technologies. Cham: Springer, pp. 890-903, https://doi.org/10.1007/978-3-030-63270-0_61.
8. Bondar, A., Bushuyev, S., Onyshchenko, S., Hiroshi, H. (2020). Entropy paradigm of project-oriented organizations management. *Proceedings of the 1st International Workshop IT Project Management (ITPM 2020)*, vol. 1. Lviv, pp. 233-243, <http://ceur-ws.org/Vol-2565/paper20.pdf>.
9. Bondar, A., Bushuyeva, N., Bushuyev, S., and Onyshchenko, S. (2020). *Modelling of Creation Organisational Energy-Entropy*. 2020 IEEE 15th International Conference on Computer Sciences and Information Technologies (CSIT), Zbarazh, Ukraine, pp. 141-145, <https://doi.org/10.1109/CSIT49958.2020.9321997>.

10. Bondar, A., Bushuyev, S., Bushuieva, V., Bushuyeva, N., Onyshchenko, S. (2021). Action-Entropy Approach to Modeling of ‘Infodemic-Pandemic’ System on the COVID-19 Cases. In: N. Shakhovska, M.O. Medykovskyy (eds.), *Advances in Intelligent Systems and Computing V. CSIT 2020. Advances in Intelligent Systems and Computing, vol. 1293*. Cham: Springer, https://doi.org/10.1007/978-3-030-63270-0_61.
11. Onyshchenko, S., Leontieva, A. (2018). Modeling of the optimal composition of the enterprise technical development program. *Technology audit and production reserves*, 5(2), pp. 36-41, <https://doi.org/10.15587/2312-8372.2018.146463>.

ORGANIZATIONAL CREATIVITY MANAGEMENT BASED ON THE INTELLECTUAL CAPITAL

Jelena DEMENTJEVA¹, Rimantas STAŠYS^{2*}

¹ Klaipeda University, Management department; jelena.dem@gmail.com, ORCID: 0000-0002-6857-6845

² Klaipeda University, Management department; rimantas.stasys@ku.lt, ORCID: 0000-0002-3991-5940

* Correspondence author

The aim of this research is the determination of the creativity management level in the organization and directions of its improvement.

Methodology: The empirical study was conducted using an integrated research method, i.e., using quantitative and qualitative research. A conceptual link between creativity and intellectual capital phenomena has been identified to underline the importance of *comprehensive* management of an organization's creativity.

Findings: Based on the system approach, a conceptual model of organizational creativity management based on intellectual capital has been developed. This model's core feature is six organizational creativity management areas that interact with intellectual capital components and management functions. The methods allow investigating the specificity of organizational creativity management and evaluating the overall creativity management level, making it possible to identify the guidelines for the improvement of organizational creativity management.

Originality/value: In this article, creativity is explored in the context of intellectual capital structure, emphasizing the importance of the comprehensiveness of organizational creativity management in terms of organization management. The integrated empirical research allowed recognizing the importance of organizational creativity management areas, their links, and interactions and assessing the organization's creativity management level.

Keywords: creativity, organizational creativity, intellectual capital, creativity management level.

Category of the paper: research paper.

Introduction

The phenomenon of creativity as a hardly tangible resource acquires a horizontal and interdisciplinary dimension, as it is crucial for management, economics, and other sciences and practical human activities. In recent times, the phenomenon of creativity has been interpreted

as a social and cultural aspect emphasizing the necessity of organizational creativity management for the effectiveness and continuity of an organization's operations. The ability to generate and implement new ideas, adapt quickly and flexibly to varied external conditions and make an upgrade are today's challenges for organizations. Integrating creativity as an organization's resource into the value chain and management is becoming a key factor in increasing the value-added of an organization to gain a competitive market advantage. Managing creativity creates an intangible value that increases the intellectual capital of an organization forming its specific knowledge, skills, and abilities.

The relevance of organizational creativity management presumes the conduction of a scientific research involving the identification of the connection between creativity and intellectual capital, the creation of an organizational creativity management model and methodology to assess the specificity of organizational creativity management and to establish the level of creativity management. This methodological tool will enable organizations to manage creativity effectively in pursuit of unique competencies and competitive advantage in markets over the long term.

The aim of the scientific research is the determination of the creativity management level in the organization and directions of its improvement based on the methods of the assessment of organizational creativity management developed based on intellectual capital.

The specificities of creative organization and organization's creativity and its management aspects are investigated by G. Morgan (1989), F. Damanpour (1991), D. Goleman, P. Kaufman, M. Ray (1992), G. Morgan (1993), L. Gundry, J. Kickul, C. Prather (1994), I. Nonaka, H. Takeuchi (1995), I. Nonaka, T. Teece (2001), T.A. Stewart (1997), R.E. Caves (2000), J. Henry (2006), A.M. González (2003), K. Starkey, S. Tempest, A. McKinlay (2004), I. Meriam (2005), C. Henry (2007), M. Jifeng, P. Gang, L. Edwin (2008), S. Madsen (2009), M. Dobson (2010), L. Girdauskienė, A. Savanevičienė (2010), J. Lerner (2012), N. Šedžiuvienė, J. Vveinhardt (2011), J. Almonaitienė (2011), L. Girdauskienė (2011, 2012), M. Bettiol, E. Di Maria, R. Grandinetti (2012), B. Litovchenko (2016), L. Bam, P.J. Vlok (2016), J. Antony (2016), I. Grabner, A. Klein, G. Speckbacher (2018) and others. The aspects of organizational creativity management in the context of economic sectors has been studied by D. Araya, M.A. Peters (2010), R.G. Kraus, J.E. Curtis (2000), M. Кольчугина (2008), A. B. Шевырев, M.H. Романчук (2008), J. Howkins (2013) and others.

However, the scientific research related to the interpretation and analysis of creativity as an almost intangible resource and the systematic management of creativity is somewhat fragmented, especially in the context of intellectual capital and its management (L. Edvinsson (1997), G. Roos & J. Roos (1997), T.A. Stewart (1997), N. Bontis (1998), R. Florida, (2003), A. Bradburn & E. Coakes (2004), R. Florida & J. Goodnight (2005), D. Grundey & D. Varnas (2006), E. McWilliam & S. Dawson (2008), V. Barkauskas (2009), L. Uzienė & J. Staliūnienė (2009), J. Howkins (2010), M. Cabrita & C. Cabrita (2010), A. Amiri et al. (2011), S. Krätke

(2012), A. Bonfour & L. Edvinsson (2012), C. Mellander & R. Florida (2014), Y. Chien (2015), F. Luiza (2016), B. Obeidat et al. (2017), H. Hussinki et al. (2017), S. Abualloush et al. (2018)).

The genesis of the creativity and intellectual capital

The concept of creativity in scientific literature is analysed as a person's trait, ability to solve problems, as a process or product of creative activity, and also as an interaction between the environment and the creator. It represents the modern diversity of interpretation of the creativity concept and the tendencies of creativity as a phenomenon. According to M. Rhodes (1961), creativity can be interpreted in four ways: 1) person means creativity as a person's trait; 2) process means creativity as a process (motivation elements, perception, learning, communication); 3) product means as a result of activity; and 4) press (environment) means creativity as a relationship of the creator with the environment.

The analysis of the concept of creativity in the context of organization's management shows that the phenomenon of creativity is interpreted from a social and cultural point of view emphasizing the necessity of creativity management for society, economy, business and organization management and efficiency of operations. Thus, it is obvious that the complexity of the creativity phenomenon in terms of management of organizations is reflected in the field concept and includes the social and cultural system approach.

The authors of the research state that the organization's creativity is an organization's ability to generate and implement ideas using internal and external competencies to achieve a competitive advantage. Organization's competences are the symbiosis of knowledge, skills and abilities of its internal and external participants. Organization's creativity is associated with the phenomenon of intellectual capital. Intellectual capital is a knowledge-based organization's resource, an effective management of which provides it with a special competitive advantage. The category of intellectual capital has three main features: 1) it is almost intangible or hardly tangible (Brooking, 1996; Sveiby, 1997); 2) therefore, it is difficult to calculate (Amiri et al., 2011; Howkins, 2013); 3) due to unclear identification it is difficult or almost unreproducible for competitors, which gives the organization a competitive advantage in the market and enables to create added value (Bradburn & Coakes, 2004; Užienė & Staliūnienė, 2009).

According to the identified features distinctive to intellectual capital, it can be stated that those features can be attributed to the phenomenon of creativity. The following is a model of the structure of intellectual capital (see Figure 1) depicting the place of creativity in the structure of such inexhaustible capital. It has been found that, subject to the interpretation of the concept of creativity, it is found in different structural parts of intellectual capital.

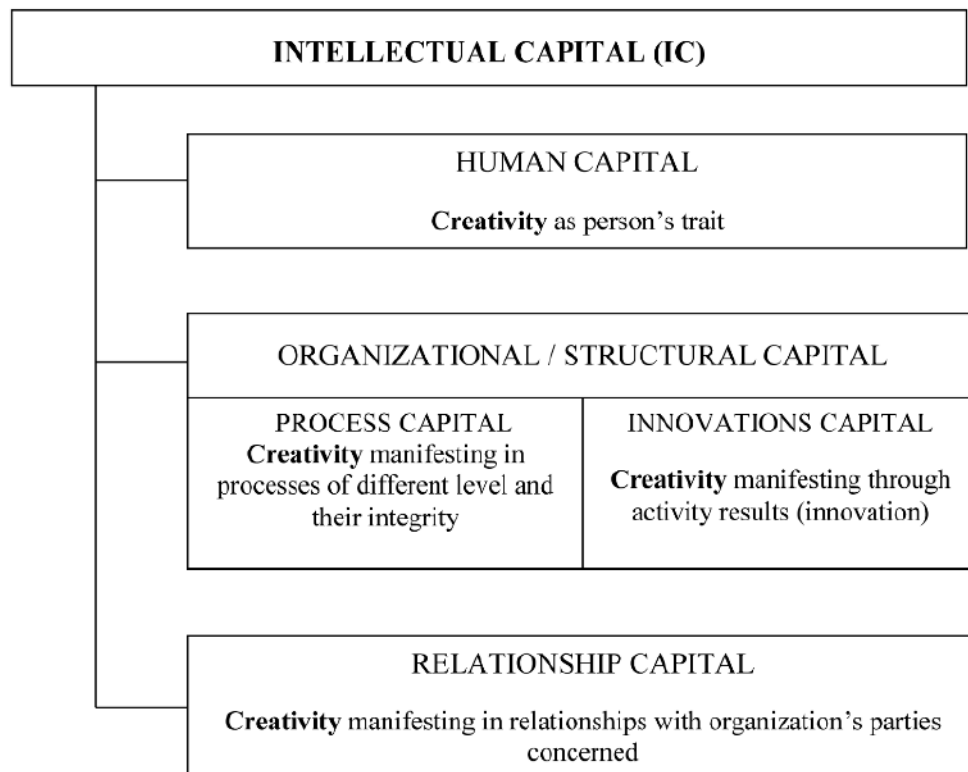


Figure 1. Manifestation of Creativity in the Structure of Intellectual Capital. Adapted from: L. Edvinsson (1997), K.E. Sveiby (1997), T.A. Stewart (1997), E. Campos (1998), J. Nahapiet & S. Ghoshal (1998), W. Johnson (1999), R. Mikulėnienė & R. Jucevičius (2000), H. Agndal & U. Nilsson (2006), P. Flöstrand (2006), G. Kamath, (2007), L. Vaškeliene & J. Šelepen (2008), A. Znakovaitė & A. Pabedinskaitė (2010), A. Amiri et al. (2011), G. Aryanindita & A. Budi (2011), S Abualoush et al. (2018).

The identification of creativity in every segment of intellectual capital gives rise to a systemic factor and the need to manage creativity, which is particularly important for profit-making organizations. The established points of interaction between creativity and intellectual capital clearly demonstrate the link between creativity and intellectual capital in a complex approach and provides a justification for the importance of organizational creativity management (see Figure 2). This Figure illustrates the relationship between creativity and forms of intellectual capital expression, which suggest the category of creative capital. This is actually the origination of the concept of creative capital.

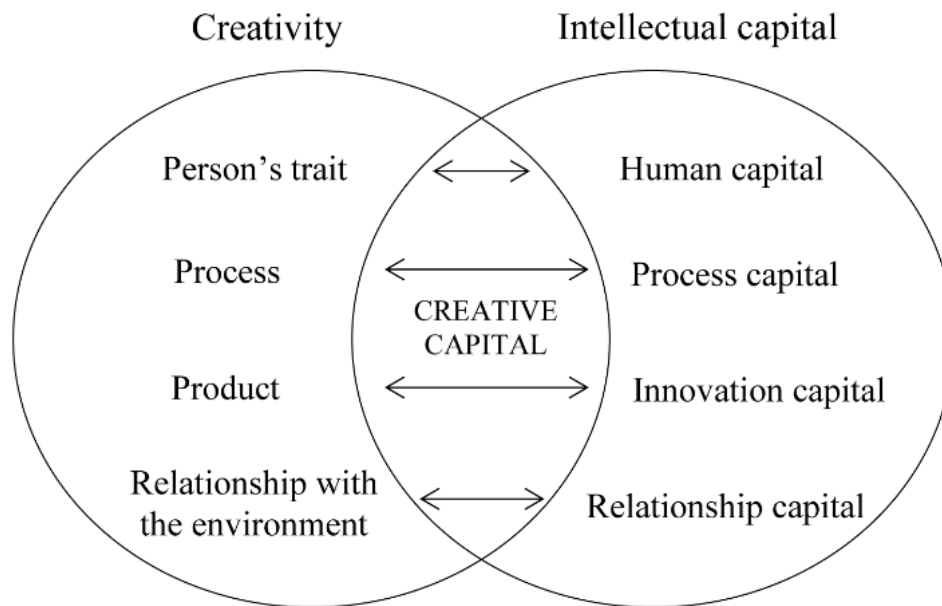


Figure 2. Relationship between Creativity and Intellectual Capital. Source: authors' own study.

According to J. Howkins (2013), it is logical to interpret creativity as a form of capital. It has the necessary features: It comes from investments that the owner can increase or change. This is a significant contribution to future creativity and creative products. Thus, creativity based on intellectual capital is not in itself an added value for an organization, it is an organization's ability to use its intellectual capital to gain added value. Organizational creativity management is the process of targeted planning, organizing, promoting, and controlling creativity for the purpose of competitive advantage by using the available intellectual capital resources.

According theoretical analysis of the organization's intellectual capital and organizational creativity management research, a conceptual theoretical model has been developed depicting the links between the areas of organizational creativity management and the components of intellectual capital, the management of which affects the acquisition of competencies, and the relationship with the external environment.

The model includes the main management functions that integrate into the fields of interaction between the areas of organizational creativity and intellectual capital. The entire conceptual model is based on the field concept and represents the interfaces of five fields (see Figure 3). Such fields are as follows:

1. Organization's competences.
2. Components of intellectual capital.
3. Management functions.
4. Areas of organizational creativity management.
5. Relationship with the external environment.

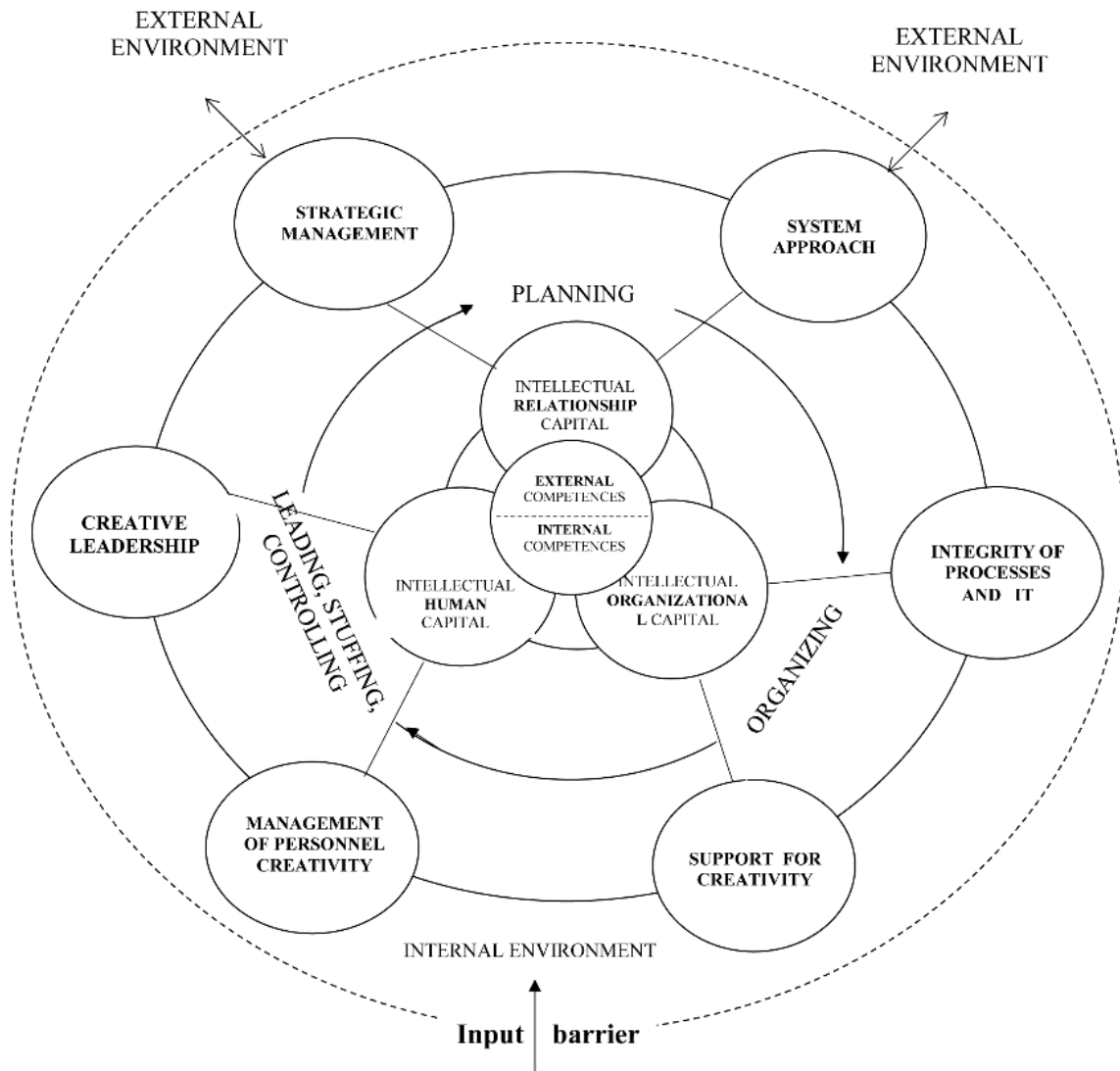


Figure 3. Theoretical Model of Creative Management Based on Intellectual Capital. Source: authors' own study.

The conceptual theoretical model has the following essential features:

- Organizational creativity management areas: creative leadership, management of personnel creativity, process and information technology integrity, support for creativity, strategic management, system approach. These areas are the dimensions of assessment of organizational creativity management.
- Links between the areas of organizational creativity management, components of intellectual capital (human, organizational, relationship capital), management functions (planning, organizing, leading, stuffing, controlling) and organization's competencies (internal, external).

Such areas of organizational creativity management as creative leadership and management of personnel creativity shape and generate the human capital. There is a general belief that management of creativity is actually related only to human resources (human capital). In the authors opinion, this dominant approach was formed by the perception of creativity as

a person's trait. However, a closer look at the concept of creativity makes it clear that organizational creativity management must also cover other aspects of management in organizations. Consequently, areas that shape and generate organizational capital become important in managing creativity. It is the integrity of processes and information technologies and the support for creativity that manifest through the organizational structure as well as the culture and the psychological climate prevailing in the organization.

Organizational creativity management areas (see Figure 3) that create human and organizational capital form the internal exclusive organization's competencies. Organizational creativity management on the basis of intellectual capital is closely linked to the relationship with the external environment of the organization. This connection is defined by the relationship capital generated by such areas of organizational creativity management as strategic management and system approach. All this helps the organization to develop its external competences. It is important to emphasize that the model developed has a systems nature, i.e. the model components describe (represent) the social and cultural aspect of an organization, which is a part of a social cultural system.

Methodology of the organizational creativity management based on intellectual capital

The analysis of creative management is based on a comprehensive adaptive theory that allows integrating different approaches. The analysis of scientific literature is conducted using the descriptive comparative method with a review of literature sources, methodologies, directions, approaches, and research results. This method has identified the areas of organizational creativity management and at the same time defined the concept of organization creativity from a system point of view as well as identified the specifics and aspects of creative management using a comprehensive approach within the context of intellectual capital.

The empirical research was conducted using an integrated research method, i.e. using quantitative and qualitative research: 1) the analysis and evaluation of the areas of organizational creativity based on intellectual capital were completed using written questionnaire and semi-structured interview. The processing of the data obtained through the questionnaire survey was based on statistical data analysis processed in SPSS program; 2) the assessment of the data obtained during the interviews was based on the content analysis; 3) the assessment of the overall organizational creativity management level using the integrated approach was based on the analysis of quantitative indicators (weighted and standardized means, weight coefficients, ratio coefficients).

The empirical research was conducted in accordance with the hypothetical deductive methodological approach, when the research was planned and methodologically justified.

The integrated empirical research consists of the results of qualitative and quantitative research. The entire empirical research consists four main parts, i.e. research segments on the organizational creativity management areas based on intellectual human, organizational, and relationship capital as well as the calculation of creativity management level in the organization.

The research was conducted in a Lithuanian maritime sector organization owned by an international corporation headquartered in Denmark. The corporation has 27 large functional divisions operating in five countries of the European Union.

The following empirical research hypotheses have been raised:

H1: The organizational creativity management areas have a connection;

H2: All six organizational creativity management areas have equal importance.

The latter hypotheses are important to prove the validity of the theoretical model of the Creative Management Based on Intellectual Capital. The empirical research hypotheses were based on the analysis of scientific literature and identified organizational creativity management areas. Their choice was conditioned by the analysis and synthesis of the results of the researchers listed in the table below (see Table 1). The empirical research is based on the system approach to investigate the maximum possible number of manifestation characteristics of the object under investigation. In this way, the probability of acquiring a general knowledge of the object investigated increases.

Table 1.

Dimensions of Organizational Creativity Management Areas

Areas	Dimensions
Area 1. Creative leadership	<i>Qualities of a director as a creative leader:</i> <ul style="list-style-type: none"> Qualities that shape key competences, Qualities that shape strategic competences.
Area 2. Management of personnel creativity	<i>Motivation for creativity:</i> <ul style="list-style-type: none"> Internal – external, Personal – group – organizational.
	<i>Creativity training and retraining:</i> <ul style="list-style-type: none"> Individual – organizational.
	<i>Formation of creative skills:</i> <ul style="list-style-type: none"> Creative thinking, solving of non-standard problems.
Area 3. Integrity of processes and IT	<i>Processes:</i> <ul style="list-style-type: none"> Process tools and management systems integrated in organization.
	<i>Integrity of IT systems:</i> <ul style="list-style-type: none"> IT introduction, application, and compatibility across processes in different management areas.
Area 4. Support for creativity	<i>Organization management structure:</i> <ul style="list-style-type: none"> Type, specificity; application of teams, Personalization (knowledge exchange) + codification (knowledge storage)
	<i>Organization culture and climate:</i> <ul style="list-style-type: none"> Values, attitudes, networks, Tolerance, time management, no fear of mistakes, physical space.

Cont. table 1.

Area 5. Strategic management	<ul style="list-style-type: none"> • Creating a creativity (innovation) management strategy • Developing a creativity (innovation) management strategy.
	<ul style="list-style-type: none"> • Using creative <i>thinking</i> and creative <i>methods</i> to form strategies
Area 6. System approach	<ul style="list-style-type: none"> • Ideas and projects focused on creating an <i>open social environment</i>. • Strong communication (social relations) and collaboration with stakeholders (suppliers, partners, etc.).

Source: authors' own study.

A case study research method was selected for the research to analyze the activities of one or several subjects in one group. According to K. Kardelis (2005), this research method can be applied both in developing new scientific knowledge and in solving various practical situations. Attention is paid to the subtlety and complexity of the individual case. The case study research method has an attribute of triangulation in terms of the complexity of the research methods.

The validity of the choice of the case study research method and the research subject:

1. the Lithuanian maritime business organization under investigation is a part of a multinational enterprise group (hereinafter referred to as the Group), which consists of organizations from Denmark, Sweden, Germany, Finland, Holland, England, France, Russia, Spain, Poland, Estonia, Latvia, and Lithuania;
2. the Group has been operating for more than 150 years, i.e. has a successful management experience;
3. the Group's recent activities are influenced by external environmental factors, which implies a need for more effective management of creativity;
4. the choice of the organization was also determined by the spheres of activity (marine business and logistics) in which the company operates. The transportation and logistics business is one of the priority areas of smart specialization strategy in Lithuania and the EU.

Results of organizational creativity management empirical research

In order to assess the overall organizational creativity management level, the results of the standardized means of the dimensions of the creativity management areas obtained through the quantitative research and the results of the qualitative research were used. Based on the generalized results of the quantitative research, each area of organizational creativity management was assessed. It has been found that organizational creativity management areas such as creativity support (mean value or standardized mean are 75.45 points) and creative leadership (standardized mean is 74.55 points) have been developed the most. Meanwhile, the organization's processes and IT integrity is weak (standardized mean is 26.5 points). In order to unify the coding of the questionnaire questions, the values of standardized means, rather than

of weighted means (from 1 to 100 points) were used to compare the areas of organizational creativity management.

The raised empirical research hypothesis H1: The organizational creativity management areas have a connection. To validate or deny this hypothesis raised, a correlation test was performed using Pearson Correlation coefficient. The assessment of the correlation (Pearson Correlation) between the creativity management areas in the organization showed that creative leadership has the most impact on other areas, i.e. its effect is the highest (1). The strongest positive correlation (.333) is observed between creative leadership and management of personnel creativity, i.e. the stronger the manager's creative leadership qualities are, the better the creativity of the staff is managed. Creative leadership has a positive impact (.254) on support for creativity, i.e. the stronger the manager's creative leadership qualities are, the more creativity support the employees receive. A positive correlation (.320) has been identified between strategic management and integrity of processes and IT. Other connections are weaker. However, there is a negative connection (-.089) between creative leadership and a system approach. Thus, the first hypothesis of the empirical research H1 has been confirmed because the organizational creativity management areas are interrelated.

In order to determine the overall mean value of organization creativity management or the creativity management level, the weight factor for each management area is calculated as the results of the correlation test show that each area of organizational creativity management has different significance. The results of the qualitative research (total values of the matrix sub-codes) are used for the determination of weight factor. Below is a summary of the qualitative research results.

The interpretation and conceptualization of the qualitative research data revealed that the topic of management of personnel creativity has most of the sub-codes (31 in total), while the topic of system approach has least of the sub-codes (6 in total). This shows the level of importance of each creative management area, i.e. the respondents have identified these categories of topics as relevant. Based on the determined total values of the sub-codes, an index (weight factor) for each connection (topic) or organizational creativity management area was calculated, where the sum of the sub-codes of each area (topic) is divided by the maximum amount of sub-codes. This makes it possible to rank the values of the creativity management area in organization (in descending order of importance or weight).

Thus, the second hypothesis of H2 has not been confirmed because all creativity management areas have different importance. The most important are management of personnel creativity and support for creativity. Ranking results for the organizational creativity management areas allow testing the hypothesis of the empirical research H2: All creativity management areas are equally important. According to the research results, the second hypothesis H2 was not confirmed as all creativity management areas have different importance.

The next step is to determine the ratio of each organizational creativity management area in a quantitative research. Since the organizational creativity management areas have different number of dimensions and questions in the questionnaire, the ratio coefficients are calculated. After determining the weight factors and ratio coefficients for each organizational creativity management area, the overall mean value or level of creativity management in the organization was calculated (see Table 2) according to the following formula as proposed by the author:

$$CML = ((X_1 * S_1 * P_1) + (X_2 * S_2 * P_1) + \dots + (X_i * S_i * P_1)) / i;$$

where:

CML – creative management level in the organization (mean value);

X1 ... Xi – standardized mean of creative management i area;

S1 ... Si – weight factor of creative management i area;

P1 ... Pi – ratio coefficient of creative management i area; i – number of creative management areas (i.e. 6).

Table 2.
Creativity Management Level in the Organization

Area	Standardized mean, in points	Ratio coefficient	Weight factor	Value, in points
<i>Creativity management areas based on human capital</i>				
1. Creative leadership	74.55	0.6	0.45	20.13
2. Management of personnel creativity	63.76	0.166	1	10.58
<i>Creativity management areas based on organizational capital</i>				
3. Integrity of processes and IT	26.5	4.05	0.61	65.47
4. Support for creativity	75.45	0.338	0.87	22.19
<i>Creativity management areas based on relationship capital</i>				
5. Strategic management	33.2	4.05	0.52	69.9
6. System approach	54.18	2.43	0.19	25.01
Total sample mean:				35.5

Source: authors' own study.

As it can be seen, organizational creativity management in the organization is not of high level (35.5 points out of 100). Thus, based on the results of the integrated empirical research, it can be stated that the organization under study does not manage its creativity in a sufficiently effective way. Most efficiently, the organization uses human capital to manage creativity (see Table 2 for standardized means of human, organizational, and relationship capital). It is worth mentioning that the comparison of the effectiveness of the management of intellectual capital components in this methodology is limited as the weight coefficients are determined in the range of all areas of organizational creativity management and their dimensions. Thus, the organization under investigation makes more use of its internal competences (based on the data in Table 2). If the use of internal and external competences (of all agents, i.e. participants of the organization and its external environment) becomes the dominant principle, the flow of knowledge between the agents is greatly enhanced by the synergy effect. Such a network of agents (participants) takes on the character of an informal management mechanism because trust becomes crucial in the organization's system of values.

Directions for the improvement of creativity management in the organization

The research of the organizational creativity management areas allowed identifying the shortcomings and difficulties faced by the organization in managing its creativity based on intellectual capital. Based on the research results, the directions that allow improving the organizational creativity management were developed.

Area 1. Creative leadership. Leader-oriented training programs should take into account the development of general competences such as communicability, interest, motivation and impartiality; and the development of such strategic competence-forming qualities as social awareness, creative approach to profession, empathy, imagination, and curiosity.

Area 2. Management of personnel creativity. Stuff-oriented training programs should take into account the development of such general competence-forming qualities as the qualities of an organizer and leader as well as the development of such strategic competence-forming qualities as uniqueness, initiative, and determination. It is also proposed to organize more of training sessions on the improvement of creative thinking skills. In order to successfully implement organizational changes and alter employee attitudes according to the new declared philosophy of the organization, it is suggested to focus on creativity training for technical employees.

In regards of manager-oriented motivational programs, it is proposed to develop/improve a set of external motivation tools as a tool for managers to motivate their subordinates. It is also proposed to regulate the distribution of income and work volumes between the divisions of different countries on the Group scale. In regards of stuff-oriented motivational programs, it is suggested to increase support of their initiative towards the understanding of systematic and process management (for example, to update presentations on operation of other stakeholders and other organization divisions).

Area 3. Integrity of processes and IT. To improve the management of processes and IT integrity, it is proposed to improve the quality of time management; to improve communication between departments and with stakeholders in the organization (for example, organize presentations between functional units, with customers, with suppliers (better communication, emergence of procedural and systematic approaches)).

It is proposed to allocate the organization's financial resources in the area of information technology in a more rational way. It is suggested to improve the compatibility and integrity of the processes of IT program and shipping management. Improvements are also required for IT applications that control financial management (accounting) and sales management processes.

Area 4. Support (Fromm, 1959) for creativity. To eliminate the negative consequences of restructuring of organizational structure, it is proposed to clarify the situation among the employees, to make a presentation on the updated organizational structure for the employees of

the organization. subordination, responsibility and other issues. It is also proposed to remove restrictions on personnel recruitment for cultural identity and race. It is proposed to review the workflows of the financial department and eliminate their duplication.

Area 5. Strategic management. In order to improve the creativity management process in the organization, it is proposed to implement the 'bottom-up' development of the Group's strategy, when the strategic plan is developed according to the recommendations of all management levels.

Area 6. System approach. As mentioned earlier, the organization held meetings with clients and suppliers for the presentation of their activities. Such meetings made it possible to seek for greater systematic understanding among employees. It is proposed to resume this practice with a view to developing a systematic approach.

Summarizing the results of the empirical research, it is stated that: 1) all organizational creativity management areas are interrelated; 2) the organizational creativity management areas have different effects. Creative leadership affects other areas the most, i.e. its effect is the greatest. The strongest positive relationship is between creative leadership and management of personnel creativity. In addition, there has been a negative connection found between the areas of creative leadership and system approach; 3) Management of personnel creativity is the most important creativity management area.

Summary

The concept of creativity in a comprehensive approach involves four aspects: creativity as a person's trait is an inherent characteristic of a person, component of cognitive abilities associated with divergent thinking that manifests itself unequally in different areas of individual activity; as a process, creativity is a logical sequence of certain stages and a reconceptualization of previous ideas or knowledge; as a result of the creative process, creativity is a created product that can be interpreted in terms of uniqueness, practicality, social value or universal recognition; as a connection between the creator and the environment, creativity is an interaction between a cultural symbol system, a person or an organization as a creator and a social environment.

Creativity is a way of divergent thinking and the ability to react to the environment in a non-standard way when a new product is created. Organization's creativity is the ability of an organization to generate and implement ideas, to use internal and external competencies to achieve competitive advantage. Creativity is an organization's resource to gain added value, yet is not in itself an added value for such organization.

The links between creativity and intellectual capital concepts are as follows: Creativity as a person's trait and skills is found in human capital; Creativity as a process and its result is found in organizational capital; Creativity as a result of relationships with the environment is found in relationship capital.

Organizational creativity management is the process of targeted planning, organizing, staffing, leading, and controlling creativity for the purpose of competitive advantage through the use of available intellectual capital resources.

The theoretical model of the creative management based on intellectual capital has the following essential features:

- Organizational creativity management areas: creative leadership, management of personnel creativity, integrity of processes and information technology, support for creativity, strategic management, system approach. At the same time, these areas are the dimensions of the assessment of creativity management.
- Links between the organizational creativity management areas, intellectual capital (human, organizational, relationship capital), management functions (planning, organizing, staffing, leading, and controlling) and organization's competencies (internal, external).

Calculation methodology including weight factor and weighted mean analysis is proposed to identify the overall organizational creativity management level in the organization. The uniqueness of the empirical research methodology is that it allows quantifying the level of management of the hard-to-calculate organization's resource, i.e. creativity. This methodological tool for assessing organizational creativity management is focused on medium and large service-providing organizations.

The application of the integrated method of empirical research helped to analyze organizational creativity management in the selected internationally operating organization. It has been found that the organizational creativity management areas have a correlation, i.e. the empirical research H1 hypothesis has been confirmed. Other areas are mostly affected by creative leadership. The strongest positive link is observed between creative leadership and management of personnel creativity.

In addition, a negative connection was determined between the indicators of creative leadership and system approach. It was also found that all areas of organizational creativity management had different importance (weight), thus, the second H2 hypothesis was not confirmed. The most important areas are management of personnel creativity and support for creativity.

The calculation of the overall organizational creativity management level revealed that such level is not high. This means that the organization manages its creativity in insufficiently effective way, and is attributable to the third type of non-creative organization with low creativity. The organization uses human capital to manage creativity with most efficiency.

References

1. Abualoush, S., Masa'deh, R., Bataineh, K., & Alrowwad, A. (2018). The role of knowledge management process and intellectual capital as intermediary variables between knowledge management infrastructure and organization performance. *Interdisciplinary Journal of Information, Knowledge, and Management*. <https://doi.org/10.28945/4088>.
2. Agndal, H., & Nilsson, U. (2006). Generation of human and structural capital: lessons from knowledge management. *Electronic Journal of Knowledge Management*, 4(2), 91-99.
3. Almonaitienė, J. (2011). *Kūrybingumo ir inovacijų psichologija*. Technologija.
4. Amiri, A.N., Jandaghi, G.H., & Ramezan, M. (2011). An investigation to the impact of intellectual capital on organizational innovation. *European Journal of Scientific Research*, 64(3), 472-477.
5. Antony, J. (2016). Creativity Coaching: An Experiment with Adolescent Girls in Kerala. *Journal of Social Work Education and Practice*, 1(2), 1-18.
6. Araya, D., & Peters, M.A. (2010). *Education in the Creative Economy*. Peter Lang. <https://www.peterlang.com/view/title/21285>.
7. Aryanindita, G.P., & Budi, A.S.L. (2011). The Intellectual Capital for University Ranking: A Conceptual Framework Study for Indonesian Higher Education Institutions. *ICICKM2011-Proceedings of the 8th International Conference on Intellectual Capital, Knowledge Management & Organisational Learning: The Institute for Knowledge and Innovation Southeast Asia (IKI-SEA) of Bangkok University, Bangkok Thailand*, 50.
8. Bam, L., & Vlok, P.J. (2016). Towards a framework for systemic creativity in engineering organisations. *South African Journal of Industrial Engineering*, 27(2), 95-108. <https://doi.org/http://dx.doi.org/10.7166/27-2-1288>.
9. Barkauskas, V. (2009). Intelektualaus kapitalo įtaka įmonių konkurencingumui. *Ekonomika Ir Vadyba*, 14, 223-229.
10. Bettiol, M., Di Maria, E., & Grandinetti, R. (2012). Codification and creativity: Knowledge management strategies in KIBS. *Journal of Knowledge Management*. <https://doi.org/10.1108/13673271211246130>
11. Bontis, N. (1998). Intellectual capital: an exploratory study that develops measures and models. *Management Decision*. <https://doi.org/10.1108/00251749810204142>
12. Bounfour, A., & Edvinsson, L. (2012). Intellectual capital for communities: Nations, regions, and cities. In *Intellectual Capital for Communities: Nations, Regions, and Cities*. <https://doi.org/10.4324/9780080478562>
13. Bradburn, A., & Coakes, E. (2004). Intangible assets and social, intellectual and cultural capital: origins , functions and value. *Fifth European Conference on Organisational Learning and Knowledge*. https://warwick.ac.uk/fac/soc/wbs/conf/olkc/archive/oklc5/papers/k-2_braddburn.pdf.

14. Brooking, A. (1996). *Intellectual Capital: Core Assets for the Third Millenium Enterprise*. International Thompson Business Press. <https://books.google.lt/books?id=trzBnQAACAAJ>
15. Cabrita, M.R., & Cabrita, C. (2010). The Role of Creative Industries in Stimulating Intellectual Capital in Cities and Regions. *Proceedings of the European Conference on Intellectual Capital*.
16. Campos, E. (1998). *El capital intangible como clave estratégica en la competencia actual*.
17. Caves, R.E. (2000). *Creative Industries Contracts Between Art And Commerce*. Harvard University Press.
18. Chien, Y.-C. (2015). *The Influences of Knowledge Management on Organizational Performance of Taiwan-Listed IC Design Houses:Using Intellectual Capital as the Mediator*.
19. Damanpour, F. (1991). Organizational Innovation: A Meta-Analysis of Effects of Determinants and Moderators. *The Academy of Management Journal*, 34(3), 555-590. <https://doi.org/10.2307/256406>.
20. Dobson, M. (2010). *Creative Project Management*. Mcgraw-hill. <https://books.google.lt/books?id=6Fc5mAEACAAJ>.
21. Edvinsson, L. (1997). Developing intellectual capital at Skandia. *Long Range Planning*. [https://doi.org/10.1016/s0024-6301\(97\)00016-2](https://doi.org/10.1016/s0024-6301(97)00016-2).
22. Florida, R., & Goodnight, J. (2005). Managing for creativity. *Harvard Business Review*, 83(7-8), 124-131+193. <https://hbr.org/2005/07/managing-for-creativity>.
23. Florida, R. (2003). Cities and the Creative Class. *City & Community*, 2(1), 3-19. <https://doi.org/10.1111/1540-6040.00034>.
24. Flöstrand, P. (2006). The sell side - Observations on intellectual capital indicators. *Journal of Intellectual Capital*. <https://doi.org/10.1108/14691930610709112>.
25. Fromm, E. (1959). Values, Psychology, and Human Existence. In: A.H. Maslow (Ed.), *New Knowledge in Human Values*. New York: Harper and Row, 151-164.
26. Girdauskienė, L. (2011). Ar reikia kūrybinės organizacijos lyderiams ugdyti darbuotojų lojalumą? *Ekonomika Ir Vadyba*, 743-752.
27. Girdauskienė, L. (2012). *Kūrybinės organizacijos vadybos sistemos įveiklinimas žinių aspektu*. Kauno technologijos universitetas.
28. Girdauskienė, L., & Savanevičienė, A. (2010). Žinių valdymo ypatumai kūrybinėje organizacijoje. *Ekonomika Ir Vadyba*, 15, 491-497.
29. Goleman, D., Kaufman, P., & Ray, M. (1992). *The creative spirit: Companion to the PBS television series*. Dutton.
30. González, A.M. (2003). Ethics in Global Business and in a Plural Society. *Journal of Business Ethics*, 44(1), 23-36. <https://doi.org/10.1023/A:1023230222707>.
31. Grabner, I., Klein, A., & Speckbacher, G. (2018). Managing the Trade-Off Between Delegation and Task Interdependence in Creative Teams. *Academy of Management*

- Proceedings*. <https://doi.org/10.5465/ambpp.2018.14647abstract>.
32. Grundey, D., & Varnas, D. (2006). Transformations in Corporate Culture and Human Capital Management. *Transformations in Business and Economics*, 5(2), 10.
 33. Gundry, L.K., Kickul, J.R., & Prather, C.W. (1994). Building the creative organization. *Organizational Dynamics*, 22(4), 22-37. [https://doi.org/10.1016/0090-2616\(94\)90076-0](https://doi.org/10.1016/0090-2616(94)90076-0).
 34. Henry, C. (2007). *Entrepreneurship in the Creative Industries: An International Perspective*. Edward Elgar Publishing Limited. <https://books.google.lt/books?id=poFv9E2KC4gC>.
 35. Henry, J. (2006). *Creative Management and Development*. SAGE Publications. <https://books.google.lt/books?id=Wi-BqBgm9n0C>.
 36. Howkins, J. (2010). *Kūrybos ekonomika*. Vilnius: Technika.
 37. Howkins, J. (2013). *The Creative Economy: How People Make Money from Ideas* (2nd ed.). Penguin UK.
 38. Hussinki, H., Ritala, P., Vanhala, M., & Kianto, A. (2017). Intellectual capital, knowledge management practices and firm performance. *Journal of Intellectual Capital*.
 39. Jifeng, M., Gang, P., & Edwin, L. (2008). Interfirm networks, social capital, and knowledge flow. *Journal of Knowledge Management*, 12(4), 86-100. <https://doi.org/10.1108/13673270810884273>.
 40. Johnson, W.H.A. (1999). Integrative taxonomy of intellectual capital: Measuring the stock and flow of intellectual capital components in the firm. *International Journal of Technology Management*. <https://doi.org/10.1504/ijtm.1999.002788>.
 41. Kamath, G. B. (2007). The intellectual capital performance of the Indian banking sector. *Journal of Intellectual Capital*. <https://doi.org/10.1108/14691930710715088>.
 42. Kardelis, K. (2005). *Mokslinių tyrimų metodologija ir metodai: (edukologija ir kiti socialiniai mokslai)* (3rd ed.). Lucilijus.
 43. Krätke, S. (2012). The Creative Capital of Cities: Interactive Knowledge Creation and the Urbanization Economies of Innovation. In *The Creative Capital of Cities: Interactive Knowledge Creation and the Urbanization Economies of Innovation*. <https://doi.org/10.1002/9781444342277>.
 44. Kraus, R.G., & Curtis, J.E. (2000). *Creative management in recreation, parks, and leisure services*. McGraw-Hill College.
 45. Lerner, J. (2012). *The Architecture of Innovation: The Economics of Creative Organizations*. OUP Oxford. <https://books.google.lt/books?id=URkqKQKnWVIC>.
 46. Litovchenko, B. (2016). Origin of the Creative School of Management: Retrospective Analysis. *Journal of European Economy*, 15(4), 361-377.
 47. Luiza, F. (2016). *The role of intellectual capital in achieving the competitive advantage of economic institutions in the knowledge economy: Cement company case study*. Unpublished Doctorate Thesis. Baskra, Algeria: Mohammad Khader University.

48. Madsen, S. (2009). *Volunteerism in a Creative Organization: Factors leading to Continuing Participation*.
49. McWilliam, E., & Dawson, S. (2008). Teaching for creativity: Towards sustainable and replicable pedagogical practice. *Higher Education*. <https://doi.org/10.1007/s10734-008-9115-7>
50. Mellander, C., & Florida, R. (2014). The Rise of Skills: Human Capital, the Creative Class, and Regional Development. In: M.M. Fischer & P. Nijkamp (Eds.), *Handbook of Regional Science* (pp. 317-329). Berlin-Heidelberg: Springer. https://doi.org/10.1007/978-3-642-23430-9_18.
51. Meriam, I. (2005). Creative climate and learning organization factors: their contribution towards innovation. *Leadership & Organization Development Journal*, 26(8), 639-654. <https://doi.org/10.1108/01437730510633719>.
52. Mikulėnienė, R., & Jucevičius, R. (2000). Organizacijos intelektinis kapitalas: sandaros ir pagrindinių sąvokų interpretacijos. *Socialiniai Mokslai*, 3, 65-76.
53. Morgan, G. (1989). *Creative organization theory: A resourcebook*. SAGE Publications.
54. Morgan, G. (1993). *Imaginization: The Art of Creative Management*. SAGE Publications.
55. Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review*. <https://doi.org/10.5465/AMR.1998.533225>.
56. Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: how Japanese companies create the dynamics of innovation*. Oxford University Press.
57. Nonaka, I., & Teece, D. (2001). *Managing Industrial Knowledge: Creation, Transfer and Utilization*. <https://doi.org/10.4135/9781446217573>.
58. Obeidat, B.Y., Tarhini, A., Masa'deh, R., & Aqqad, N.O. (2017). The impact of intellectual capital on innovation via the mediating role of knowledge management: a structural equation modelling approach. *International Journal of Knowledge Management Studies*, 8(3-4), 273-298.
59. Rhodes, M. (1961). An Analysis of Creativity. *The Phi Delta Kappan*, 42(7), 305–310. <http://www.jstor.org/stable/20342603>.
60. Roos, G., & Roos, J. (1997). Measuring your company's intellectual performance. *Long Range Planning*. [https://doi.org/10.1016/s0024-6301\(97\)00022-8](https://doi.org/10.1016/s0024-6301(97)00022-8).
61. Šedžiuvienė, N., & Vveinhardt, J. (2011). Žinių valdymas organizacijoje: darbuotojų kūrybingumo vystymo prielaidos. *Profesinės Studijos: Teorija Ir Praktika*, 8, 277-286. https://www.researchgate.net/profile/Jolita_Vveinhardt/publication/318377802_Knowledge_Management_in_Organisation_Prerequisites_for_the_Development_of_Personnel_Creativity_Ziniu_valdymas_organizacijoje_darbuotoju_kurybingumo_vystymo_prielaidos/link/s/5969e.
62. Starkey, K., Tempest, S., & McKinlay, A. (2004). *How Organizations Learn: Managing the Search for Knowledge*. Thomson. <https://books.google.st/books?id=SE8G0d0ib3EC>.

63. Stewart, T.A. (1997). *Intellectual Capital: The New Wealth of Organizations*. Crown Business.
64. Sveiby, K.E. (1997). *The New Organizational Wealth: Managing and Measuring Knowledge-Based Assets*. Berrett-Koehler Publishers.
65. Užienė, L., & Staliūnienė, J.D. (2009). Intelektinio Kapitalo Auditas : Samprata, Uždaviniai Ir Realios Galimybės. *Ekonomika Ir Vadyba*, 14, 123-131.
66. Vaškelienė, L., & Šepelen, J. (2008). Informacijos apie intelektinį kapitalą atskleidimas Lietuvos akcinėse bendrovėse. *Ekonomika Ir Vadyba*, 13, 88-97.
67. Znakovaitė, A., & Pabedinskaitė, A. (2010). Intelektinio kapitalo valdymas transporto sektoriuje. *Mokslas-Lietuvos Ateitis [Science-Future of Lithuania]*, 2(2), 126-133.
68. Кольчугина, М. (2008). Синергия образования и науки как инновационный ресурс. *Мировая Экономика и Международные Отношения*, 10, 84-92.
69. Шевырев, А.В., & Романчук, М.Н. (2008). Формирование и развитие системно-креативного мышления – базовая стратегия образования XXI века. *V Международная Научная Конференция*, 119-130.

TECHNIQUES OF MOBILE APPLICATION DEVELOPMENT PROCESS

Mateusz DRUĆ^{1*}, Ireneusz J. JÓŹWIAK², Alicja M. JÓŹWIAK³, Wojciech M. NOWAK⁴

¹ Wrocław University of Science and Technology, Faculty of Computer Science and Management, Wrocław;
druc.mateusz@gmail.com

² Wrocław University of Science and Technology, Faculty of Computer Science and Management, Wrocław;
ireneusz.jozwiak@pwr.edu.pl, ORCID: 0000-0002-2160-7077

³ Wrocław University of Science and Technology, Faculty of Architecture, Wrocław; ajozwiak07@gmail.com

⁴ Wrocław University of Science and Technology, Faculty of Architecture, Wrocław;
wojciech98nowak@gmail.com

* Correspondence author

Purpose: The purpose of the paper is to present the approaches of developing mobile applications and the technologies used for this process to facilitate the choice of the right programming approach in the initial phase of an IT project.

Design/methodology/approach: Taking the right and adequate decision on choosing the proper approach to software development should be preceded by searching for available solutions and a there reliable comparison. The collected and compared information comes from current scientific sources and official conferences, which is the basis for making the right decisions at the start of a new project.

Findings: Hybrid approach to the manufacture of mobile applications provide applications to run the most popular mobile operating systems. However, the technologies used in this programming approach are not adopted to the extent they have been in the native approach.

Originality/value: The article summarizes and compares the approaches of developing mobile applications. The presented comparison, together with information on the used technologies, helps system architects and programmers in making a decision about the use of a given programming approach based on the given technologies when creating a new project.

Keywords: mobile application, native, hybrid, Android, iOS.

Category of the paper: Research paper.

1. Introduction

Smartphones are multimedia, portable devices that combine the functions of a portable computer and a mobile phone. They are made of many sensors, modules and sensors such as GPS module, gyroscope, proximity sensor or GSM module. In addition to the distant

communication, these devices also enable, for example, e-mail client support, installation of thousands of different applications, high-resolution shooting, video recording and multimedia playback (Charlesworth, 2009). With the development of such devices, which are often equipped with touch screens covering a significant part of their surface area, there was a need to develop operating systems adapted to the needs and expectations of users. Many companies have tried to develop operating systems to find applications in tens of millions of devices around the world to meet demand.

Over the last few years, several main competing solutions have appeared on the market. According to the authors of the article entitled "Evaluating cross-platform development approaches for mobile applications" from 2012 (Heitkötter, Hanschke, & Majchrzak, 2012), until some time ago the mobile technology market was dominated by several companies providing mobile operating systems developed by them. They were: Android developed by Google, Symbian provided by Nokia, iOS available on Apple brand devices, Blackberry by RIM and then evolving Windows Phone developed by Microsoft. However, as today's market analyzes show, Google and Apple (Mobile Operating System Market Share Worldwide) (Mobile, 2020) remain the major corporations with the largest share in the mobile operating system market. According to these analyzes (data from April 2020), the Android operating system currently occupies over 70% of the market, while iOS nearly 29%. The remaining mobile operating systems do not exceed 0.2% of the global market share.

2. Native application development

The presence of two competing mobile platforms on the market creates the need to develop mobile applications that will be able to run on each of them. Providing a mobile application supported on only one of the platforms automatically deprives you at least 30% of potential application users from ever using the application. The basic and primary form of developing a mobile application dedicated to a given platform is the native programming approach. It means the use of programming tools, a programming environment and languages dedicated and specific to a given platform, provided by the designers of a given technology. The main disadvantage of this approach is the final development of an application supported by only one of the available mobile operating systems. This is due to the inability to share native code between platforms (Huynh, Ghimire, & Truong, 2017). Therefore, the desire to deliver the application to the widest possible group of potential recipients means the need to develop two separate native applications. Most often, this requires the launch of two development teams with separate skills and specific knowledge of the given platform.

3. Hybrid application development

A relatively new and alternative approach to native application development is a hybrid approach. It is a concept the idea of which is to share one application source code between many development platforms (Que, Guo, & Zhu, 2016). The concept of a hybrid approach to application development does not define the use of specific tools, languages or technologies, but covers all concepts of sharing source code across more than one platform. The hybrid approach is gaining more and more popularity in the mobile industry due to the reduced costs of application development (maintaining one team of programmers instead of two) and often shortened development time. Ultimately, to make a mobile application available to 99% of smartphone users in the hybrid process, fewer specialists who do not need to have the broad knowledge required to develop native applications are needed.

Nevertheless, not all mobile applications that are currently being developed using this approach. In the majority of new applications vendors choose not to adopt this relatively new development approach. For companies that develop new applications, achieving satisfaction by their customers when the last uses their applications, is a priority. The native app development approach is well established with a strong technical background and a broad developer community. It provides a satisfying app user experience. In the process of developing mobile applications, positive feelings of the end user during use of the application are one of the key aspects determining success in the market. In addition to the proper operation of the application and providing the expected functionalities, application performance also determines a positive user experience (Ballard, 2007). Low performance manifested by a drop in the number of displayed frames per second, excessive CPU use (resulting in increased device temperature) or excessive battery consumption, very often causes the user to resign from using the application (Mainkar, 2017). Providing the functionalities needed by the user without ensuring the application performance at a satisfactory level will not bring developers success in the mobile application market.

4. Techniques of mobile application programming

4.1. Preliminary remarks

As presented by the authors of the article "Evaluating Cross-Platform Development Approaches for Mobile Applications" (Heitkötter, Hanschke, & Majchrzak, 2012), currently most of the mobile market is occupied by Google, which has developed the Android system, and Apple, which owns iOS. Other platforms popular in recent years have not survived on the market or have lost some of their shares and currently do not play a significant role in the mobile

industry. An example of such a platform is the Windows Phone operating system released by Microsoft (Gajewski) in 2010.

In addition to various platforms for which mobile applications are created, there is also a division into approaches to the development of these applications. This division was created as a result of the development of many mobile software implementation techniques. According to Mahesh Panhale, the author of the book "Beginning Hybrid Mobile Application Development" (Panhale, 2016), we distinguish three approaches in the development of mobile applications: native, web and hybrid.

4.2. Native applications

Native applications are those, which include written for a specific operating system, with the usage of technology strictly indicated by the designers of a given platform applications. In case of native Android applications, it is preferable and most common to use Java and Kotlin, while in case of iOS applications – Swift and Objective-C languages are the most relevant choice (Native vs Hybrid – what type of mobile application should you choose?) (Native vs Hybrid, 2020). The most popular development environment for developing native applications for the Android platform is currently Android Studio (Hagos, 2019), and for the iOS platform Xcode (Knott, 2016). Applications designed in a native approach are not compatible with more than one operating system, which makes it necessary to prepare several applications in order to reach a wider group of potential users. The significant advantages of the native approach in the development of mobile applications include (Liu, 2013):

- high performance of the software being built,
- no restrictions on the implementation side,
- potentially less chance of various errors (the application is dedicated to a given platform),
- direct access to operating the device components (e.g. Bluetooth),
- popularity of the approach and the technologies used (developed community network),
- a very large number of publicly accessible libraries.

In the case of disadvantages of the described approach, the following should be mentioned (Panhale, 2016):

- the need to implement several applications (separate for each platform),
- system maintenance (several applications) requires more work,
- the size of the application in terms of the number of lines of code,
- lower reusability of the code created,
- the need for more knowledge.

4.3. Web applications

The web application is an application that can be displayed in a web browser on a computer station as well as in a web browser installed on a mobile device. It is designed and made in such a way as to display the information correctly on both types of devices and it also gives the impression of using a traditional mobile application on the smartphone (Internet or mobile application?) (Application, 2020). When building web applications, technologies such as HTML and JavaScript are most often used. In order to achieve the impression of using a typical mobile application, there is also a solution consisting of running such an application in a specially adapted application web view (WebView). Then the user installs the application on the device in the traditional way and the application launches a built-in browser inside the given web application running. The effect achieved in this way can be satisfactory in the case of uncomplicated applications. The advantages of using the web-based approach to developing a mobile application are as follows (Hartman, Rokitta, & Peake, 2013):

- a shared code that can be run on any device using a web browser,
- the ability to update the appearance and functionality of the application without the need to update it on the user's side,
- the application code does not take up space on the mobile device,
- the universality of the technologies used,
- relatively low cost and short application development time,
- the ability to install the application in a traditional way or run it from the level of a web browser.

The disadvantages of the web approach to the development of mobile applications are (Hartman, Rokitta, & Peake, 2013):

- Internet connection required for the application to function,
- difficult process of implementing functionalities using access to the hardware components of the device (such as e.g. a camera),
- relatively low application performance,
- worse adjustment of the user interface to the platform on which the application is run than in the case of a native application,
- the inability to write native code.

4.4. Hybrid applications

A hybrid application is defined as an application resulting from the fusion of two solutions. These solutions are native and web approaches. Thanks to this combination, it is possible to obtain a product that combines the advantages of both aforementioned solutions (Lehman) (Lehman, 2020). The tools that are currently most often used to implement this type of application are:

- Flutter (using the Dart programming language),
- React Native (using the JavaScript programming language),
- Xamarin (using the C # programming language).

Knowledge of one of the mentioned technologies allows you to build an application supported by both platforms (Android and iOS). Undoubtedly, this is one of the advantages of this programming approach. The other advantages are:

- 1) the ability to write native application components,
- 2) access to the components of the mobile device as in the case of native applications,
- 3) the possibility of implementing separate user interfaces for both platforms,
- 4) higher performance of the implemented application than in the case of the web approach,
- 5) knowledge of one technology enables the implementation of applications for both platforms,
- 6) lower cost of development and maintenance of the application than in the case of the native approach,
- 7) the growing popularity of the hybrid approach, its rapid development and continuous improvement.

However, this approach is not just about advantages. By writing applications using hybrid approach, some elements still need to be implemented separately for each platform. This involves the need to handle the components of a mobile device (such as an accelerometer) differently for different platforms. Google provides different guidelines and requires a different implementation of such a module comparing to Apple. According to the author of the book "Beginning Hybrid Mobile Application Development" by Mahesh Panhale (Panhale, 2016), currently approximately 80% of the hybrid application code is shared by both platforms, while 20% is still native code, written for each platform separately. Other disadvantages of implementing a mobile application in the hybrid approach are:

- the need for frequent adaptation of changes in the design as a result of hybrid technologies' dynamic development and their frequent updates,
- fewer publicly available libraries than in the native approach.

Among the described approaches to the implementation of mobile applications, technologies used in the native and hybrid programming approach will be discussed and compared. Web applications were not considered due to the above-described disadvantages of the web approach to mobile application development.

5. Technologies used in the native programming approach

Android is a comprehensive, completely open source platform for mobile devices. It includes the entire technology stack, from low-level Linux modules to native libraries, from the application framework to complete mobile applications. This platform was launched by Google with the goal of accelerating mobile innovation and offering consumers richer, cheaper and better mobile features. Android is licensed (Apache/MIT) so that it can be freely extended and implemented for personal use, making the source code of the system available to developers (Gargenta, 2011).

Dedicated tools are used when implementing a native application on the Android platform. Google supports and develops the development environment called Android Studio released under the "Apache 2.0" license which is also free for commercial use (Studio, 2017).

Google supports two programming languages in the process of implementing native mobile applications on the Android platform. These languages are Java and Kotlin.

The leading programming language was originally Java, but from 2019 the main language promoted by Google is Kotlin.

The iOS operating system (iOS, 2020) has been developed for the group of Apple mobile devices such as iPhone, iPod touch and iPad, published by Apple. According to its architects, the key to the success of iOS was simplicity and intuitiveness. This system is very popular on the mobile market, but its use is much lower than in the case of Android, due to the very limited number of devices supporting this solution (iOS).

Apple, like Google, supports two programming languages in the process of implementing native applications for iOS. These languages are: Objective-C and Swift.

The official Apple-backed development environment for developing native iOS applications is xCode (Tiano, 2016). The architects of the xCode environment claim that the application was designed to speed up and streamline the work of programmers and ensure a high level of comfort in using this solution.

6. Technologies used in the hybrid programming approach

Currently, one of the most widely used technologies in the hybrid programming approach are (Fayzullaev, 2018): React Native and Xamarin and Flutter.

React Native is a technology based on a library developed by Facebook, used to build user interfaces called React. However, applications developed in React Native technology are not dedicated to web browsers (as is the case with React technology), but to mobile devices. React Native is a JavaScript framework that allows you to compile a written application to

native code. This technology allows you to build applications in a similar way as in the case of React, but allows you to display them on mobile devices in such a way that they appear native. The JavaScript programming language and its JSX extension are used to write applications in React Native, which technically resembles the XML markup language and is used for simple composing of user interface elements (Eisenman, 2015). The React Native technology also allows you to write application fragments in native languages for the Android and iOS platforms. As a result, critical application areas, exposed to high loads and performance degradation, can be written with native code and thus match the performance of native applications.

Figure 1 shows a diagram of the React Native technology architecture. As shown in the Figure 1, the React Native architecture consists of several main components. Code written in JavaScript language is properly interpreted by the React Native development platform and then separate projects are created for each of the target platforms. The result of the standard compiler work on the Android platform is the native code of the application intended for the Android platform, while the standard iOS compiler generates a native application intended for the iOS platform as a result. Another of the technologies mentioned is Xamarin. It is a development platform that allows you to write cross-platform (Android, iOS, Windows Phone) code using the C# programming language and the XAML user interface description language (Co to jest środowisko Xamarin?) (2020). A dedicated development environment for developing applications using Xamarin is Visual Studio and Xamarin Studio (in the case of the macOS operating system). The code written with this technology, as in the previous case, is compiled to native code for each of the supported platforms. Similarly, when writing some functionalities, it is also necessary to write native code fragments for each of the mobile operating systems separately. Figure 2 shows the architecture of the discussed technology for the case of compiling the application for the Android platform.

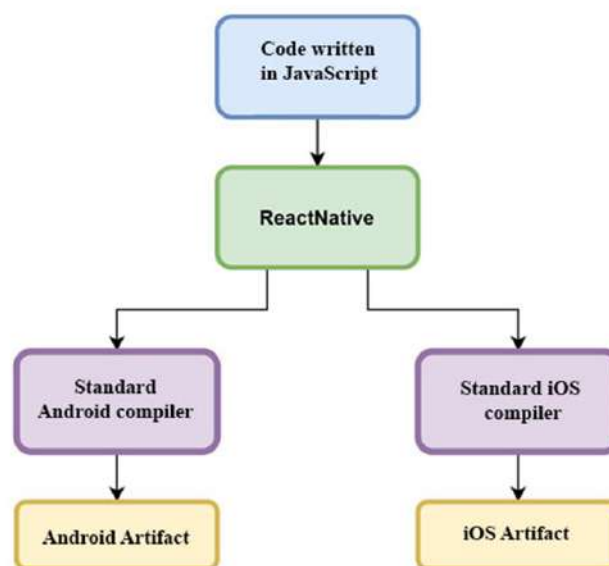


Figure 1. React Native architecture diagram (Frachet, 2020).

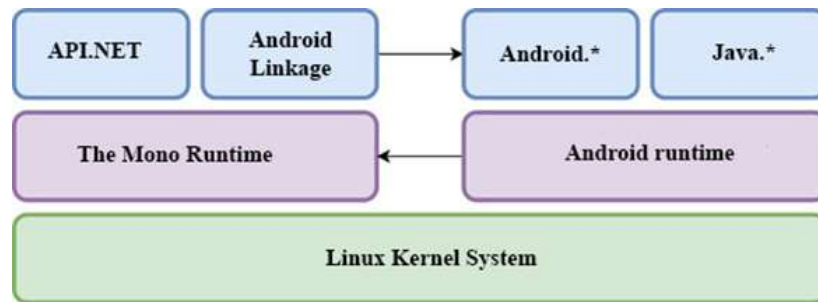


Figure 2. Xamarin technology architecture diagram when compiled for the Android platform (Flutter vs Xamarin vs Native trends, 2020).

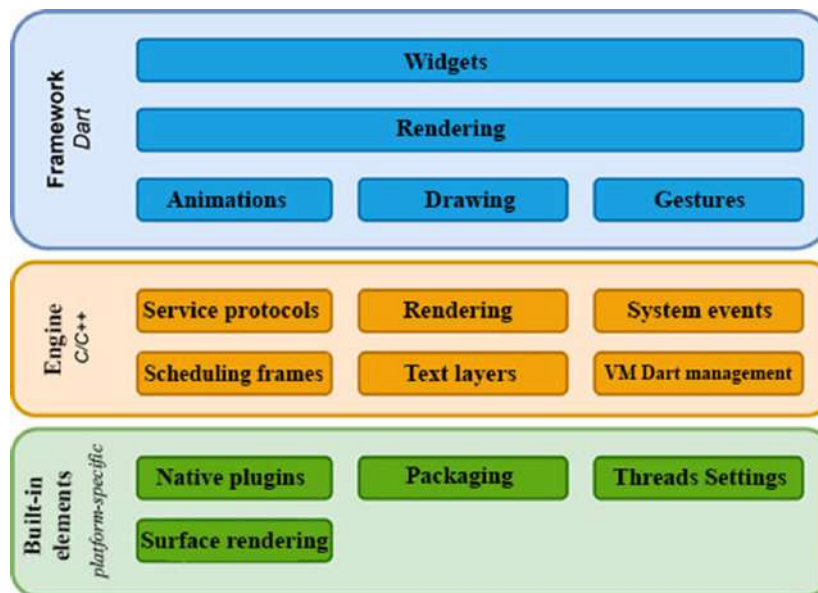


Figure 3. Diagram of the Flutter technology architecture (Flutter internals, 2019).

In the case of compiling a Xamarin application (in the Android version), it is done from C# to the intermediate language and then the code is compiled into a native assembly immediately before the execution of the given code fragment (just-in-time compilation). These applications run in the mono runtime using the Android Runtime virtual machine. Each of these runtime environments runs on top of the Linux kernel.

The third of the listed technologies is Flutter. It is a mobile application development toolkit (mobile SDK), built and provided by Google. Flutter is a free tool, also provided for commercial usage. It is currently the newest available hybrid technologies, which enjoys great and constantly growing interest of programmers. The user interface in Flutter is constructed of elements called widgets, which can adapt to each one of the supported platforms and thus maintain a fully native appearance without the need to write several implementations. Flutter designers strive to ensure that once written code can be run on any platform and operating system. Currently, the application written in Flutter can work with platforms such as: Android, iOS and ChromeOS. However, the system designers note that in the near future, the application will also be available in the web version as well as on any of the popular operating systems. Flutter is a complete tool that provides programmers with a rendering engine, ready-made user

interface components as well as development platform for testing applications (Windmill, 2020).

Figure 3 shows a diagram of the Flutter technology architecture. When writing an application in Flutter using the Dart language the programmer moves on the level of the programming platform marked in the diagram with a blue color. This level interacts with the Flutter engine through an abstraction layer called Window. In turn, this layer provides a number of interfaces for communication with the device (Flutter internals) (2019). The abstraction layer is also used to notify the programming platform (framework) when:

- a significant action occurs at the device level (e.g. device orientation change, memory problem, settings change),
- there is an action on the part of the user (e.g. a gesture on the screen),
- Flutter engine is ready to render the new frame.

7. Conclusion

The previous chapter described three popular technologies currently used for application development in a hybrid approach. On the ground of the information collected and the data obtained from the Google Trends website, it is possible to decide on the technology that should be used to implement the application in a hybrid approach. Over the last year, a technology called Flutter (Flutter vs Xamarin vs Native trends, 2020) has been the most popular. The technology provided by Google is relatively new and has recently become more and more popular.

The last choice that had to be made was the choice of language for both of the most popular technologies described. In the case of Flutter, the only supported language is the Dart programming language, the use of which is inevitable when it comes to implementing the application in a hybrid approach. In the case of Android, there are two programming languages, which are mainly used today. These are Java and Kotlin. Due to the fact that during the Google I/O 2019 conference Kotlin was officially the main language for the development of Android technology (Lardinois, 2019), it is a natural choice to use this language when implementing an application in a native approach.

References

1. A. Studio (2017). *Android Studio. The Official IDE for Android*.
2. *Aplikacja internetowa czy mobilna?* <https://mansfeld.pl/programowanie/aplikacja-internetowa-vs-mobilna/>, 08.04.2020.
3. Ballard, B. (2007). *Designing the mobile user experience*. John Wiley & Sons.
4. Charlesworth, A. (2009). *The ascent of smartphone*. IET.
5. *Co to jest środowisko Xamarin?* <https://docs.microsoft.com/pl-pl/xamarin/get-started/what-is-xamarin>, 22.04.2020.
6. Eisenman, B. (2015). *Learning react native: Building native mobile apps with JavaScript*. O'Reilly Media, Inc.
7. Fayzullaev, J. (2018). *Native-like cross-platform mobile development: Multi-os engine & kotlin native vs flutter*. Kaakkois-Suomen ammattikorkeakoulu.
8. *Flutter internals*. <https://www.didierboelens.com/2019/09/flutter-internals/>, 22.04.2020.
9. *Flutter vs Xamarin vs Native trends*, <https://trends.google.com/trends/explore?geo=US&q=react%20native,flutter,Xamarin>, 27.04.2020.
10. Frachet, M. (2020). *Understanding the React Native bridge concept*, <https://hackernoon.com/understanding-react-native-bridge-concept-e9526066ddb8>, 12.05.2020.
11. Gajewski, M. (2017). *Windows Phone umarł. Tym razem formalnie i na dobre*, <https://www.spidersweb.pl/2017/07/microsoft-windows-phone.html>, 10.05.2020.
12. Gargenta, M. (2011). *Learning android*. O'Reilly Media, Inc.
13. Hagos, T. (2019). *Android Studio IDE Quick Reference: A Pocket Guide to Android Studio Development*. Apress.
14. Hartman, R., Rokitta, C., Peake, D. (2013). *Oracle Application Express for Mobile Web Applications*. Springer.
15. Heitkötter, H., Hanschke, S., Majchrzak, T.A. (2012). *Evaluating cross-platform development approaches for mobile applications*. International Conference on Web Information Systems and Technologies.
16. Huynh, M.Q., Ghimire, P., Truong, D. (2017). Hybrid app approach: could it mark the end of native app domination? *Issues in Informing Science and Information Technology*, vol. 14, pp. 049-065.
17. iOS, <https://teamquest.pl/baza-wiedzy/systemy-operacyjne-systemy-mobilne/ios/62.html>, 16.04.2020.
18. Knott, M. (2016). *Beginning Xcode: Swift 3 Edition*. Apress.
19. Lardinois, F. (2020). *Kotlin is now Google's preferred language for Android app development*. <https://techcrunch.com/2019/05/07/kotlin-is-now-googles-preferred-language-for-android-app-development/>, 04.05.2020.

20. Lehman, M. (2020). *Aplikacja mobilna – Hybryda, Progresywna, czy Natywna?* <https://www.gmi.pl/blog/aplikacja-mobilna-hybryda-natywna/>, 03.05.2020.
21. Liu, F. (2013). *Android native development kit cookbook*. Packt Publishing Ltd.
22. Mainkar, P. (2017). *Expert Android Programming: Master skills to build enterprise grade Android applications*. Packt Publishing Ltd.
23. *Mobile Operating System Market Share Worldwide*. Retrived from: <https://gs.statcounter.com/os-market-share/mobile/worldwide>, 12.04.2020.
24. *Native vs Hybrid – jaki rodzaj aplikacji mobilnej wybrać?* <https://appchance.com/pl/blog/native-vs-hybrid-jaki-rodzaj-aplikacji-mobilnej-wybrac>, 24.04.2020.
25. Panhale, M. (2016). *Beginning hybrid mobile application development*. Heiderberg: Springer.
26. Que, P., Guo, X., Zhu, M. (2016). *A comprehensive comparison between hybrid and native app paradigms*. 8th International Conference on Computational Intelligence and Communication Networks (CICN).
27. Tiano, J. (2016). *Learning Xcode 8*. Packt Publishing Ltd.
28. Windmill, E. (2020). *Flutter in Action*. Manning Publications.

CONCEPTUALISATION OF USING TECHNICAL DEBT TO MEASURE THE INNOVATION LEVEL OF NEW PRODUCT – SELECTED ISSUES

Paweł FILIPOWICZ

Faculty of Management, AGH University of Science and Technology; pafilip@zarz.agh.edu.pl,
ORCID: 0000-0003-2807-2295

Purpose: Conceptualisation of the technical debt use as the new product innovativeness measure.

Design/methodology/approach: This paper adopts the J. Highsmith perspective on the technical debt as the essential of agile project management. The presented customer centered perspective of product value allows to use the technical debt as base for the new product innovativeness parametrization. The presented approach is possible also with the behavioral conception of innovativeness being directly associated with the subjective customer perception and works to build theory accordingly. The research is entirely theoretical and uses two points of reference. The first was used to explore the possible use of the technical debt as innovativeness measure through the use of user function. The second, consisting of presentation the possible modification of F. Sgobbi value model as the management tool for analyzing the value of new technology based product.

Findings: The Concept of technical debt use as the measure of technology value is presented.

Research limitations/implications: Future research suggestions will concerne the discretization of presented concept.

Practical implications: The Presented conception may became the an interesting base for analyse and assesement of innovatives products and also in this way it can be used for new management tool designing, particularly in the domain of value based management process.

Originality/value: Elaboration and operationalization of new technology based products model development with application of technology life cycle.

Keywords: technical debt, innovativeness, new technology based product value, use function.

Category of the paper: Conceptual paper.

1. Introduction

Today's economic dynamism depends to a large extent on the entrepreneurial spirit of a company. Saturated markets are no longer a prospective source of its growth. New markets need to be developed by creating new customer needs. Entrepreneurs are increasingly looking for an opportunity to increase the value offered to the customer by creative diversification of manufactured goods. Such creativity should translate into effective commercialisation of new products, which will strengthen the company's market position. J.A. Schumpeter considers business innovation (Schumpeter, 1960) a prerequisite for accomplishing such a vision of development. Innovation level today affects customer perceived value, measurement of which can be a very interesting research area. Consequently, F. Malerba draws attention to the evolutionary aspect of innovation linked to the cyclical vision of economic development, stressing the importance of its dynamics (Malerba, 2006).

The possibility of measuring innovation of a new product using technical debt is therefore an important research objective outlined in this paper. Management practice indicates the need to conceptualise such a quantifying tool, which will, among others, identify the financial resources necessary for the effective introduction of new technologies to the market.

In a preliminary manner, the paper presents the nature and scope of technical debt, its application and changes in its value over the course of the new product development process. A description of the possible use of the technical debt of a use function to measure the level of innovation of the product is provided. The paper also describes the relationship between the use function and technical debt of a technology, basing on the latter's life-cycle model. This justifies linking the concept of innovation level to the size of technical debt of a technology. Consequently, on the assumption that a certain amount of technical debt determines the level of technological innovation and the level of technology translates into technology value, the paper presents a modification of the F. Sgobbi model estimating technology value. The modification enables linking the innovation level with technology value.

2. The importance of technical debt in the development of a new product

In most innovative companies or innovative projects, given their initial phase, the practice of financing them is based on an increase in external debt, which in extreme cases can be converted into equity, becoming an important element in the estimation of project or company value. Limited access to the sources of funding and high costs of debt service put a constant pressure on reducing operating costs and meeting accepted commercialisation deadlines. The drive to increase competitiveness and attractiveness of the products offered to customers

forces companies to strive for continuous innovation, no longer anticipating market behaviour but embracing adaptive innovation to meet customer needs (Loch, and Kavadias, 2008).

Adaptive innovation, however, runs counter to the classic management process that usually focuses on planning, business strategy, or budget. According to J. Highsmith, evolution and adaptation based approach cannot be synonymous with planning and optimization. Innovations are subject to the same principles as living organisms – they mutate, survive, develop, and thrive (Highsmith, 2009). This principles should also be adopted when designing new products, and their absence means that there is a significant gap in the company between the need to offer new and therefore innovative products and the real possibilities of delivering them to customers.

Despite some similarities, technical and financial debt are two different concepts. The main difference is the definition of the interest rate on the debt and the inevitability of its payment. By creating technical debt, the company makes a trade-off between quality and productivity. On the one hand, in the short term, the costs of maintaining product functionality or production costs are reduced for the time being, on the other hand, despite present benefits, there will be cost implications in the future. The analysis of these dependencies is an important decision-making issue affecting the functioning of the whole company (Alves et al., 2016). The concept of technical debt was introduced into IT management practice in the 1990s by W. Cunningham and is gradually gaining increasing attention not only in this sector (Codabux et al., 2017). The origins of this concept are related to a situation where the project carried out is not properly supervised and there is considerable time pressure to complete it (Martini, and Bosch, 2017).

Technical debt can already appear at the very beginning of the project and is defined as the gap between the current costs of making changes and optimal costs. The control of technical debt level allows determining the trade-off between the current benefits offered to customers and meeting their expectations in the future.

Any decision to change technology has financial consequences in the future, today's emergence of technological debt requires its repayment in the future, which will limit the decision-making possibilities. Thus, its growth or decline today is crucial for the future financial situation and could translate into the company's future competitive position (Guo et al., 2016).

J. Magnusson and B. Bygstad B. developed a model for the process of creating technological debt based on exante assessment and expost investment decisions on the introduction of new technologies. This type of decision-making process is based on three basic concepts: the past, current, and future technological state of the company. The past state describes the changes in the company's technological resources in terms of trends and practice of the time, as a result of the influence of the surroundings on managing these resources. The current state is today's technological infrastructure and all processes and organizational resources, and the future state is the assumed level of technological potential resulting from the institutional logics adopted by the company. Based on the concept of technical debt used by programmers, the concept of technological debt has also been defined. The starting point for defining its concept is the recognition that the emergence of corporate debt is linked to company

development and is the normative component of liabilities and the result of managerial decisions. Technological debt can therefore be defined as future expenditure caused by today's measures to reduce the costs of commercialising new technology. Neglecting the development of documentation, schematic diagrams, standards, and procedures and the absence of the prototyping process are among the actions overlooked due to market pressures. Like any other, technological debt is also fraught with interest rates and payment dates in the future (Magnusson, and Bygstad, 2014). This approach only makes it possible to determine the investment levels necessary to achieve the assumed technological capacity by analysing the benchmarks presented by other companies. However, it does not make it possible to determine the value of technology as it is linked to the market and customers' perception of the products based on this technology.

Using software industry as an example, it can be observed that the costs of making changes increase slowly during the first years, and then their amount goes up rapidly, which leads to frequent abandonment of product development. The constant emphasis on reducing working time and spending leads to instability and rising costs of introduced changes. Rising technical debt reduces the ability to respond to customer needs, which makes them confused why minor modification requires a long implementation period. Customers typically want more use functions to be added as soon as possible, and trying to meet their needs leads to an even greater increase in technical debt in an ever-decreasing time. Then, the measures taken to reduce the amount of this debt are becoming more and more costly for the organization, not translating into an increase in the benefit to the customers, but only into maintaining the value offered to them so far. The fact that technical debt appears in the early stages of product development is important because it is not advisable to reduce it too strictly. It is at this stage that technical debt should reach its optimum value when the time pressure and the level of costs incurred are adequate to the expected results (Ampatzoglou et al., 2015). Therefore, taking corrective action as early as possible is logical and provides a future framework for controlling technical debt. Based on keeping the cost of change low, the continuous reduction of technical debt is often the reason for creating a company's technology strategy that includes a description of the structure of the value creation process. This technological strategy is based on the analysis of the consequences of the work carried out with regard to the two possible time perspectives of company value creation, short-term and long-term.

The aim of adopting such a concept of development is to enrich the management process with aspects related to the quality of the systems being developed, in particular with regard to the benefits offered to end-users (Kraft, 2012). Such a decision-making process would require the quantification framework for the estimation of technical debt. This was originally the basis for an initial concept of such a model for information technology (Nord et al., 2012). The initial assumptions of the model are based on the use of the costs of redevelopment of a given system (e.g. IT design), resulting from the introduction of each new E_i element, which is usually another use function of the system introduced into the n th version of the product.

Then T , the total cost of version n , will therefore be a function of the implementation and redevelopment costs, i.e. C_i and C_r :

$$T(E_1, \dots, E_n) = F(C_i, C_r), \quad (1)$$

where: $C_i = \sum_k C_i(E_k)$ and $C_r = \sum_k C_r(E_k)$.

The model assumes that the implementation and redevelopment costs are added together. Implementation costs are counted as: $\sum_k C_i(E_k)$ for all new E_k elements, where implementation cost $C_i(E_k)$ is provided for all elements of architecture k . However, redevelopment costs C_r for the n th version are calculated in a similar way: $\sum_k C_r(E_k)$ for all new elements E_k , where the redevelopment cost $C_r(E_k) = \sum_j C_r(E_j)$ for all existing E_j elements. However, if E_j is already present in the previous edition of the product, $C_r(E_j) = D(E_j, E_k) \cdot C_i(E_j) \cdot P_c(n - 1)$, then $D(E_j, E_k)$ is the number of links between E_k and E_j , C_i are implementation costs of E_j , while $P_c(n - 1)$ is the level of prevalence of the n th version change, specifying the percentage of elements (use functions of the product) of the system undergoing change.

The dynamics of product distribution therefore make it possible to determine the number of system components that are subject to change caused by the introduction of the new use function. The above-presented conceptualisation of the costs that make up technical debt is linked to an increase in the functionality of the product, usually perceived by the customer as a new use function. Similarly, the same reasoning may be applied to expenditure relating to the estimation of the incurred technical debt. Differentiation and diversification strategies can therefore be translated into an increase in the use functions offered by new products. In turn, innovation is the basis for the development of new products and services and a source of value for customers and entrepreneurs. New ideas translated into innovation after effective commercialization are currently the main tool for the development of the product, but they also become a development impetus for manufacturing systems (Taura, and Nagai, 2017).

According to G.A. Akerlof and R.J. Shiller, the importance of innovation has changed significantly from a production efficiency tool to a technical development stimulator (Akerlof, and Schiller, 2017). It is because the development of the economy is not based solely on increasing production volumes, but on the ability to make effective use of innovation. Changes may also lead to the conclusion that innovation as such is not sufficient to sustain economic development. The ability to create demand for new innovations is therefore becoming an important issue. This ability will refer to the skilful impact on the sphere of perception of the future customer, thus creating the value of innovation (Kumar, and Sundarraj, 2018). The creation of the value of innovative products is characterized by the full subjectivity and persuasive nature of the impact on the potential customer (Wooddall, 2003). The value of innovation to the customer described in this way is a holistic concept, but at the same time a concept of highly individualised importance. One of the conclusions is that the value of an innovative product to the customer should be objectively quantified in order to objectively

assess the effectiveness of the commercialisation processes carried out in terms of optimising that value.

If new technology is behind an increase in the efficiency of manufacturing systems, then it is also a basis for the development of new products. This also generates interest in possible practical ways of determining new technology value, especially in terms of market development caused by technological progress. This mostly concerns a particular company or even a new product based on the use of such technology. However, the value of new technology is not an unambiguous or easy-to-quantify concept, as it includes a number of non-standardised factors that are unreasonable from the scientific perspective.

3. The level of new product innovation and the dynamics of the technical debt of new technologies

The most widely accepted way of describing technological development is a model based on radically new technology whose novelty makes the existing state of competence outdated. Radical innovation as the foundation of new technology is further refined to optimise its manufacturing and market characteristics (Petric, and Echols, 2004). The result of this process is the creation of dominant design that later becomes the standard for a given field, and only undergoes an incremental changes. This results in two ways in which innovation affects organisational competence. In the case of radical innovation, competences quickly become outdated, the rules of the game in the sector are changed and competition to establish their new form intensifies. On the other hand, incremental innovation in the development of technology leads to the development of organisational competences already possessed.

Since the quality of the competences translates into the market behaviour of the company, it can be concluded that the process of developing a new product must be carried out taking into account the dynamics of technological evolution. The use of presumption in the company in relation to the course of the innovation process makes it a major challenge to accurately identify new use functions of the product in response to future user needs (Keinonen, and Takala, 2006). In this case, it will be important for the company to set up a portfolio of new products based on the use of innovations, taking into account future modifications to their structure by introducing new use functions, especially those that result from the use of new technologies.

Developing the concept of cognitive ease, D. Kahneman provides the basis for a stricter definition of the concept of innovation in relation to technical debt (Kahneman, 2012). Cognitive ease can be linked to a sense of comfort resulting from the use of a given product. A sense of comfort increases the satisfaction resulting from the use of the product, which causes a sense of its increasing value perceived by the customer. The concept of innovation presented here is subjective and refers directly to the behavioural trend in the process of value creation.

Cognitive ease means that there is nothing new that requires mobilisation and concentration, i.e. the perceived value of the product is optimal and its innovation is perceived favourably. This perception is achieved when technical debt level is possible to determine. The opposite of such a condition will be cognitive effort, that is to say, a sense of discomfort. It results in a decrease in satisfaction and a decrease in the perceived value of the product. Its innovation is then assessed negatively, which results in cognitive effort to reduce the negative debt that has been negatively felt. Unlike cognitive ease, cognitive effort will mean the need to mobilize and concentrate, as there are new needs to perform certain activities in the use of a given product. In a state of cognitive ease, the user will concentrate on cause-and-effect and relative holistic approach. Feeling cognitive effort increases the feeling of alertness and suspicion and leads to mental exertion, which means that the customers will make fewer mistakes, but the use process will become less intuitive and creative for them. Both concepts introduced by D. Kahneman are multifaceted. Hence, the possibility of linking them to the concept of product innovation or technology understood as the relationship between the user and the object used. These notions of innovation are dynamic and change over time.

New technology that has been successfully introduced to the market should create a state of cognitive ease in the user, due to a number of factors. These factors may be due to the characteristics of innovation or may be a result of an intentional pressure on the user, unrelated to the essence of innovation (Rampino, 2011). The ongoing use might result in a state of cognitive effort resulting from a growing awareness of imperfections in the functioning of technology and from the need to modify it. It might mean a decrease in the innovation of the product or technology. The emergence of a state of cognitive effort is an important moment in the proposed concept of measuring the dynamics of innovation level, a moment of the emergence of technical debt. That assumption therefore makes it possible to determine the rate at which the user perceived innovation is declining and to determine the necessary inputs to maintain that innovation at the level expected by the company. Such broadening and enrichment of the concept of innovation enhances its capacity to shape it, and its link with the concept of technical debt or technological debt makes it possible to define the determinants of the financial strategy for the technological development of the company.

When new use functions are offered, customers often appreciate innovation and respond positively to the value presented by the company. As a result of this process, the number of effective commercialisations of new products is increasing, resulting in an increase in the company's development potential (Schulz et al., 2013). This approach makes innovation one of the most important strategic factors and reflects the flexibility and adaptability of the organisation.

Innovation measurement and analysis are a key to determining the effectiveness of applying new technologies not only to the products offered, but also to determining the configuration of the company portfolio. This is particularly important in the case of the expected high market dynamics, when the company should assume the use of new technologies (Mui Di Benedetto,

2011). In addition, such an analysis should take into account the future financial effects of new technologies and those new use functions that are possible to identify. This becomes an interesting challenge for the decision-making process determining the effectiveness of the commercialisation of a new product or its innovation (Artmann, 2009). Customers are not aware that they are receiving a new product with technical debt. As a consequence, they undergo various experiences in the use of the product and are confused unable to assess its quality.

Gradually, the debt begins to increase (Fig. 1). Other participants of the value chain aim to minimise technical debt, hence the need for more versions of the product with its reduced value. This would be happening slower than if technical debt had been reduced from the outset. However, these activities will be limited in terms of the propagation of technical debt along the entire chain, and a significant part of it may therefore be frozen. For the customer, this will mean a loss of value associated with the use of the product (McGregor et al., 2012).

Therefore, the concept of the analysis of a product as a set of use functions is interesting; each use function is due to the new meaning given to innovative technology and its life cycle phase (Filipowicz, 2018). This approach is based in part on the concept of product modularity and then becomes the basis for the conceptualisation of innovative products in the company. The idea of modularity can be formalised at the product level (P) as the sum of use functions offered to the customer, calculated as the sums of vectors $P = \sum_{i,j}^{n,m} \vec{Fu}(dt_i, cpv_j)$. Each use function is defined on a vector composed of technical debt resulting from its technology (dt) and its customer perception value (cpv).

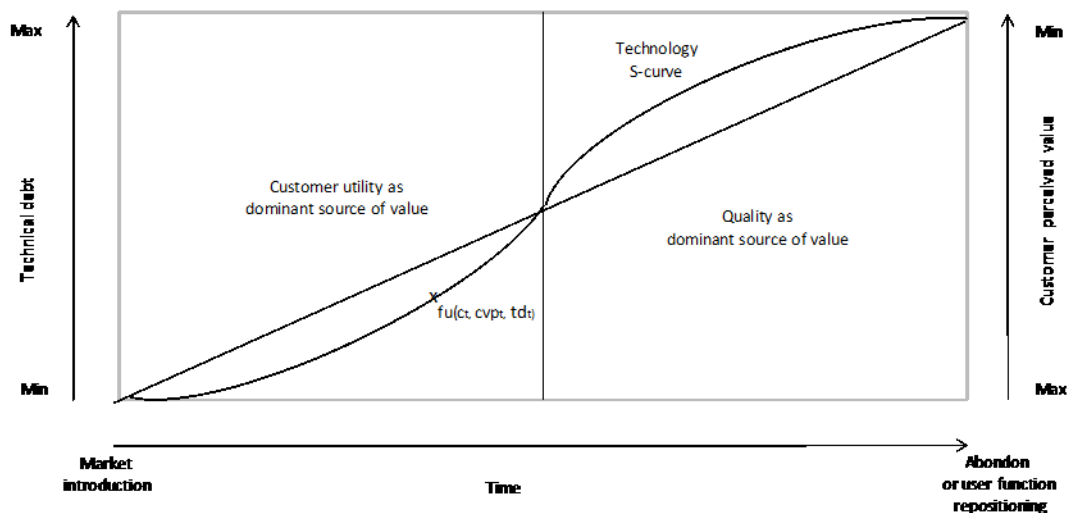


Figure 1. Conceptualisation of the evolution model of the use functions of a product based on the application of new technology. Source: Filipowicz, P. (2019). New product conceptualisation through the technology based use function reconfiguration. *International Journal of Innovation in Management*, vol. 7, no. 2, pp. 81-87.

It is also possible to imagine new use functions whose market offer will result from the use of new technologies. In the extreme case, the mix of new functions will be a base for the concept of an innovative product in technological terms (Filipowicz, 2019). The proposed approach enriches the conventional perception of the product model and can be used in a pro-customer perspective. Product structure modelling based on the use of new technologies can become an interesting direction for the company to seek market advantage, based on the optimization of technical debt of the product's use functions. As a result, it will result in the possibility of configuring the entire company portfolio, which will give an opportunity to monitor the dynamics of technical debt of individual use functions of products. The question of determining technical debt for new technologies commercialised through a product offer therefore arises further, in particular as regards the possibility of financing the commercialisation of new technologies by the company.

4. Technical debt of a product use function as an indicator of innovative technology value dynamics

For the efficiency of the investment process, it will be particularly important to determine the level of innovation for new products based on the use of a new technology in the initial phase. From a market perspective, start-up technologies are characterised by being completely different from previous ones, with limited market use and a limited number of users. These technologies may become generic in the future and are therefore seen as a very interesting subject of economic analysis that clearly justifies the need for their development. Determining the level of their innovativeness and the dynamics of its decline, from a market perspective is most expected, especially given an increase in technical debt of the whole product. An interesting starting point for such an evaluation may be a modification of the model of extended value (Sgobbi, 1995). The modification of this model is intended to include the importance of the technical debt resulting from the use of new technology in relation to the use functions of the new product.

Such a model will aim to optimise the amount of technical debt of the new product by configuring the use functions according to the expected benefits at a given stage of the sales process. It will therefore be appropriate also to be able to evaluate the innovation of individual new technologies in terms of the product as a whole. This will give a better opportunity to adapt it to customer needs as well as to economic and time resources available to the company (Buchmann, 2015). The level of innovation of the product and its quantification cannot be determined on the basis of statistical data since there is a lack of historical values and comparative analogies, especially in the case of the design of a new product involving new technologies.

All these limitations and challenges are analogous to attempts to determine the future market value dynamics of such products, hence an interesting prospect of modifying and using the extended value model as a model of extended technical debt. It is therefore a question of determining the level of innovativeness of a product offering several use functions derived from the use of different technologies with different technical debt value. Extended technical debt will entail the expenses necessary to adapt the new product to customer needs, on the assumption made in accordance with J. Highsmith's theory. It is assumed that the newly offered product has very high innovation, which decreases with the emergence and accumulation of technical debt. This accumulation is the result of customer response reflecting the expectations of specific modifications to adapt this product to increasingly specific needs. In line with the above concept, it is assumed that product innovation decreases as knowledge of the practical possibilities of restrictions on new innovative products increases. In this way, the predefined volume of the extended technical debt (PDT) of a given technology can be expressed as (2):

$$PDT_{i,j} = f_{i,j}(DT), \quad (2)$$

where:

$PDT_{i,j}$ is a matrix of applied technical debt resulting from the first application of a given technology for the j th use function ($i = 1, 2, \dots, n; j = 1, 2, \dots, m$),

DT is the vector of expected net technical debt associated with the i th technology, hence $DT = [dt_1, dt_2, \dots, dt_p]$.

The identification of net technical debt as the sum of technical debt and its reduction by synergies from the use of other technologies linked to the introduction of new technology will be based on the detalization of PDT matrix recordings. Technical debt formalisation, as proposed by F. Sgobbi, will consist in adopting the criterion of discounted cash expenditure to calculate net updated value as a means of expressing PDT in a formula (3):

$$PDT_{ij} = \sum_{t=1}^N \frac{f_{ij}(DT_1, DT_2, \dots, DT_p, t)}{(1 + r_t)} \quad (3)$$

or in matrix form:

$$\begin{bmatrix} PDT_{1,1} & \dots & PDT_{1,m} \\ \vdots & \ddots & \vdots \\ PDT_{n,1} & \dots & PDT_{n,m} \end{bmatrix} = \sum_{t=1}^N \begin{bmatrix} \frac{f_{1,1}(DT_1, DT_2, \dots, DT_p, t)}{(1 + r_t)} & \dots & \frac{f_{1,m}(DT_1, DT_2, \dots, DT_p, t)}{(1 + r_t)} \\ \vdots & \ddots & \vdots \\ \frac{f_{n,1}(DT_1, DT_2, \dots, DT_p, t)}{(1 + r_t)} & \dots & \frac{f_{n,m}(DT_1, DT_2, \dots, DT_p, t)}{(1 + r_t)} \end{bmatrix}$$

where:

$f_{ij}(DT_1, DT_2, \dots, DT_p, t)$ is the cash expenditure resulting from the use of j th technology for the i th use function during the t th period of technology offering,

r_t is a discount rate for the t th unit offering period (e.g. for the year $t = 1, 2, \dots, N$); N is the number of periods of offering a given technology.

Further, in order to maintain the correctness introduced by the original model, the proposed entry will still have to allow for the limitation of the data taken into account to quantitative variables. Such simplification is desirable for the use of such a defined concept for optimising the investment plan related to the introduction and development of new technology. The flow-through interpretation adopted here still needs to be specified as the proposed reformulation of the model is based on an estimate of expenditure resulting from the dynamics and possible coverage of resulting technical debt. The presented approach based on extended technical debt helps to determine the decline of commercialized product value derived from the loss of its innovativeness for the customer. Also it's the makes possible to estimate the indispensable investment to finance the effective adaptation of concerned product to the client expectations.

5. Conclusions

The initial measurement concept of technical debt presented as a tool for measuring the level of product innovation makes it possible indirectly to parameterise the innovation of new technology indirectly. The measurement of its level in both cases is based on the more popular modular structure of the product and points at the customer as an exogenous source of perceived innovation, which refers to accepted trends. The concept of technical debt is thus becoming worth more detailed analysis and broader research in terms of the economy of the company. The development of its possible applications can have a significant impact on a reliable and accurate measurement of innovation dynamics and contribute to increasing the effectiveness of decision-making processes in the field of technological development. The decision-making uncertainty that accompanies the development of these technologies is also becoming important for the development of the concept of the use of technical debt.

References

1. Akerlof, G.A., Shiller, R.J. (2017). *Złować frajera Ekonomia manipulacji i oszustwa*. Warszawa: Polskie Towarzystwo Ekonomiczne.
2. Alves, N., Mendes, Th., de Mendonca, M., Spinola, R., Shull, F., Seaman, C. (2016). Identification and management of technical debt: A systematic mapping study. *Information and Software Technology*, no. 70, pp. 100-121.
3. Ampatzoglou, A., Chatzigeorgiou, A., Avgeriou, P. (2015). The financial aspect of managing technical debt: A systematic literature review. *Information and Software Technology*, Vol. 64, pp. 52-73.
4. Artmann, C. (2009). *The Value of Information Updating in New Product Development*. Berlin-Heidelberg: Springer-Verlag.
5. Buchmann, J. (2015). *Valuing the Innovation Potentials of Firms What Theory Suggests, Practitioners do, and both Implies for Existing Theory*. Wiesbaden: Springer Gabler.
6. Codabux, Z., Williams, B.J., Bradshaw, G.L., Cantor, M. (2017). An empirical assessment of technical debt practices in industry. *Journal of Software: Evolution Process*, Vol. 29, no. 1894. pp. 1-32.
7. Filipowicz, P. (2018). Use function and its technical debt as the foundation for modeling innovative products. *Central and Eastern European Journal of Management and Economics*, Vol. 6, no. 1, pp. 9-20.
8. Filipowicz, P. (2019). New product conceptualization through the technology based use function reconfiguration. *International Journal of Innovation in Management*, Vol. 7, no. 2, pp. 81-87.
9. Guo, Y., Seaman, C., da Silva, F. (2016). Costs and obstacles encountered in technical debt management – A case study. *The Journal of Systems and Software*, 120.
10. Highsmith, J. (2009). *Agile Project Management: Creating Innovative Products*. USA: Addison-Wesley Professional.
11. Kahneman, D. (2012). *Pułapki myślenia*. Poznań: Media Rodzina.
12. Keinonen, T., Takala, R. (2006). *Product Concept Design A Review of the Conceptual Design of Products in Industry*. Germany: Springer Science + Business Media.
13. Kraft, Ch. (2012). *User Experience Innovation*. New York: Springer-Verlag.
14. Loch, Ch.H., Kavadias, S. (2008). *Handbook of New Product Development Management*. UK: Elsevier Butterworth-Heinemann.
15. Magnusson, J., Bygstad, B. (2014). *Technology Debt: Toward a New Theory of Technology Heritage*. 22 European Conference on Information Systems, Tel Aviv, Israel.
16. Malerba, F. (2006). Innovation and the evolution of industries. *Journal of Evolutionary Economics*, no. 16, pp. 3-23.

17. Martini, A., Bosch, J. (2017). On the interest of architectural technical debt: Uncovering the contagious debt phenomenon. *Journal of Software Evolution Process*, Vol. 29, no. 1877. pp. 1-18.
18. McGregor, J.D., Monteith, J.Y., Zhang, J. (2012). *Technical Debt Aggregation in Ecosystems*. Joint Working Conference on Software Architecture & 6th European Conference on Software Architecture. USA: IEEE Computer Society, pp. 27-30.
19. Mu, J., Di Benedetto, C.A. (2011). Strategic orientations and new product commercialization: mediator, moderator, and interplay. *R&D Management*, 41(4), pp. 337-359.
20. Nord, R., Ozkaya, I., Kruchten, Ph., Gonzales-Rojas, M. (2012). *In Search of a Metric for Managing Architectural Technical Debt*. Joint Working Conference on Software Architecture & 6th European Conference on Software Architecture. USA: IEEE Computer Society, pp. 91-100.
21. Petric, I.J., Echols, A.E. (2004). Technology roadmapping in review: A tool for making sustainable new product development decisions. *Technological Forecasting and Social Change*, no. 71, pp. 81-100.
22. Rampino, L. (2011). The Innovation Pyramid: A Categorization of the Innovation Phenomenon in the Product-design Field. *International Journal of Design*, Vol. 5, No. 1, pp. 3-16 (6-7 innovation driven product designing process).
23. Schultz, C., Salomo, S., Talke, K. (2013). Measuring New Product Portfolio Innovativeness: How Differences in Scale Width and Evaluator Perspectives Affect its Relationship with Performance. *Journal of Product Innovation Management*, Vol. 30, no. S1, pp. 93-109.
24. Schumpeter, J. (1960). *Teorie rozwoju gospodarczego*. Warszawa: PWN.
25. Sgobbi, F. (1995). An integrated approach to the diffusion of technological innovation: the non-manufacturing advanced robotics field. *Technovation*, Vol. 15, no. 1, pp. 11-24.
26. Taura, T., Nagai, Y. (2017). Creativity in Innovation Design: the roles of intuition, synthesis, and hypothesis. *International Journal of Design Creativity and Innovation*, Vol. 5, no. 3-4, pp. 131-148.
27. Vijay Kumar, V., Sundarraj, R.P. (2018). *Global Innovation and Economic Value*. India: Springer.
28. Woodall, T. (2003). Conceptualising 'Value for the Customer': An Attributional, Structural and Dispositional Analysis. *Academy of Marketing Science Review*, no. 12, pp. 1-44.

SUPPORTING REMOTE EDUCATION IN THE CONDITIONS OF THE PANDEMIC IN POLAND

Karolina GABRIEL

University of Economics in Katowice; karolina.gabriel@edu.uekat.pl, ORCID: 0000-0001-6930-1379

Purpose: The aim of the paper is to compare the possibilities of providing education in the field of on-line learning by presenting tools enabling teaching in the pandemic conditions.

Design/methodology/approach: The following methods are used: literature review, analysis of websites of companies, which offering the use of education platforms necessary to conduct distance learning, case study analysis of platforms, which are a remote education tool: Integrated Educational Platform, Microsoft Teams, Google Classroom and ClickMeeting.

Findings: One of the first solutions to prevent the spread of the SARS-CoV-2 virus pandemic in Poland was the suspension of teaching, educational and care activities in schools and educational institutions for designated periods. The next stage was the introduction and implementation of the obligation to carry out educational tasks using distance learning methods and techniques. Remote learning, which was introduced in a relatively short time, requires meeting many conditions by potential users, i.e. having efficient computer equipment, a place at home to study, access to high-speed internet and educational platforms.

Research limitations/implications: The article contains an analysis based on the examples of various educational platforms applied in Poland. In further research, it is possible to create a survey to find out about users' opinions on educational platforms. With the advancement of technology as well as users' feedback, online learning can be significantly improved in the near future. There are some limitations in research related to conducting distance learning in the country, due to the short period of analysis, lack of information and the difficulty of obtaining comparable data.

Originality/value: The presented different solutions, which are used for distance learning, are a comparison of various educational platforms and may constitute their recommendations. Hence the analysis of the case of using various educational platforms in the pandemic reality. The article presents the value of teaching for the society and for its continued proper functioning. Currently, the conditions of the pandemic place significant restrictions on all kinds of education, in schools, colleges, businesses and other training. The article is addressed both to pupils, students, as well as to professionals who use the platforms for training or improvement of their business activities.

Keywords: education, on-line learning (remote learning), educational platforms.

Category of the paper: case study analysis, content analysis.

Introduction

The main goal of general education in Poland, as well as university education, is to provide knowledge that is an essential element of active and creative participation in the life of the community. Educational units shape the values important for the proper functioning of free citizens, acting in accordance with democratic principles. The pillars for citizens should be elements such as tolerance, respect for human rights as an individual, including the rights of minorities. Any society should function in freedom, share the sense of solidarity, and the goal of citizens is to develop respect for the idea of the common good. Education is supposed to educate people in the spirit of patriotism and create the sense of bonds in the society. Teaching in a balanced way creates active cooperation of individuals, both at the professional level and in family life, in order to select and achieve jointly set goals. Educational units are designed to stimulate social responsibility towards themselves and the ability to account their activities to others (Pietrzyk, Sieprawska).

In addition to the above values, education should provide skills, i.e. the ability to learn effectively, to think critically, to know at least two foreign languages, to use the foundations of mathematics at the fluent level, to use information transfer techniques in the advanced manner, and to communicate. In addition, the school aims to implement in students the skills of understanding and using information that is typical and most common in everyday life, i.e. at work, school, public life and local communities (Pietrzyk, Sieprawska).

The above-mentioned skills should be shaped on a level that allows to implement elementary skills in everyday life. The scope of teaching should be defined at the primary as well as secondary level, using gradually improved standards. On the other hand, the level of mastery of these skills should be verified using standardized, nationwide external exams.

Education in Poland is common and available to all, while the current pandemic situation generates the need to introduce new solutions in the field of education. According to the Report of the Minister of National Education, legal solutions were applied in Poland, which also enabled distance learning (Pietrzyk, Sieprawska).

One of the first solutions to prevent the spread of the SARS-CoV-2 virus pandemic was the suspension of teaching, educational and care activities in schools and educational institutions for designated periods. The next stage was the introduction and implementation of the obligation to carry out educational tasks using distance learning methods and techniques. The very method of organizing the work of teachers and students in the field of distance learning was decided by the directors of the institutions themselves, in consultation with teachers, taking into account the students' abilities. Poland was among the countries that reacted the fastest to the developing pandemic situation, and on March 4, 2020, the first decision was made to suspend educational activities in educational institutions (Report of the Minister of National Education, 2020).

During the videoconference with ministers of education from different countries of the European Union, views and experiences in the field of the functioning of the education systems were exchanged and compared. Solutions for the forms of distance education of students were discussed and legal regulations were developed, enabling the so-called remote learning. Among state initiatives, schools were allowed to use the Integrated Educational Platform (www.epodreczniki.pl) (Report of the Minister of National Education, 2020).

As part of the preparation and implementation of distance education, the Minister of National Education appointed a team for the implementation of distance education in order to prevent the spread of the SARS-CoV-2 virus. The tasks of this team include coordinating and monitoring all distance learning, the epodreczniki.pl platform, cooperation with education curators at the distance learning level, the functioning of a network of methodological advisers in helping teachers in the new reality of teaching, cooperation with Telewizja Polska S.A. as a part of ongoing educational programs, ongoing review of EU activities in the field of distance education, as well as monitoring legal solutions and cooperation with all representatives of electronic journal platforms. The work of the above team is supervised by the Undersecretary of State in the Ministry of National Education (Report of the Minister of National Education, 2020).

Methods

Currently, there is a noticeable digital revolution and the associated widespread use of technology in everyday life. Hence, as already mentioned, the prevailing pandemic situation forced the necessity to use the above solutions in everyday education. On-line lessons were conducted instead of teaching in schools. Thanks to these solutions, the school was to become a modern place that functions in the era of the socio-technological revolution. The new information and communication solutions are aimed at supporting the didactic process, and thus developing digital competences in society. Preparing all e-learning users to fully and properly function on-line requires broadening their knowledge of technology. In addition, the proposed educational solution requires constant access to appropriate computer equipment, as well as to a reliable internet connection for all participants of the educational process, i.e. teachers, students, parents, lecturers and students. The available equipment and internet infrastructure should enable the realization of education in various forms, either collectively or individually (Ptaszek, Stunża, Pyżalski, 2020).

The rapid implementation of education on-line in Poland met with a wide response from IT companies in terms of creating new educational platforms. The aim of the paper is to compare the possibilities of developing and providing education in the field of on-line learning by presenting tools enabling teaching in the pandemic conditions. The proposed purpose of the

study was assigned the following question by researchers: do the educational platforms offered in Poland meet the expectations of different audience? To answer the question, the methods used are literature review, analysis of websites of companies, which offering the use of platforms necessary to conduct distance learning, case study analysis of platforms, which are a remote education tool.

Currently functioning remote education both in schools and as a part of vocational training courses has advantages and disadvantages. The following table lists the pros and cons of online learning (Wedel-Domaradzka, Raczyńska, 2013).

Table 1.
Advantages and disadvantages of distance learning

Advantages	Disadvantages
Freedom in choosing the place of study, and saving time in terms of commuting.	There is no suitable place at home to allow proper concentration.
Increase in users' competences in the field of IT.	Difficulty operating a wide variety of learning platforms.
Adapting to the needs of students – creating an individualized didactic offer.	Lack of sufficient motivation and the ability to organize independent work.
New forms of integration and networking.	The need to have an appropriate IT infrastructure.
Often freedom and possibility to independently choose the time to study – in the case of training based on recordings.	Feeling of loneliness.

Adapted from: How to effectively conduct classes on the educational platform?, A. Wedel-Domaradzka, A. Raczyńska, National Center for Supporting Vocational and Continuous Education, Warsaw 2013, pp. 6-7.

According to the above study, the visible advantages, allowing a better organization of the working day, are confronted with numerous disadvantages. The on-line learning solution for people working professionally may be a significant organizational facilitation, while among children and adolescents who only devote themselves to education, it may generate numerous problems due to the feeling of loneliness.

The basic element necessary for remote education is the possession of efficient computer equipment. According to data collected by PISA 2018, this condition was not met by all countries before the outbreak of the SARS-CoV-2 pandemic. In Poland, 96% of students have computer equipment and can use it to work at home.

In addition to the appropriate equipment, each student must have a suitable place and atmosphere for home education. According to the above research, as many as 96% of students in Poland reported having a quiet place to work and study at home (Report of the Minister of National Education, 2020).

The aforementioned platform for schools, introduced by the Polish ministry, as part of the Integrated Educational Platform, is a modern and safe educational tool, enabling distance learning with an extensive database of proven and widely developed digital educational materials. The integration of the platform with the Educational Information System allowed the creation of 5.7 million user accounts, while teachers gained access to data on classes and schools in which they conduct educational activities. The introduction of this platform was

dictated by the will to continue teaching in the pandemic reality (Report of the Minister of National Education, 2020).

The Integrated Educational Platform epodreczniki.pl (ZPE) was implemented in February 2019. It is currently a professional and safe for users tool for distance learning, recommended by the Minister of National Education. All content made available on the platform in question is free and available anytime, anywhere. All content available on the platform can be printed in PDF version. The proposed materials on the platform facilitate education through forms of communication activity, as well as interactive exercises and multimedia materials. ZPE gives the opportunity to create interdisciplinary lessons, acting, teacher versions of the textbook, group work and individual education (Centrum Informatyczne Edukacji, 2021).

The e-textbooks portal is distinguished by accessible and free e-materials. The platform also allows the teacher to import classes based on data from the Educational Information System, create their own e-materials using a wizard, edit and personalize materials, as well as share notes with other users and check learning results. Additionally, ZPE allows for the creation of videoconferences and the inclusion of links to meetings in the calendar (Centrum Informatyczne Edukacji, 2021). Certainly, the distinguishing feature of the proposed solution is the possibility to access free materials and exercises for specific groups of students.

Another distance learning solution is a platform created by Microsoft, called Microsoft Teams. It is a tool that facilitates on-line learning as well as hybrid learning (Microsoft, 2021b). Teams is a digital hub for students and teachers. All conversations, content and applications are accumulated in one place. Thanks to synchronization, work is more efficient, and the flow of information is more readable. This tool enables teachers to create personalized learning environments. The app highly supports collaboration between teachers and students and facilitates communication in the classroom (Microsoft, 2021a).

Unlike the previous solution, the Microsoft Teams platform is a paid learning tool. The application is aimed at handling not only meetings as part of lessons and lectures, but also business videoconferences. The tool does not offer any teaching materials directly. Any sharing of notes, presentations or materials must come from teachers. However, operating in the Windows environment, it is certainly a highly advanced technological solution that allows to integrate many applications and environments necessary for on-line learning.

Another platform that enables distance learning is Google Classroom. This solution is available to schools that use Google Workspace for Education. The bundle includes drive, docs, sheets, presentations, and other Google services all in one place. By combining services, teachers and students are able to access all proposed services through standardized tools. It is free for all users (Google Classroom, 2021b). In the platform, the teacher has the opportunity to start a video meeting, create classes, projects, and give grades to students. On the other hand, the student can monitor tasks and submitted projects, hand them over via the platform and correspond with lecturers, as well as share their materials and communicate in the stream of classes and send synchronized e-mail messages. The tutor can easily summarize the activities of the students and also check the advertisements (Google Classroom, 2021a).

Another solution is the ClickMeeting platform. The platform allows communication between lecturers and recipients through chat conversations, as well as direct participation in classes. In addition to standard options, such as sharing materials, recording meetings, organizing tests, ClickMeeting also allows to promote business models. One of the users of this form is the Subway company, which promotes itself to franchisees and educates them in the field of running a business using distance learning tools. Using a platform to present new ideas and business strategies within a functioning franchise network. Subway is a company with 44,000 locations worldwide. Hence, the use of the ClickMeeting platform enables quick and easy communication between individual branches and easy exchange of opinions, experiences and the clash of new ideas (ClickMeeting, 2021).

Discussion

According to the research of subject platforms: Integrated Educational Platform epodfinansniki.pl (ZPE), Microsoft Teams, Google Classroom and ClickMeeting it has been noticed that they meet with different preferences in terms of recipients. Each of the platforms, has similar basic functions, but differs in terms of additional solutions, such as sharing files during classes or the possibility of synchronization with other applications.

The platforms presented above show how fast technology is developing in the current situation. The rapid introduction of on-line learning has received a wide response from leaders in the IT industry. The selection of the educational platform is dictated by the preferences of specific users. Of course, the wide range of distance learning platforms does not solve the problems of users related to the feeling of loneliness, less attention at home, and the generation of poorer learning results. Further research will not only improve the solutions offered by educational platforms, but will also be able to focus on the negative implications of confinement at home and distance learning.

According to the PISA research conducted in 2018, many developed countries in relation to the opinion of school heads do not have an effective e-learning platform that is available online and supports such learning. In Poland, 35% of those running educational institutions stated that there is an effective online learning platform available in the country. With regard to the pandemic situation, the situation has changed. It was forced by the necessity to introduce new teaching conditions. In response to the research, the ministry introduced the previously mentioned Integrated Educational Platform (Report of the Minister of National Education, 2020). Above are some of the most popular distance learning tools. Not only the free solutions proposed by the state began to function in new forms of education, but also IT companies took the opportunity to create new paid platforms, which in practice find a number of recipients.

In addition to introducing online teaching tools, already in 2019 more emphasis was placed on educating students' digital competences and skills in the use of modern technologies to solve problems in various fields. The new core curriculum referred, *inter alia*, to learning programming from an early age and the introduction of an increased number of hours of computer science. Extending IT education is aimed at preparing students to solve problems in areas, *i.e.* economy, life, science, while consciously using the available IT tools. Education in this field also supports logical thinking, creativity in the field of problem-solving, the ability to undertake and implement innovations and optimize tasks (Report of the Minister of National Education, 2020).

Results

The rapid introduction of distance learning in connection with the SARS-CoV-2 virus pandemic quickly stimulated the development of IT in Poland. Additionally, steps were taken to analyze students and teachers in terms of adaptation to new forms of education, *i.e.* the purchase of computer equipment for students, internet connection. The presented platforms, which are often used, offer the possibility of creating online meetings, along with joining participants in the conversation, conducting chats or sharing presentations. Hence, the presented educational platforms are to present a wide range of possibilities in the field of educational solutions for on-line learning. In Poland, the platforms used, among others, include Integrated Educational Platform epodfinansniki.pl (ZPE), Microsoft Teams, Google Classroom and ClickMeeting. The presented educational platforms differ in terms of operating costs, the possibility of using them with other applications. Due to the short test period of using on-line learning in Poland and the lack of comparable results of students' work, further research is necessary. In such research, it is possible to conduct not only a questionnaire among platforms' users, but also compare the results of learning of pupils, students as well as students taking part in improving their professional qualifications. In addition, further studies on remote education may enable the improvement of the on-line platforms and their functionality to the potential and diversify user. Significant technological advances and further research allow for rapid implementation of improvements to the platforms concerned.

According to the analysis of the case study and a critical analysis of the content of ministerial reports, remote learning in Poland, introduced in a short period of time requires the fulfillment of many conditions, *i.e.* having appropriate computer equipment, a place at home for quiet learning and access to the Internet. At the same time, it is necessary to have an appropriate and effective platform for online learning, depending on the expectations and the form of classes. In the case of learning after primary or secondary school level, information maneuverability is important so that the teacher can communicate with the student. With regard

to universities or training to a large number of users, it is important that the platform has the ability to conduct education with a large audience, while avoiding disruption. As can be seen in the case study analysis, there are currently several efficient educational platforms available, which, depending on the preferences and expectations of users, have various solutions to facilitate work on-line.

References

1. *Centrum Informatyczne Edukacji*. Available online <https://cie.gov.pl/zpe/>, 09.04.2021.
2. *ClickMeeting*. Available online https://blog.clickmeeting.com/subway-case-study?_ga=2.105063621.730751359.1617962632-1220698368.1617962632, 09.04.2021.
3. *Google Classroom a*. Available online <https://support.google.com/edu/classroom/answer/6020279>, 09.04.2021.
4. *Google Classroom*. Available online <https://support.google.com/edu/classroom/answer/6020279>, 09.04.2021.
5. *Google Classroom b*. Available online <https://support.google.com/edu/classroom/answer/6025224?hl=pl#zippy=%2Ckto-może-korzystać-z-classroom%2Cile-kosztuje-classroom%2Cco-łączy-classroom-z-google-workspace-for-education>, 09.04.2021.
6. *Microsoft, a*. Available online <https://education.microsoft.com/pl-PL/resource/d5b62e3e>, 09.04.2021.
7. *Microsoft, b*. Available online <https://www.microsoft.com/pl-pl/microsoft-teams/log-in>, 09.04.2021.
8. Pietrzyk, K., Sieprawska, A. *Education for Development Program, Civic responsibility for national education*. Ombudsman.
9. Report of the Minister of National Education (2020). *Ensuring the functioning of education system units during the COVID-19 epidemic*. Warsaw.
10. Stunża, G., Pyżalski, J., Ptaszek, G. (2020). *Remote education*. Gdańsk: Gdańskie Wydawnictwo Psychologiczne Sp. z o.o.
11. Wedeł-Domaradzka, A., Raczyńska, A. (2013). *How to effectively conduct classes on the educational platform?* Warszawa: National Center for Supporting Vocational and Continuing Education.

THE ROLE OF MANAGEMENT SUCCESSION IN THE GROWTH OF POLISH SMEs

Grzegorz GLISZCZYŃSKI^{1*}, Filip BERKOWSKI²

¹ Lublin University of Technology, Faculty of Management; g.gliszczynski@pollub.pl,
ORCID: 0000-0003-0668-7037

² MCI Capital TFI S.A.; filip.berkowski@hotmail.com

* Correspondence author

Purpose: The aim of this article is an attempt to prove the hypothesis, that one of the key obstacles for growth of Polish SMEs is a lack of management succession, understood as the employment of a professional management team and/or allowing for an external investor.

Design/methodology/approach: In this article the authors used external studies, industry reports and data published by domestic and international statistical offices and financial institutions. In order to draw conclusions, the authors used the comparative analysis of available statistical data and case studies of five Polish companies listed on the Warsaw Stock Exchange.

Findings: Findings include: 1. characteristics of the SME sector and its importance for the Polish economy, 2. explaining the role of management succession in the growth of the company and identifying barriers to this process, 3. indicating relationship between size/success of the company and presence of professional management and corporate governance, 4. presenting the impact of institutional environment on management succession, 5. showing the relationship between success of selected Polish companies and their management succession model.

Research limitations/implications: The space of management succession in Polish companies has never been a subject to any comprehensive research neither in the theoretical, nor in statistical dimension. To better understand the actual scope, forms, limitations and effects of the succession, the authors made an empirical research based on a representative sample of 200 Polish SMEs. Findings from this research will be published in a separate paper.

Practical implications: The authors see the practical effects of sharing the results of this research mainly in the possibility of changing the skeptical behavior of Polish entrepreneurs towards management succession.

Originality/value: The originality of the article results from the multifaceted approach to the research problem, which has no equivalent in the domestic literature. It is important for management practitioners and for setting directions for further research.

Keywords: Polish small and medium enterprises (SMEs), barriers of growth, management succession, case studies.

Category of the paper: Literature review/Case study.

1. Introduction

In the broader context the article deals with issues related to management methods and development of Polish private enterprises, which play the key role in the economy of the whole country. They create many workplaces and generate a large portion of the Polish gross domestic product. Especially small and medium enterprises (SMEs) were the key growth driver and the main source of success of the Polish economy in recent years. However, we note the problem, that despite the success of many SMEs (and despite a number of institutional programs supporting their development and innovation), very few reached an international scale and recognition. Except for limited examples, Polish entrepreneurs find it difficult to overcome barriers of growth, which would allow them to become regional champions.

The authors make the hypothesis that lack of the management succession is one of key barriers of growth for Polish enterprises. Many Polish companies are managed by their founders, who cannot or do not want to make a use of external professional managers and, as a consequence, are not able to properly manage a growing organization.

So far, studies on the management and development of Polish SMEs focus mainly on quantitative data and statistics describing the SME pool, their size, employment and profile of operations, which has been reflected in this paper, as well as their legal form (Jagodziński, 2015; Kosmal, 2019). Some SME-related studies and reports deal with issues like innovation (Okoń-Horodyńska, & Zachorowska-Mazurkiewicz, 2008; MPiT, & Siemens, 2018; Włodarczyk, 2017; Ribau et al., 2017), macroeconomic environment (Wach, 2016; Zygmunt, & Zygmunt, 2016), legal framework (Kabut, & Malesa, 2015; ZPiP, 2017) and institutional needs (Lachiewicz, 2016; Wójcik-Karpacz, & Rudawska, 2016) such as cost of labor and social contributions (Chład, 2016; Papaj, 2016), access to technology (Kaliszczak, & Pawłowska-Mielech, 2019; Nowak, & Wieteska, 2020) and external financing (Korzeniewska, 2016; Steinerowska-Streb, 2015), etc.. On the other hand, studies on the management succession are usually described only in the case of family businesses, where both management and ownership are transferred between generations of a single family (for example this issue is covered by the Polish institute dealing with family businesses: Instytut Biznesu Rodzinnego). However, hardly any studies focus on the management succession between entrepreneur and professional, external management team. Although this issue is fundamental for the whole Polish economy, where the first generation of entrepreneurs is now approaching the retirement age, there are no complex studies describing it in neither statistical, nor theoretical manner.

The aim of the article is to prove the working hypothesis through:

1. Description of the scale of the issue and its importance for the Polish economy.
2. Understanding why the management succession helps in maintenance of a sustainable growth and defining the institutional environment, which supports such succession.

3. Finding a relation between the size/success of the company, and presence of professional management and corporate governance.
4. Finding a relation between development of institutions supporting the professionalization of corporate governance and presence of international companies in a given country.
5. Understanding the relations between the success of the largest Polish companies and their management succession model and corporate governance.

2. Methods and materials

In this article the authors used external studies and industry reports covering: 1. research on SMEs, 2. family businesses, 3. studies on organizational life cycle, 4. private equity funds, 5. stock markets and capitalization of local stock exchanges. The detailed list is attached in the bibliography at the end of this article.

The article also quotes statistical data published by Polish statistical office (GUS), International Monetary Fund, Eurostat and the portal TheGlobalEconomy.com, as well as publicly available data on companies listed on the Warsaw Stock Exchange (WSE) included in stock indexes WIG20 (large companies) and mWIG40 (mid-sized companies).

The authors used the following research methods:

1. Analysis of statistical data, as well as information about the shareholder structure and corporate governance of the largest Polish enterprises.
2. Analysis of statistical data for Poland and other selected developed countries to point out relations between presence of institutions impacting professionalization of the management boards of local enterprises and presence and development of international companies in a given country.
3. Case studies of five largest Polish companies listed on Warsaw Stock Exchange controlled by entrepreneurs, to find out the relations between a business success and a chosen model of management succession.

In this article the authors used their professional and research experience related to the Warsaw Stock Exchange, private equity industry, co-operation with Polish and foreign entrepreneurs, work in supervisory boards, corporate governance, as well as the diagnosis and innovation of the companies' management systems (Gliszczyński, 2013; Gliszczyński, & Panasiewicz, 2020).

3. The general description of the Polish SME sector

The socialist system implemented in Poland after the second world war effectively stopped any development of private entrepreneurship until the end of 80thies. However, since the time of political transformation, which took place in Eastern Europe in early 90ties, Poland has been seen as a very entrepreneurial country. Thousands of new, Polish businesses are registered every year. Between 2009 and 2018 the number of active companies grew from 1.7 to 2.2 million (GUS, 2019a). The vast majority of Polish enterprises (99.8%) are classified as SMEs, including: 1. 2,079 thousand of microenterprises with up to 9 employees (96.7% of total), 2. 52.7 thousand of small enterprises with 10-49 employees (2.4%) and 3. 15.2 thousand of mid-sized enterprises with 50-249 employees (0.7%). In Poland there are only 3.7 thousand of large enterprises employing more than 250 people (0.2%) (PARP, 2019).

The enterprise sector generates 73.9% of Polish GDP, which includes 49.8% generated by SMEs (PARP, 2019). At the end of 2018 there were 10.0 million employees working in the non-financial enterprises in Poland, of which 6.8 million in small and medium enterprises (and roughly 4 million in microenterprises) (GUS, 2019b). Between 2010 and 2018 the average salary in enterprise sector in Poland increased from ca. PLN 3.4 thousand to ca. PLN 4.8 thousand (GUS, 2019b).

The above statistics clearly underline the importance of the SME sector for the whole Polish economy. The performance of SMEs obviously depends on the quality of management in individual companies, which is now starting to be negatively affected by demographic factors because many Polish entrepreneurs, who started their businesses in 90thies, are now approaching the retirement age.

Despite strong, local position of many Polish companies, very few became regional champions and hardly any reached a truly international recognition. The average resident of the European Union would easily name a number of brands of German cars, French luxury goods, or British banks. However, he or she would find it difficult to name any brand of Polish company. Similarly, the popular ranking of top 100 most valuable global brands, although dominated by the US brands, includes also German (8 items) and French brands (4 items), but does not name even a single brand from Poland (MillwardBrown, and WPP, 2019).

Comparison of the market capitalization of leading European companies leads to the same conclusions. The study carried out by Polish portal bankier.pl in 2017 shows that the largest (at that time) Polish company (PKN Orlen, state controlled fuel and energy player) was classified only at place number 306 (Torchała, 2017). Unfortunately, the statistics do not lie here. Currently in Poland there is not a single company, that could become an European leader in terms of size and recognition.

The lack of international recognition of Polish businesses is a complex problem and, as always in the economic science, cannot be explained by a single variable. One can argue that Polish companies still find it difficult to catch up with Western European businesses, which reached the international scale long before political transformation in Poland. The unfortunate capital structure can be perceived as another reason for lack of international success of Polish businesses. As a result of a fast privatization of Polish post-socialistic economy, many Polish businesses become subsidiaries of German or French companies and currently, as a part of capital group, they follow the strategy of Western European headquarters. The foreign investments in Poland are mainly concentrated in mid-sized and large Polish companies (20.3% and 36.8% of entities respectively). Only 1.1% of small and microenterprises has a foreign ownership (own calculation based on GUS data). 57.5% of foreign capital in Poland is invested into large companies with over 250 employees (GUS, 2019a), while 65% of Polish export sales is generated by companies with foreign investors (PARP, 2019).

One can easily name a dozen of other macroeconomic conditions, which may limit the international growth of Polish businesses, including: insufficient level of accumulated domestic capital, lack of sufficient government programs to support innovation, complex and unpredictable legal and tax framework, dominant share of state in key sectors (such as banking, energy, mining), or education system that is not properly adapted to market needs. The level of direct foreign investments is yet another issue (Soylu, 2019). However, this article focuses on one, often neglected factor, namely the difficulties in the management succession in Polish companies.

4. Management succession in the sustainable business development

To understand the importance of the management succession for the future success of the business, let's focus first on the usual phases of the business development cycle. The available studies give a handful of multiphase models of organizational life cycle (OLC), where the number of phases oscillate from 3 up to 10. These models were developed over several dozen of years to address the changing environment, in which organizations (mainly companies) operate. Some models were criticized, but the fact that the business development can be split into separate, distinctive phases is widely accepted (Lichtenstein & Lyons, 2008). One of the most popular organizational development models has been developed by Quinn and Cameron, who aggregate four phases, that are also described in other studies, into: 1. foundation phase (entrepreneurship), 2. growth phase (collectivity), 3. maturity phase (formalization and control), 4. expansion phase (adjusting the organization, decentralization) or decline (Quinn, & Cameron, 1983).

Every new business starts with an idea developed by an entrepreneur. Once the idea proves on the market as a working business concept, the company starts to grow. The founder invests into the new real assets and employs people to increase the scale of operations. In the vast majority of cases, in early stages of development, the founder becomes a CEO and runs the company as a one-man show. Founder usually takes all decisions, maintains all key business relations and runs the controlling function through a simple review of the bank account statement.

The one-man show businesses can be extremely lean and efficient organizations, only as long as one person can successfully manage the whole company. However, every successful business, by definition, is a growing one, which means that at some point it outgrows its founder. The next phase of the business development is associated with strengthening of the management team (e.g. by adding sales director, CFO, chief operating officer, etc.) and building a proper organization structure to control growing (and therefore constantly changing) business. This may also change a role of the founder. The 1,000 people strong organization has different requirements than a 10 people start-up and being a successful entrepreneur does not always mean being a successful manager.

As this stage, in developed countries many founders decide to hand over the management of the company to external CEOs, controlled by the founder through supervisory board, or through a group of non-executive directors. Some other founders, decide to stay at executive position, but focus more on strategic issues and surround themselves with the group of professional managers, who deal with day-to-day operations.

Employment of the external management team clearly requires establishing the proper corporate governance in the company, i.e. a split of competences between the owner and the manager. The corporate governance issue is broadly discussed in the literature (e.g. Castaner et al., 2019; Gerged, 2020). From the one hand balanced rules will allow the new team to properly manage the organization, while from the other should allow the owner for the effective control and supervision over his wealth. Implementation of the clear and balanced corporate governance rules plays a key role in the sustainable growth of the business, while the lack of such governance is an obstacle to grow. However, it does not mean that there is a one model that fits well into all companies. Quite the opposite, both structure of the management and corporate governance rules should always be adjusted to individual needs (Shafi, 2004).

The common goal, such as an increase in value of the company, is a very basic condition of a proper cooperation between the management team and the owner. Professional management teams usually participate in the management option programs, which give them additional benefits, if the value of the company grows under their management. Ownership participation of management would increase the motivation of the management team, help keeping key managers in the organization and would make sure that managers and owners have the same goals, but also would help in the effective management succession (PWC, 2017). In the pool of the largest European enterprises, the employee option programs usually comprise the shares representing ca. 3% of total share capital of the company (PWC, 2017).

For a family business, bringing in an external manager is also an alternative to the family-based management and succession between generations. This is especially important, since the research shows that succession between generations is very difficult. Based on estimates, less than 30% of family businesses survive into the third generation under family management (Ballini, 2020). Only 30% of family businesses are successful in the second generation and only 8% in third (IBR, 2019). The presence of the independent directors from outside the family in management and supervisory boards helps in separating business and family issues and eases the management succession in the company (Ballini, 2020).

The management succession, while common for many developed countries, is not an usual case in Poland. Many Polish SMEs, although initially successful, stop their development at the stage when the founder is no longer able to manage the business on his own. The expected management succession does not happen and sustainable growth of the business is gone. From the European perspective, the succession issue is relatively neglected by Polish entrepreneurs. Finding the right successor is perceived as a key issue by 32% of European family businesses, compared to only 9% of Polish respondents. This means that Polish entrepreneurs either do not plan any succession, or it is obvious for them that the company will be taken over by their children and they do not even consider any external candidates for the management team (KPMG, 2020).

Moreover, Polish entrepreneurs often neglect the corporate governance issue. Based on the KPMG survey on 100 of SMEs, only 56% of family businesses have a formal management board, 25% have a formal advisory body and only in 16% of cases a shareholders' agreement is in place (KPMG, 2020). The ultimate decision about a change in the management team and introduction of the formal corporate governance would always be made by an owner (e.g. the founder of the company), and the potential rejection of that change would usually be caused by both behavioral and financial reasons, which are often impacted by institutional factors.

5. Analysis of the relation between size of the company and its management

According to estimates of the Polish institute dealing with family businesses, 92% of enterprises in Poland are owned by private entrepreneurs (IBR, 2016). There are no precise studies showing how many of them have an external management team. However, given that: 1. the vast majority of these enterprises belong to the SME group and 2. only 15% of them have a formal management board, it is fair to assume that over 85% of all enterprises controlled by private individuals are still managed by their founder (IBR, 2016).

The above wide group of enterprises, which statistically may represent the SME pool, was compared to the largest Polish companies controlled by private individuals. For this exercise we have selected companies listed on the WSE, included in indexes WIG20

(5 companies) and mWIG40 (15 companies), for which a private entrepreneur (alone or together with other entrepreneurs based on the shareholders' agreement) is the largest shareholder and owns at least 25% stake in the company (own analysis based on the data from companies listed on the Warsaw Stock Exchange included in indexes WIG20 and mWIG40). The outcome of this comparison is presented in table 1.

Table 1.

The share of external CEOs in different groups of companies controlled by entrepreneurs

Group of companies	Companies with the external CEO (%)
Largest companies controlled by an entrepreneur WIG20	60%
Large companies controlled by an entrepreneur mWIG40	40%
SMEs controlled by an entrepreneur (estimate) n/a	< 15%

Source: own study.

All large companies (WIG20 and mWIG40) included in the table 1 were founded by private entrepreneurs after 1990 and given their current market capitalization, by definition, they reached the market success. The analysis of data from the table 1 gives a clear conclusion: there is a statistical dependence between an employment of the external CEO and a size/success of the company (i.e. the larger the company is, the more likely it is managed by the external CEO).

This conclusion is consistent with the authors' experience based on years of co-operation with Polish companies and entrepreneurs. However, the authors are aware of the weakness of the above analysis, which is based on a very limited and uncomplete set of data. It is fair to say that no detailed data on the composition of management boards are available for a wide group of Polish enterprises. Collecting such data might be considered as a subject of a separate research study and publication.

6. Behavioral factors impacting decision about the management succession

Most of the Polish entrepreneurs are self-built men, i.e. they did not inherit any significant wealth, but built their fortune on their own (unlike in Western Europe, the accumulation of private wealth in Poland started only after 1990). Therefore, the company, which he (or she) created, usually constitutes the vast majority of founder's personal wealth. Such entrepreneurs are very reluctant to entrust their company to the external management team, whom they do not know and do not fully trust. Also, since the accumulation of private wealth in Poland started only some 30 years ago, still 85% of entrepreneurs believe that their company should stay in family's hands, i.e. should be taken over by their children (KPMG, 2020). On the other hand, according to the study of Polish institute dealing with family businesses, only 6.3% of entrepreneurs' children are interested in a family succession (IBR, 2019) (because of the success of their parents' business, children are usually less hungry for success and money than

their parents were some 30 years ago). As a result, so far only 5% of Polish businesses controlled by an entrepreneur went through the family succession between generations (IBR, 2016).

It is obvious that compared to Western Europe, Polish society is relatively less affluent (according to Eurostat data for 2018 the average monthly salary in Poland reached EUR 1,059 compared to the EU average of EUR 2,981). Therefore, an entrepreneur, who managed to build a successful mid-sized company in Poland is already perceived as a very affluent person (e.g. an entrepreneur who owns a business with say EUR 10 million revenues and EUR 1 million profit would easily fall into top 1% of richest Poles). That makes entrepreneurs less hungry for success and money, and makes them care less about continuous growth of the business. According to the Polish Business Roundtable 62% of Polish entrepreneurs do not intend to increase the scale of their business, because they are happy with what they achieved so far and think that further development might be too risky (PRB, 2019). Further, the management succession and the corresponding business development (i.e. entering new markets, development of new products, employing more people, or building the new production plant) would normally move the founder outside his (or her) comfort zone. People, especially those who are already perceived as successful by their community, do not like changes, which creates yet another obstacle for successful management succession process.

Although the successful management succession can take a company to the next level, the transition process is also risky (the new CEO and his team may not fit the organization, which may harm the company), brings material costs and requires a major effort to find the right people. Although all major European headhunting firms have their offices in Poland, they are poorly staffed (compared to Western European offices), focus on large enterprises or private equity firms and rarely provide services to SMEs. Therefore the challenge of finding the right people is usually in the hands of an entrepreneur. Without a proper experience and due to time constraints, many entrepreneurs abandon such search.

The succession process is very complex and finding the right successor is always a challenge. Moreover, unlike in the case of many Western European family businesses, many Polish enterprises are facing the succession for the first time (KPMG, 2020). The work of an external manager in a family business does not only require pure management skills, but also the understanding of the family values and goals (which may be different to the ones of listed companies with dispersed shareholder structure, or the ones controlled by private equity funds), which makes management of such business even more difficult (Blikle, 2013). The case, where external managers support an entrepreneur who stays in the company as a CEO, may also bring an additional complexity. The coexistence of family and business relations, may lead to an uneven treatment of employees from the family and from outside the family (Matejun et al., 2017).

Apart from the time effort, management transition brings a real money cost. Many Polish SMEs are subcontractors of German, of French holdings, strictly controlled by their key business partners, who allow only for a small profit mark-up. Such SMEs operate on relatively

low, single digit margins, which do not leave much space for additional costs. On the other hand, the external, experienced management team of, say, 5 senior executives, by definition cannot be cheap and may cost EUR 0.5 – EUR 1.0 million a year. Such expense usually pays back in longer term, but as an immediate effect it wipes out a significant portion of profits of the SME. For many entrepreneurs such expense is unacceptable, especially given the risk that the whole transition may turn out to be unsuccessful and disruptive for the business.

Finally, for many entrepreneurs, running the own business is just a regular lifestyle, which they do not want to change. They enjoy being the boss, take all decisions in the company and they do not want to change this status quo.

7. Institutional factors and the management succession

The above factors seem, to some extent, universal for all entrepreneurs and the obvious question is why Polish entrepreneurs are more reluctant to management changes than their peers from Western Europe. It seems that the institutional environment of developed countries creates more incentive for entrepreneurs to transform their businesses into professionally managed companies with a potential for international growth: on the one hand entrepreneurs are encouraged to make a change (because there are certain institutions which limit risks of the management transition), while on the other they are discouraged to remain in “as is” situation (because they see examples of successful transformation in other companies and understand how they increased value of these businesses). The depth of capital markets plays a key role here, especially the presence of private equity (PE) and venture capital (VC) funds, as well as the efficiency of the local stock exchange market.

VC funds are firms that invest into companies in a relatively early stage of their development. They usually offer the founder a relatively decent valuation for a stake in the business (usually a minority stake) and become the co-owner of the company. The founder benefits from both money proceeds, which diversify his personal wealth, and fund’s support in further development of the company. Given the fact that the fund would only invest, when it sees prospects for a further business growth, it would normally enforce the management succession in the firm, which could take the organization to the next level. Also, as an external investor, VC fund would need to bring both executive and non-executive directors to the firm to control the company and balance the power of founder, who would normally stay as an executive director in the firm. With the fund’s support, founders are usually more eager to allow for management transition. First, they have a partner (VC fund), who has seen such transition many times before and would normally have an access to the pool of experienced managers willing to take a role, which eases the search for proper candidates. That also mitigates a risk that transition may fail. Second, after a partial cash-out of their stake in the

company, founders have less to loose and are more willing to take a chance of a rapid business development.

PE funds are similar to VC, but they usually invest in a later stage of a business development, when companies already generate material cash flows. The usual PE investment would be a 100% buyout, or buyout of a majority stake in the company, which usually results in the founder stepping down from running the business. Therefore, establishing the proper management team and corporate governance is fundamental in every private equity investment. Similarly to VC, the management succession and an effective supervision over the company is obviously the key competence of the fund. Finding the right managers, creating the optimal work conditions and a proper motivation through the management option program play a fundamental role in realization of the investment strategy of the fund. The research shows that portfolio companies of private equity funds were experiencing changes in the composition of the management team more often than companies without such investor (Siegel et al., 2010).

Stock market plays a very similar role to PE and VC firms, but usually at a later stage of development (depending on the market, there is a certain size of the company required for a successful initial public offering). It is common that public stock market purchases shares of successful businesses from VC/PE firms, which execute exit strategy after their investment horizon. Public investors require: transparency of financial results, clear strategy of the business, depth of the management and proper corporate governance, which ensure continuity of the business in case of a resignation of the CEO. Therefore, a strong and experienced management team is a must in every listed company.

It is also fair to say that private equity investment or listing on the stock market does not automatically result in a successful composition of the management team and an ultimate business success. There are many examples of failed private equity investments in Poland and across the region (for various reasons, including failures in the composition of the management team). Although the change in an ownership structure does not guarantee a success, at least it results in an attempt of introduction of the professional management and gives a chance to maintain a sustainable growth of the business.

In order to find the relation between institutional factors and successful management succession, the authors have analyzed an institutional environment of three countries: Germany, France (where large international companies are present) and Poland (where there are no such companies). The goal was to verify, if a presence of institutional factors, such as: 1. developed local stock exchange market, 2. presence of private equity investments and 3. employee stock option programs, is correlated with the size of companies in a given country. The outcome of this exercise is summarized in table 2.

Table 2.

Relation between selected institutional factors and presence of the large companies in a given country

Institutional factor	Poland	Germany	France
Total capitalization of the local stock exchange as % of GDP	27%	44%	85%
PE investments as % of GDP	0.15%	0.27%	0.70%
Participants of employee option/stock programs as % of population	0.19%	0.84%	4.33%
Number of companies with market cap above EUR 10 billion	0	26	34

Source: own analysis based on the statistics published by portal TheGlobalEconomy.com and International Monetary Fund, (Invest Europe, 2019), (PWC, 2017).

The summary presented in table 2 shows that the Polish capital market is clearly far behind the developed markets of Western Europe. The access to financing from a stock exchange market and a private equity in Poland is still limited: based on a recent questionnaire, the main source of external financing of entrepreneurs in Poland is the bank financing (42% of respondents), while most of entrepreneurs use financing from accumulated profits (74%) and capital from family and friends (71%) (KPMG, 2020). The Ernst & Young (EY) report published in 2009 also points out: a liquidity gap in Polish SMEs, problems with access to bank financing and insufficient presence of private equity funds on the Polish market (EY, 2009).

Despite being the largest in Central and Eastern Europe, the Warsaw Stock Exchange is still far behind the Western Europe markets, not to mention the US market. The total market capitalization of assets listed on the WSE in 2018 amounted to USD 160 billion i.e. ca. 27% of Polish GDP, compared to USD 1,755 billion market cap in Germany (44% of GDP) and USD 2,366 billion in France (85% of GDP) (own analysis based on the statistics published by portal TheGlobalEconomy.com and International Monetary Fund). Out of 140 largest Polish companies listed on the WSE, only 31% has implemented the employee stock option program (PWC, 2017). Similarly, despite being a regional leader, Poland is far behind Germany and France in terms of the size of private equity investment as percentage of GDP.

The above analysis confirms the statistical relation between the presence of large, international companies, and development of institutional factors, which promote corporate governance and the effective management succession in companies.

The EY report published in 2009 pointed out weaknesses of the government SME support programs, which were in place at that time (EY, 2009). It seems, that over the last decade, Polish governments realized that SMEs struggle to maintain the sustainable growth long before reaching the international scale. The issue has been identified as a lack of sufficient funds to finance growth and innovation, and led to (among others) foundation of government sponsored Polish Development Fund (PFR), which is supposed to stimulate SMEs through both direct and indirect VC and PE investments. Although unintentional, the increased activity of state funds (through VC and PE vehicles) may ultimately lead to more attempts of management successions and may educate the market (i.e. the group of entrepreneurs) that management transition is a normal step in the growth path of the company. However, this could only work, when entrepreneurs see multiple examples of successful transition processes in Polish SMEs.

Now, would this happen? It may work, but the ultimate result would depend on effectiveness of investment managers responsible for spending PFR funds.

8. Case studies

Although many Polish enterprises find it difficult to achieve a regional success, still, there are examples of successful Polish firms, which reached the status of countrywide, or even a regional champion. Below, we present case studies for five such companies: Dino, CD Projekt, CCC, LPP and Cyfrowy Polsat, which are the only entities that are both: included in WIG20 index (which comprises of the largest companies listed on the WSE) and are under control of an entrepreneur, which is better illustrated on figure 1. Case studies focus on corporate governance and the relation between the management succession within these companies and the business growth.

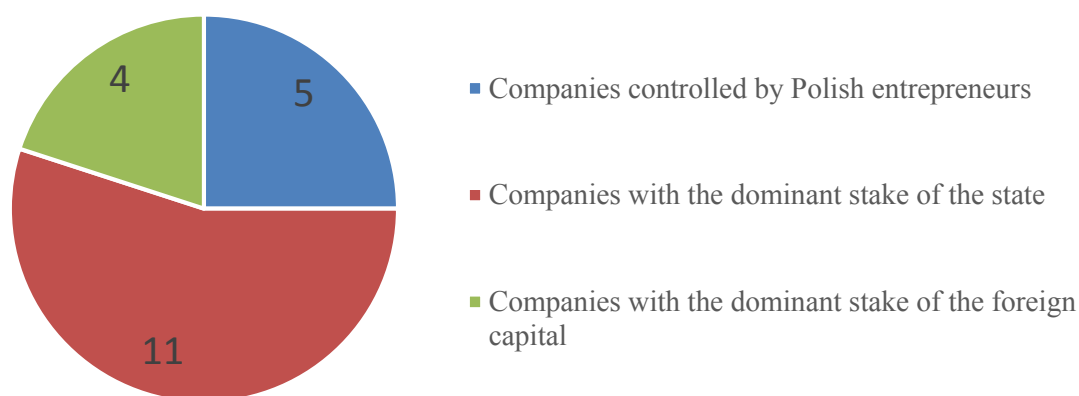


Figure 1. Shareholder structure of WIG20 companies. Source: own study.

8.1. Dino Polska S.A.

Dino Polska S.A. is the countrywide proximity supermarket chain with revenues exceeding PLN 7.6 billion in 2019. The company was founded in 1999 and is one of the largest success stories of the Polish entrepreneurship in the last thirty years. Dino is also an excellent example of the company founded by an entrepreneur, which went through the private equity investment and ultimately was listed on the stock exchange. PLN 200 million investment was intended for financing the further growth of the business. As a result, the fund acquired 49% stake in Dino. Tomasz Biernacki, the founder and so far the CEO, remained the majority shareholder, and become a Chairman of the Supervisory Board, while the new management team had no stake in the business. At the beginning of 2017 the private equity fund sold its stake in Dino in the initial public offering (IPO) at the Warsaw Stock Exchange for PLN 1,655 million.

At the time of the IPO the management option program was settled and the management team gained shares in the company. Good corporate governance practices introduced before the IPO helped the company in further development. At the end of 2019 the network had already 1,218 stores (including 243 stores opened in 2019), while the market capitalization of Dino exceeded PLN 16 billion at the beginning of 2020.

8.2. CD Projekt S.A.

CD Projekt S.A. is the largest Polish developer and distributor of video games. Thanks to the Witcher trilogy games and their global distribution, CD Projekt become the best recognized Polish company in the world. In 2010 CD Projekt used the backdoor to enter the Warsaw Stock Exchange through the merger with other listed company Optimus. Entrepreneurs, who founded CD Projekt in 90ties, Adam Kiciński, Marcin Iwiński and Piotr Nielubowicz, still remain the key shareholders and stay in the management board of the company. However, listing the company in 2010 had an impact on its corporate governance. They were supported by independent Supervisory Board Members, the company implemented the best WSE standards and introduced the management stock option program motivating the key employees to increase the value of the company. Thanks to the clear strategy, open communication with the market, success of the Witcher trilogy and high expectations about the new game based in Cyberpunk 2077 universe, the price of CD Projekt share increase from PLN 5 in 2012 to over PLN 300 currently. At the beginning of 2020 the market capitalization of CD Projekt exceeded PLN 30 billion and the company become the most valuable Polish enterprise.

8.3. CCC S.A.

CCC S.A. is the largest shoe retailer in Central and Eastern Europe and the largest shoe producer in Europe. The company has almost 800 stores in 16 countries, is one of very few Polish businesses, which reached the status of a regional champion and successfully entered foreign markets with its own brand. The company was founded in 90ties by Dariusz Miłek, who until March 2019 remained its CEO and holds 30% stake in the business. The company started as a shoe retail and wholesale business. Over time CCC created its own franchise retail chain in Poland and in 2001 started its own shoe production. In 2004 the company generated revenues of PLN 278 million and made an IPO on the WSE. The presence on the stock market made CCC introduce the professional corporate governance. The new members of the management and supervisory board were gradually joining the company. Over the next fifteen years CCC was very consistent in its development and was gradually opening local offices and stores in foreign markets in the region. In 2016 the company acquired e-obuwie.pl, the leader in e-commerce shoe distribution, which only strengthened the regional power of CCC. At the beginning of 2017 the new managers experienced in capital markets joined the management board. In 2019 one of them replaced Dariusz Miłek on the CEO position, while the entrepreneur become the Chairman of the Supervisory Board. Between 2017 and 2019 the

revenues of CCC increased from PLN 3.2 billion to over PLN 5.8 billion, while EBITDA almost doubled.

8.4. LPP S.A.

LPP S.A. is the largest Polish designer and retailer of apparel sold under own brands, of which Reserved gained the strongest recognition. LPP forces the regional foreign expansion alongside with the development of the Polish retail chain. Currently, the international chain of LPP comprises of ca. 1,600 stores, while the Reserved brand (alongside with CCC) is the most widely recognized Polish fashion brand in the region. LPP was founded in 1991 by Marek Piechocki and Jerzy Lubianiec, who still have ca. 30% stake in the company and 60% of voting rights. In 2001 the company generated revenues of PLN 171 million and was listed on the Warsaw Stock Exchange. In that period, the management and supervision functions of the two partners were separated (CEO and Chairman). In years from 2003 to 2005 the company experienced the investment from the private equity fund managed by Enterprise Investors. Over time the company attracted the external managers dealing with logistics, IT, e-commerce and financial matters. Since the IPO, LPP is constantly entering the new regional markets, promotes the new fashion brands and keeps developing its e-commerce function. Over the last two decades, the company experienced a sustainable growth reaching PLN 2 billion in sales in 2010 and close to PLN 9 billion currently, while the market capitalization of LPP remains above PLN 10 billion.

8.5. Cyfrowy Polsat S.A.

Cyfrowy Polsat S.A. is the largest Polish multimedia group providing integrated services in the space of: pay digital TV, telecommunication, TV production and broadcasting. In 2019 the group generated PLN 11.7 billion in sales. The history of Cyfrowy Polsat, founded by Zygmunt Solorz-Żak, starts in late 90ties, when the company started broadcasting the satellite signal. In 2003 the company got the state concession for broadcasting the satellite TV and radio signal and became a fully independent operator of the digital platform. In 2008 the number of subscribers reached 2.7 million, Cyfrowy Polsat generated PLN 787 million of revenues and was listed on the Warsaw Stock Exchange. Since the IPO, the company continues its strategy of both organic growth and growth through acquisitions. The acquisition targets included: Polsat television (TV production) in 2010, Polkomtel (mobile phone services) in 2014, Netia (telecommunication) in 2018 and interia.pl (Internet portal) in 2020. As a result Cyfrowy Polsat is constantly increasing its scale of operations, its consolidated revenues grew to PLN 11.7 billion in 2019 and market capitalization exceeds PLN 15 billion. Since the very beginning, the entrepreneur used the support of external managers and until 2014 remained the CEO of the group. In 2014 Zygmunt Solorz-Żak led the management succession between generations and gave up the CEO position to his son, Tobiasz Solorz. The entrepreneur became a Chairman of the Supervisory Board of the key companies within the group. It seems that, the succession

between generations did not fully meet expectations of the entrepreneur. Between 2015 and 2018 the growth of the business significantly slowed down (to less than 3% revenue growth annually). At the beginning of 2019 Tobiasz Solorz resigned from CEO position and was replaced by external managers, while Zygmunt Solorz-Żak remains the majority shareholder with 57% stake in the company and together with his two sons focuses on supervision of the business.

The management succession issue discussed in the five case studies above has been summarized in table 3.

Table 3.

Management succession in the analyzed companies – comparison

Company	Foundation year/ industry	IPO / PE investment	Key changes in the corporate governance	Key outcomes of the succession
Dino Polska S.A.	1999/ food retail	2010 – PE investment 2017 – IPO on WSE	2010 – the founder moves to the Supervisory Board; External managers take a lead in the Management Board	1. Fast growth of the store network; 2. Increase in revenues coupled with the improvement of profitability; 3. Large success of the IPO; 4. Dino included in the group of 20 largest Polish companies
CD Projekt S.A.	1994/ video gaming	2010 – merger with the listed company	Since 2010 – independent members in the Supervisory Board, introduction of the best practices on WSE and management option program	The company is still manager by its founders, which shows that the business success can be achieved without the full succession. Currently CD Projekt is the largest Polish company with the market capitalization exceeding PLN 30 billion.
CCC S.A.	1995/ production and distribution of shoes	2004 – IPO on WSE	2017 – external managers joining the company 2019 – the founder moves to the Supervisory Board	1. Intensified foreign expansion of the company; 2. Fast increase in revenues and doubling profits; 3. Focus on e-commerce
LPP S.A.	1991/ production and distribution of apparel	2001 – IPO on WSE 2003 – PE investment	2000 – first founder moves to the Supervisory Board; second founder becomes the CEO; 2004-2008 – external managers joining the company	1. Intensified foreign expansion of the company; 2. Fast growth of the store network in Poland and abroad; 3. Introduction of the new fashion brands; 4. Focus on e-commerce
Cyfrowy Polsat S.A.	1996/ telecommunication	2008 – IPO on WSE	2014 – son of the founder replaced him as a CEO, founder moves to the Supervisory Board; 2019 – son of the founder moves to the Supervisory Board	1. Business growth slowed down, when the son of entrepreneur was the CEO of the business; 2. The results of nominating the new CEO in 2019 are still difficult to estimate

Source: own study.

9. Conclusions

In the introduction to this article, the authors made a hypothesis that lack of the management succession is one of barriers of growth for Polish enterprises, due to which only few Polish companies are reaching the international scale and recognition. The analyzed issue is particularly important because of the significance of the SME sector for the whole Polish economy and the fact that the first generation of Polish entrepreneurs, who started businesses in 90ties, is just now approaching the retirement age.

To support the working hypothesis, the authors showed that the sustainable growth of companies is correlated with: 1. professionalization of the management boards and introduction of the corporate governance system, 2. presence of the institutions, which provide funding and promote a professional management. Additionally, the authors described reasons, why the lack of an effective management succession may slow down the growth of the company. Based on presented case studies, authors showed that most successful Polish companies founded in 90thies were able to effectively deal with the management succession issue and introduced the proper corporate governance. The above supports the working hypothesis set in the article. As an outcome of the study, authors draw the following conclusions relating to both practical and academic use of given results:

In practical terms, it seems reasonable that current institutional programs of corporate support, which focus primarily on promoting innovation and export, should also deal with education and support entrepreneurs in professionalization of their management methods. In a longer run, the right education and institutional support may stimulate the sustainable growth of Polish companies, lead to creation of many new workplaces and GDP growth.

In academic terms, it should be underlined that the space of management succession in Poland has never been a subject to any comprehensive research. To better understand the issue from the statistical standpoint, it seems reasonable to carry on the research surveys among entrepreneurs, which could give a good description of SMEs, whose management was given to professional external managers and estimation of its impact on financial performance of these companies. Such studies are prepared and carried out by the authors of this study in 200 Polish enterprises. Their results will be published in a separate publication.

10. Summary

The aim of this article is to answer the question, why many Polish small and medium enterprises (SMEs) stop their development after reaching a relatively limited scale of operations and do not manage to reach an international, or even a countrywide recognition. The authors

give a number of potential answers and point out that one of the key obstacles for sustainable growth is a lack of management succession (allowing for an external investor, employment of professional management team) once the company develops, which is caused by both behavioral and financial factors, as well as insufficient institutional support. The authors aim to prove this working hypothesis through analysis, which use external studies and industry reports covering the examined issue, as well as statistical data published by relevant domestic and international agencies. In order to draw conclusions, following research methods were used: review of available external studies, comparative analysis of statistical data and case studies of selected companies. Findings include: 1. characteristics of the SME sector and its importance for the Polish economy, 2. explaining the role of management succession in the growth of the company and identifying barriers to this process, 3. indicating relationship between size/success of the company and presence of professional management and corporate governance, 4. presenting the impact of institutional environment on management succession, 5. showing the relationship between success of selected Polish companies and their management succession model.

References

1. Ballini, B. (2020, January 27). Every family business needs an independent director. *Harvard Business Review*. <https://hbr.org/2020/01/every-family-business-needs-an-independent-director>.
2. Blikle, A. J. (2013, November 18). *Menedżer spoza rodziny w firmie rodzinnej*. Inicjatywa Firm Rodzinnych. <https://docplayer.pl/61552831-Menedzer-spoza-rodziny-w-firmie-rodzinnej.html>.
3. Castaner, X., Goranova, M., Hermes, N., Kavadis, N., & Zattoni, A. (2019). Ownership and corporate governance across institutional contexts. *Corporate Governance. An International Review*, 27(6), 506-512. <https://onlinelibrary.wiley.com/doi/10.1111/corg.12308>.
4. Chład, R. (2016). Koszty pracy w strukturze kosztów działalności małych i średnich przedsiębiorstw. *Zeszyty Naukowe Politechniki Częstochowskiej – Zarządzanie*, 24(2), 172-185. <http://zim.pcz.pl/znwz/files/Koszty-pracy-w-strukturze-kosztow-dzia-alno-ci-ma-yh-i--rednich-przedsi-biorstw.pdf>.
5. Ernst & Young [EY]. (2009). *Innowacyjność sektora MSP w Polsce*. <https://docplayer.pl/780767-Innowacyjnosc-sektora-msp-w-polsce.html>.
6. Gerged, A. M. (2020, October 25). *Factors affecting corporate environmental disclosure in emerging markets: The role of corporate governance structures*. *Business Strategy and the Environment*. <https://onlinelibrary.wiley.com/doi/abs/10.1002/bse.2642>.

7. Gliszczyński, G. (2013). *Diagnoza systemów zarządzania przedsiębiorstwami w górnictwie węgla kamiennego*. Wydawnictwo Politechniki Śląskiej.
8. Gliszczyński, G., & Panasiewicz, L. (2020). Management innovation – the study of views and the concept of methodology of independent research. *Scientific Papers of Silesian University of Technology. Organization and Management*, 144, 87-104. <http://dx.doi.org/10.29119/1641-3466.2020.144.7>.
9. Główny Urząd Statystyczny [GUS] (2019a). *Działalność gospodarcza podmiotów z kapitałem zagranicznym w 2018 roku*. <https://stat.gov.pl/obszary-tematyczne/podmioty-gospodarcze-wyniki-finansowe/przedsiębiorstwa-niefinansowe/dzialalnosc-gospodarcza-podmiotow-z-kapitałem-zagranicznym-w-2018-roku,26,2.html>.
10. Główny Urząd Statystyczny [GUS] (2019b). *Działalność przedsiębiorstw niefinansowych*. <https://stat.gov.pl/obszary-tematyczne/podmioty-gospodarcze-wyniki-finansowe/przedsiębiorstwa-niefinansowe/dzialalnosc-przedsiębiorstw-niefinansowych-w-2018-roku,2,15.html>.
11. Instytut Biznesu Rodzinnego [IBR] (2016). *Model 5 poziomów definicyjnych firm rodzinnych*. <http://www.europeanfamilybusinesses.eu/uploads/Modules/Publications/poland-fam-bus.pdf>.
12. Instytut Biznesu Rodzinnego [IBR] (2019). *Skuteczna sukcesja w firmie rodzinnej. Fakty i mity, kompleksowość zagadnienia*. https://www.parp.gov.pl/attachments/article/56084/Sukcesja_w_firmie_rodzinnej_prezentacja.pdf.
13. Invest Europe (2019). *European private equity activity 2018: Statistics on fundraising, investments & divestments*. <https://www.investeurope.eu/media/2585/invest-europe-2018-european-private-equity-activity.pdf>.
14. Jagodziński, A. (2015). Formy prawno-organizacyjne przedsiębiorstw. *Zeszyty Naukowe PWSZ w Płocku. Nauki Ekonomiczne*, 21(1), 79-88. <http://cejsh.icm.edu.pl/cejsh/element/bwmeta1.element.desklight-45e33c66-f9f8-48be-93f3-55d9f3e310ad>.
15. Kabut, M., & Malesa, T. (2015). Funkcjonowanie przedsiębiorstwa, a otoczenie prawne na przykładzie branży samochodowego transportu ładunków. *Acta Universitatis Nicolai Copernici*, 42(3), 137-149. http://dx.doi.org/10.12775/AUNC_ZARZ.2015.038.
16. Kaliszczak, L., & Pawłowska-Mielech, J. (2019). Nowoczesne technologie informacyjno-komunikacyjne jako determinanta rozwoju MSP. *Nierówności Społeczne a Wzrost Gospodarczy*, 58(2), 129-140. <https://doi.org/10.15584/nsawg.2019.2.9>.
17. Korzeniewska, B. (2016). Niestandardowe formy finansowania przedsiębiorstw rola i decyzje wyboru. *Zeszyty Naukowe PWSZ w Płocku. Nauki Ekonomiczne*, 23(1), 169-180. <http://yadda.icm.edu.pl/yadda/element/bwmeta1.element.desklight-f797d986-65e1-4460-aab0-911b6e4d353b>.
18. Kosmał, A. (2019). *Pojęcie i wybrane kategorie przedsiębiorcy w ustawodawstwie polskim*. Exante Wydawnictwo Naukowe. https://depot.ceon.pl/bitstream/handle/123456789/17297/Poj%20cie_wybrane_kategorie_2p.pdf?sequence=1.

19. KPMG International Cooperative [KPMG] (2020). *Barometr Firm Rodzinnych*. European Family Businesses. <https://assets.kpmg/content/dam/kpmg/pl/pdf/2020/02/pl-raport-kpmg-barometr-firm-rodzinnych-edycja-osma.pdf>.
20. Lachiewicz, S. (2016). Rola otoczenia instytucjonalnego w rozwoju przedsiębiorczości technologicznej. *Przegląd Organizacji*, 2, 16-21. <http://bazekon.icm.edu.pl/bazekon/element/bwmeta1.element.ekon-element-000171430664>.
21. Lichtenstein, G.A., & Lyons, T.S. (2008, November 1). Revisiting the business life-cycle: Proposing an actionable model for assessing and fostering entrepreneurship. *The International Journal of Entrepreneurship and Innovation*. <https://doi.org/10.5367/000000008786208759>.
22. Matejun, M., Stasiołek, A., & Wielec P. (2017). Pozycja pracowników spoza rodziny w procesie kadrowym w firmie rodzinnej. *Przegląd Nauk Ekonomicznych*, 26, 171-181. http://www.matejun.com/pubs-pl/2017_Marek_Matejun_Agata_Stasiolek_Paulina_Wielec_Pozycja_pracownikow_spoza_rodziny_w_procesie_kadrowym_w_firmie_rodzinnej.pdf.
23. MillwardBrown and WPP (2019, May 29). *BrandZ Top 100 Most Valuable Brands 2018*. <https://www.wpp.com/news/2018/05/brandz-top-100-most-valuable-global-brands-2018>.
24. Ministerstwo Przedsiębiorczości i Technologii & Siemens [MPiT & Siemens] (2018). *Smart Industry Polska 2018. Innowacyjność w sektorze mikro oraz małych i średnich przedsiębiorstw produkcyjnych w Polsce*. <https://publikacje.siemens-info.com/pdf/169/Raport%20Smart%20Industry%20Polska%202018.pdf>.
25. Nowak, J., & Wieteska, M. (2020). *Nowoczesne technologie w przedsiębiorstwach przed, w trakcie i po pandemii COVID-19*. Polski Instytut Ekonomiczny. https://pie.net.pl/wp-content/uploads/2020/06/PIE-Raport_Nowoczesne_tehnologie.pdf.
26. Okoń-Horodyńska, E., & Zachorowska-Mazurkiewicz, A. (2008). *Tendencje innowacyjnego rozwoju polskich przedsiębiorstw*. Instytut Wiedzy i Innowacji.
27. Papaj, E. (2016). Koszty pracy we współczesnych przedsiębiorstwach. *Studia Ekonomiczne, Uniwersytet Ekonomiczny w Katowicach*, 305(8), 94-108. <http://bazekon.icm.edu.pl/bazekon/element/bwmeta1.element.ekon-element-000171462502>.
28. Polska Agencja Rozwoju Przedsiębiorczości Grupa Polskiego Funduszu Rozwoju [PARP] (2019). *Raport o stanie sektora małych i średnich przedsiębiorstw w Polsce*. https://www.parp.gov.pl/storage/publications/pdf/2019_07_ROSS.pdf.
29. Polska Rada Biznesu [PRB] (2019). *Przedsiębiorca wysłuchany. Czego potrzebuje do rozwoju*. <https://prb.pl/wp-content/uploads/2019/05/Przedsiębiorca-wysluchany.pdf>.
30. PricewaterhouseCoopers [PWC] (2017). *Employee Stock Ownership Programs – an Opportunity for Companies, an Opportunity for Poland*. <https://www.pwc.pl/pl/pdf/publikacje/raport-pwc-employee-stock-ownership-programs-2017.pdf>.

31. Quinn, R., & Cameron, K. (1983). Organizational life cycles and shifting criteria effectiveness: Some preliminary evidence. *Management Science*, 29(1), 33-51. https://econpapers.repec.org/article/inmormnsc/v_3a29_3ay_3a1983_3ai_3a1_3ap_3a33-51.htm.
32. Ribau, C.P., Moreira A.C., & Raposo, M. (2017). SMEs innovation capabilities and export performance: an entrepreneurial orientation view. *Journal of Business Economics and Management*, 18(5), 920-934. <https://doi.org/10.3846/16111699.2017.1352534>.
33. Shafi, M. (2004, September 11). *The importance of the effective corporate governance*. SSRN. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=617101.
34. Siegel, D., Wright, M., & Filatotchev, I. (2010, November 12). *Private Equity, LBOs, and Corporate Governance, International Evidence*. SSRN. https://www.researchgate.net/publication/228178586_Private_Equity_LBOs_and_Corporate_Governance_International_Evidence.
35. Soylu, Ö.B. (2019). Do foreign direct investment and savings promote economic growth in Poland? *Economics and Business Review*, 5(4), 3-22. https://www.researchgate.net/publication/337914757_Do_foreign_direct_investment_and_savings_promote_economic_growth_in_Poland.
36. Steinerowska-Streb, I. (2015). Bariery finansowe w działalności polskich przedsiębiorstw rodzinnych. *Przedsiębiorczość i Zarządzanie*, 16(7/2), 351-369. <http://bazekon.icm.edu.pl/bazekon/element/bwmeta1.element.ekon-element-000171403483>.
37. Torchała, A. (2017, January). Oto największe spółki w Europie. Jak wypada Polska?. bankier.pl <https://www.bankier.pl/wiadomosc/Oto-najwieksze-spolki-w-Europie-Jak-wypada-Polska-7490801.html>.
38. Wach, K. (2016). Otoczenie międzynarodowe jako czynnik internacjonalizacji polskich przedsiębiorstw. *Prace Komisji Geografii Przemysłu Polskiego Towarzystwa Geograficznego*, 30 (1), 7-20. <http://yadda.icm.edu.pl/yadda/element/bwmeta1.element.desklight-6e43e872-438c-417d-a8de-20d759dfdd3b>.
39. Włodarczyk, R. (2017). Działalność innowacyjna polskich przedsiębiorstw. *Zeszyty Naukowe Politechniki Częstochowskiej. Zarządzanie*, 25(2), 116-126. <http://zim.pcz.pl/znwz/files/z25t2/10.pdf>.
40. Wójcik-Karpacz, A., & Rudawska, J. (2016). Instytucjonalne formy wspierania przedsiębiorczości w Polsce. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, 419, 248-264. <https://doi.org/10.15611/pn.2016.419.22>.
41. Związek Przedsiębiorców i Pracodawców [ZPiP] (2017). *Wpływ otoczenia instytucjonalno-prawnego biznesu na jakość państwa. Polska rajem dla MSP*. https://zpp.net.pl/wp-content/uploads/2017/11/ovutmv_RaportZPPWpywotoczeniabiznesunajakopastwa.pdf.
42. Zygmunt, A., Zygmunt, J. (Eds.) (2016). *Dostosowanie przedsiębiorstw do zmian otoczenia zewnętrznego*. Politechnika Opolska. https://www.dbc.wroc.pl/Content/40106/SiM%20451%20Zygmunt%20druk%2017_03_20_POPR.pdf.

BUSINESS-UNIVERSITY COLLABORATION IN EDUCATION: AN EXAMPLE OF JOINT TEACHING IN ENTREPRENEURSHIP AND MANAGEMENT

Grzegorz GŁÓD^{1*}, Izabella STEINEROWSKA-STREB²

¹ University of Economics in Katowice, Katowice; grzegorz.glod@ue.katowice.pl,
ORCID: 0000-0001-9699-2427

² University of Economics in Katowice, Katowice; streb@ue.katowice.pl, ORCID: 0000-0001-5379-5730

* Correspondence author

Purpose: This paper aims to increase the knowledge about the cooperation between the universities and companies in education by presenting the forms of business-university collaboration in entrepreneurship education. Moreover, the article aims at formulating guidelines for universities and companies concerning the business-university collaboration in education.

Design/methodology/approach: The case study methodology was used to achieve the research aim.

Findings: The analysis indicates various forms of cooperation between business and universities in teaching entrepreneurship and management. Moreover, the results of the study show the possible directions of university-business collaboration in the future, both in the scientific and didactic fields.

Practical implications: The research results can be used by economic universities that want, together with enterprises, to teach management and entrepreneurship practically.

Social implications: The study's outcome may lead to an increase in the knowledge of future entrepreneurs and the development of students' skills desired by employers.

Originality/value: This paper is mainly addressed to universities and companies that want to cooperate in entrepreneurship education. It shows how companies can support university from their environment in teaching students.

Keywords: education, entrepreneurship, business-university collaboration, business-university cooperation.

Category of the paper: Case study.

1. Introduction

From the beginning of the 21st century, universities increasingly cooperate with companies. In many cases, their collaboration focuses on joint research and development projects to create new, innovative technologies or products (Healy et al., 2014). Some of these research efforts last for many years. Many of them fail. Nevertheless, some of them lead to groundbreaking inventions. Therefore, companies and universities' cooperation is highly appreciated, and it is perceived as a good source of innovation and disruptive technologies (Kuratko et al., 2019).

The cooperation of universities and companies is not limited to research on new or improved products and technologies (Healy et al., 2014). This cooperation also concerns other areas of socio-economic life, as more and more companies are interested not only in generating profits and satisfying the consumption needs of society. Many of them also want to show that they are beneficial for local communities (Davey et al., 2018; Porter, 2007; Steinerowski, and Steinerowska-Streb, 2012). As part of this type of activities, some companies cooperate with universities, supporting them in teaching students and preparing such curricula that meet the changing market requirements (Epure, 2017). Such business-university cooperation is precious because it enables students to develop skills desired by employers while studying at universities (European Commission, 2014; Healy et al., 2014; Orazbayeva et al., 2019).

Business-university collaboration in education has been underestimated for many years (Galán-Muros, and Plewa, 2016). Therefore, although the European Commission undertakes different activities to promote and develop cooperation between higher education and businesses, the collaboration between companies and universities in education is in Europe much less common than in the levels of R&D collaboration (Galán-Muros, and Plewa, 2016; Healy et al., 2014). Thus, business-university collaboration in education is still in Europe in the early development stage (Epure, 2017).

European reports on the cooperation between universities and companies in education show that there is a need to develop the activities supporting that cooperation. They also emphasize that the literature on business-university collaboration in education is fragmented and limited (Galán-Muros, and Plewa, 2016; Healy et al., 2014; Perkman et al., 2013). Such reports' findings indicate that it is necessary to spread knowledge about the cooperation practices between companies and universities in education. Therefore, this paper aims to increase the knowledge in this understudied field by presenting the successful business-university collaboration in education. In particular, the study shows the forms of cooperation between the University of Economics in Katowice and a company from the automotive sector in the practical field of study "Entrepreneurship and Finance". Moreover, this article aims at formulating guidelines for universities and companies concerning the business-university collaboration in education.

2. The need of business-university collaboration in teaching entrepreneurship

Entrepreneurs create the future (Doo et al., 2021). Therefore, they should be as well prepared as possible for the role they are to play in society. They must be aware that they are expected to bring social and economic change and be agents of creative destruction who destroy old paradigms and initiate changes. They should also know that they should be pioneers in introducing new processes and products (Welsh et al., 2016).

To be agents of changes, entrepreneurs should be creative, innovative, and sensitive to the environment (Welsh et al., 2016). Moreover, they ought to think critically, take the initiative, solve problems and work collaboratively (European Commission, 2014). Thus, they should be able to connect things, ideas, people, and processes (Doo et al., 2021). These attitudes, skills and knowledge entrepreneurs should obtain during their education, in particular, while studying at universities specializing in teaching in entrepreneurship and management. However, entrepreneurs do not always acquire entrepreneurial competencies in high schools or Higher Education Institutions. In practice, in many countries, a lack of sufficient entrepreneurial education constitutes a significant barrier to entrepreneurship development (Elaine et al., 2013).

Entrepreneurship education is currently "in a state of transition" (Welsh et al., 2016, p. 126). It is on its way to transformation both at the conceptual and technological levels. Global, social, political, and technological changes that took place all over the world caused that new models of entrepreneurship education started to develop. During entrepreneurship classes, e-learning and mobile devices began to be used. Besides, a new teaching toolkit is introduced. At universities offering practical entrepreneurship education, both inside and outside Europe, the theory is generally combined with practice. Everywhere, activating forms of work with students are used. These are real-life examples, learning by doing, case studies, role-plays, simulations and interaction. Nevertheless, between particular universities offering entrepreneurship programs, there are some differences in teaching methods. Some universities organize study visits to companies. Others invite entrepreneurs for meetings during which they share their knowledge and experience with students. There are also universities where students gain practical expertise by opening real enterprises with funds specially allocated for this purpose (Steinerowska-Streb, and Głód, 2021).

Universities that offer students entrepreneurship programs increasingly try to establish links between practice and theory by cooperating with local companies. Sometimes they even launch regional alliances for entrepreneurship (Davey et al., 2018). Such initiatives are the most valuable for entrepreneurship students when they allow them to observe entrepreneurs' day-to-day duties. Therefore, to build students' entrepreneurial competencies through hands-on and real-life learning experiences, universities should actively involve the business sector in teaching entrepreneurship.

To foster the efficiency of the collaboration between universities and companies in education, universities should develop a toolkit for joint teaching entrepreneurship. In creating practical tools for such cooperation, they can be helped by knowledge about other universities' successes and failures in collaboration with the business sector. In this way, emerging types of university-business cooperation can be worldwide adapted.

3. Methods

The case study methodology was used to achieve the research aim. We chose that methodology, considering that the case study is one of the most widely used qualitative research methodologies in research on education in social sciences (Yazan, 2015). We adopted the definition of the case study by Merriam (1998). According to this definition qualitative case study is “an intensive, holistic description and analysis of a bounded phenomenon such as a program, an institution, a person, a process, or a social unit” (Yazan, 2015, p. 141). Merriam states that a case study characterizes three unique, idiosyncratic attributes: particularistic, descriptive, and heuristic. Particularistic means for her that the case study focuses on the particular situation, event, program, or phenomenon. Descriptive – that the case study provides a detailed description of the phenomenon under study. Finally, heuristic means for Merriam that case study helps the reader understand the phenomenon under study.

The case study presented in this article concerns the cooperation in management and entrepreneurship education between the University of Economics in Katowice and Tenneco Automotive – a company from the automotive industry. This cooperation is carried out in the practical field of study "Entrepreneurship and Finance". That field of the study is one of two practical fields of study in entrepreneurship existing in Poland. The University of Szczecin offers the second one.

Tenneco Automotive is an American multinational corporation. It is one of the leading manufacturers in the automotive industry. It deals with production of parts for car factories. The company has been operating in Rybnik since 1997. The company produces and distributes its products in Central, Eastern and Western Europe.

It supplies silencers for all types of passenger cars, both for the primary market (OE – Original Equipment, sales are made directly to car manufacturers) and for the secondary market (AM – Aftermarket, sales of spare parts to retailers and wholesalers). Tenneco Automotive Poland produces exhaust systems for many brands of passenger cars as well as for motorcycles. The company has been systematically implementing and improving lean management solutions.

The cooperation between the University of Economics in Katowice and Tenneco Automotive began in 2007. It was launched based on the informal collaboration between the representatives of Management Scientific Circle "Manager" and representatives of Tenneco company. There were two main initiators of that cooperation. The first one was the circle's supervisor – Grzegorz Głód, and the second was the company's representative – Grzegorz Pawlak.

The data for the case study started to be gathered in 2007 through participant observation. The observation period covered 14 years. During that time, the University of Economics in Katowice and Tenneco introduced different forms of cooperation. All of them are presented in the article.

The analysis of the data from the case study includes an evaluation of the cooperation between Tenneco and the Department of Entrepreneurship and Management Innovation from the University of Economics in Katowice. The results of the analysis indicate various forms that cooperation between business and universities can take in teaching entrepreneurship and management. Moreover, the findings show the possible directions of university-business collaboration, both in the scientific and didactic fields.

4. Collaboration areas in entrepreneurship education between the University of Economics in Katowice and the automotive company

In the initial phase of cooperation, in the years 2005-2006, due to the development of a practical didactic process, management methods applied in Tenneco Automotive were presented during the classes. Later, the Department of Entrepreneurship and Innovation Management representatives organized study visits with the participation of students to the Tenneco factory in Rybnik. These visits started to be cyclical meetings following a previously planned program. All of them covered selected aspects of implementation of lean management solutions, such as 5S and TPM. The visit consisted of three parts: a short introductory lecture, a visit to the production hall, and a concluding discussion. Since 2007, several cycles of such study visits have been realized.

Additionally, in the initial period of cooperation, the University and Tenneco representatives jointly organized a didactic contest, "Manager Challenge". That contest took place at the University of Economics in Katowice in the formula of a set of practical tasks solved by teams of students. In this regard, the company prepared sets of tasks in the area of production management and lean management.

Simultaneously with the didactic collaboration, there was scientific cooperation between the University and the company Tenneco Automotive. Attempts were also made for joint scientific publications in the area of lean management. One such publication was the article

Ewolucja koncepcji Lean Management i jej zastosowanie w przedsiębiorstwach w Polsce, published in the journal *Marketing i Rynek* by Kraśnicka, T., Głód, G., Pawlak, G. (2014).

The next stage of cooperation was the involvement of Tenneco representatives in the preparation and implementation of classes within the course of study with a practical profile "Entrepreneurship and Finance". The practical profile of education was an opportunity and a challenge for the University of Economics in Katowice. Due to formal requirements, making classes in this area practical is necessary and possible to achieve only through direct cooperation with representatives of business practice. The formal cooperation between University and Tenneco has taken place since 2014. Primarily, Tenneco supported the University in the area of modern management concepts and methods. Then, the company started to conduct workshops at the university, to continue the implementation of study visits and provide interesting teaching materials in case studies. In addition, Tenneco has offered to the students of "Finance and Entrepreneurship" the possibility of carrying out diploma theses based on the company's data. They can also prepare improvement projects in the field of, among others, the operation of production lines. Interesting work in this area was, for example, the diploma thesis of a student on balancing a new production line.

5. The benefits of university-business collaboration and the directions of its development the future

The analysis of the cooperation between the University of Economics in Katowice and Tenneco Automotive indicates that university-business collaboration in teaching entrepreneurship and management can take various forms. All of them give students different possibilities to develop their knowledge and get them closer to the practice.

The main benefits of university-business collaboration include making the didactic process more practical, which is particularly important in the case of faculties with a practical profile, the possibility for students and academic teachers to familiarise themselves, the opportunity for students and academic teachers to learn about the latest trends, especially in the field of lean management, the possibility of the practical application of selected elements of modern management methods in practice, students searching for analogies of management methods implemented in the automotive industry in companies from other industries, implementation of joint projects to improve the functioning of management processes, gaining graduates as future valuable employees, creating a positive image of the company in the socio-economic environment.

There are also such benefits of university-business collaboration that one cannot point out directly. They are often intangible. These include an inspiration for students participating in this form of cooperation based on knowledge sharing, getting to know different ways of perceiving problem situations, and exchanging experiences, often of intergenerational nature.

Developing university-business collaboration requires conducting workshops at the university, continuing the study visits, and providing teaching materials in case studies. In future, the directions of cooperation development are primarily related to adjusting its form to the current needs of the university and the company. The implementation of remote cooperation is a big challenge. In this regard, it is possible to develop collaboration with Tenneco Automotive based on virtual tours and conduct more simulation games to introduce elements of competition between students. The potential for cooperation in this area is large and requires a creative approach in its use.

6. Conclusions

The education of future entrepreneurs has to link practice with theory (Ratten, and Jones, 2021). Therefore it requires close university-business collaboration. Summing up the considerations on the possibility of cooperation between the University of Economics in Katowice and a company from the automotive industry, we can positively assess the use of various forms of joint teaching in entrepreneurship and management. Based on the analysis of the cooperation carried out so far; we can point to the future development of its directions. At the scientific level, it seems possible to jointly implement scientific projects to obtain external funding. As regards the implementation of didactic projects, it is possible to conduct consulting projects in educational pathways (Głód, Raczyńska, 2018). These projects are carried out over four semesters and require systematic cooperation between the student, the academic supervisor, and the company's supervisor. To respond to the company's needs in this area, it is necessary to properly identify possible management areas, which are the subject of project work.

On the other hand, the necessity realizing of didactic classes in a remote manner, an interesting area of cooperation seems to be the participation of a company from the automotive industry in creating simulation games. Especially the area of lean management appears to be very interesting in this respect. In this way, the company representatives may become more involved in realizing didactic classes in the scope of whole modules of classes, not only frequent visits. This teaching method will make the teaching more practical and improve the quality of representation of the business environment in the teaching process. Further on, it is possible to realize scientific research in the field of students' entrepreneurial attitudes based on the implementation of new formulas of realization of practical classes in the

course of study. In the future, this may constitute an interesting area of research in entrepreneurship education at Polish universities.

Other universities may use the University of Economics in Katowice experience to create practical courses of study in cooperation with businesses. Collaboration between universities and representatives of business practice may begin from the implementation of individual projects tailored to the needs of the university in terms of the study program and the identified expectations of business partners.

Guidelines for universities and companies concerning the business-university collaboration in education include:

- identification of possible areas of cooperation that are beneficial for universities and business representatives,
- developing cooperation in the initial phase through pilot and possibly even informal activities,
- implementation of mechanisms for creating new projects in response to the current demand, for example, a new subject in the study program, the issue of diploma theses, the use of a new IT program,
- joint and systematic evaluation of implemented projects,
- promoting activities in this area to attract new business partners and students in the future.

In addition to the activities mentioned above, openness and the positive attitude of cooperation participants are essential to develop and maintain the links between universities and the business environment in an innovative manner.

References

1. Davey, T., Meerman, A., Muros, V.G., Orazbayeva, B., Baaken T. (2018). *The state of university-business cooperation in Europe*, Luxembourg: Publications Office of the European Union.
2. Dodd, S., Anderson, A., Jack, S. (2021). “Let them not make me a stone”—repositioning entrepreneurship, *Journal of Small Business Management*, DOI: 10.1080/00472778.2020.1867734.
3. Epure, M. (2017). University-business cooperation: adapting the curriculum and educational package to labor market requirements. Proceedings of the International Conference on Business Excellence. *Sciendo*, vol. 11(1), pp. 339-349.
4. European Commission (2014). *Entrepreneurship Education: A Guide for Educators*, Entrepreneurship 2020 Unit, Brussels: Directorate-General for Enterprise and Industry European Commission.

5. Galán-Muros, V., Plewa, C. (2016). What drives and inhibits university-business cooperation in europe? a comprehensive assesement. *R&D Management*, Vol. 46, Iss. 2, pp. 369-382.
6. Głód, G., Raczyńska, E. (2018). Analiza projektu " Rozwiązanie problemu w realnie funkcjonującej firmie" w ramach praktycznego profilu studiów" Przedsiębiorczość i Finanse". *Horyzonty Wychowania*, 17(44), 199-208.
7. Healy, A., Perkmann, M., Goddard, J., Kempton, L. (2014). *Measuring the Impact of University Business Cooperation. Final Report*. Luxembourg: Publications Office of the European Union.
8. Kraśnicka, T., Głód, G., Pawlak, G. (2014). Ewolucja koncepcji Lean Management i jej zastosowanie w przedsiębiorstwach w Polsce. *Marketing i Rynek*, 5(CD), 442-449.
9. Kuratko, D.F., Goldsby, M.G., Hornsby, J.S. (2019). *Corporate innovation. Disruptive Thinking in Organizations*. New York, London: Routledge Taylor and Francis Group.
10. Orazbayeva, B., Plewa, C., Davey, T., Muros, V.G. (2019). The Future of University-Business Cooperation: Research and Practice Priorities. *Journal of Engineering and Technology Management*, Vol. 54, pp. 67-80.
11. Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Brostroem, A., D'Este, P., Fini, R., Geuna, A., Grimaldi, R., Hughes, A., Krabel, S., Kitson, M., Llerena, P., Lissoni, F., Salter, A. Sobrero, M. (2013). Academic engagement and commercialization: A review of the literature in university-industry relations. *Research Policy*, Vol. 42, Iss. 2, pp. 423-442.
12. Porter, M. (2007). *Colleges and Universities and Regional Economic Development: A Strategic Perspective. Forum for the Future of Higher Education. Excerpted from Forum Futures*. Cambridge, Mass. Retrieved from: <http://forum.mit.edu/articles/colleges-and-universities-and-regional-economic-development-a-strategic-perspective/>, 06.04.2021.
13. Ratten, V., Jones, P. (2021). Entrepreneurship and management education: Exploring trends and gaps, *The International Journal of Management Education*, Vol. 19, Iss. 1.
14. Rideout, E.C., Gray, D.O. (2013). Does Entrepreneurship Education Really Work? A Review and Methodological Critique of the Empirical Literature on the Effects of University-Based Entrepreneurship Education. *Journal of Small Business Management*, 51:3, pp. 329-351.
15. Steinerowska-Streb, I., Głód, G. (2020). Praktyczny profil kształcenia w zakresie przedsiębiorczości na uczelniach wyższych – doświadczenia polskie a standardy międzynarodowe. *Horyzonty Polityki*, Vol. 11(37), pp. 99-116.
16. Steinerowski, A., Steinerowska-Streb, I. (2012). Can social enterprises contribute to creating sustainable rural communities? Using the lens of struction theory to analyze the emergence of rural social enterprise. *Local Economy*, Vol. 27, No. 2, pp. 167-182.

17. Welsh, D.H.B., Tullar, W.B., Nemati, H. (2016). Entrepreneurship education: Process, method, or both? *Journal of Innovation & Knowledge*, Vol. 1, pp. 125-132.
18. Yazan, B. (2015). Three Approaches to Case Study Methods in Education: Yin, Merriam, and Stake. *The Qualitative Report*, Vol. 20, No. 2, pp. 134-152. Retrieved from: <http://www.nova.edu/ssss/QR/QR20/2/yazan1.pdf>, 06.04.2021.

EUROPEAN UNION FUNDS IN INFRASTRUCTURE DEVELOPMENT OF POLISH RAIL TRANSPORTATION BETWEEN 2014-2020

Daniel GRICER¹, Ireneusz J. JÓŹWIAK^{2*}, Jan SWITANA³

¹ Wrocław University of Economics and Business, Faculty of Management, Wrocław; danielgricer@gmail.com

^{2*} Wrocław University of Science and Technology, Faculty of Computer Science and Management, Wrocław; ireneusz.jozwiak@pwr.edu.pl, ORCID: 0000-0002-2160-7077

³ Wrocław University of Science and Technology, Faculty of Microsystem Electronics and Photonics, Wrocław; switana.jv@gmail.com

* Correspondence author

Purpose: The purpose of the paper is to present the importance of the EU Funds in infrastructure development in Poland.

Design/methodology/approach: The analysis is based on a survey, which indicated importance and directions of EU Funds in Polish rail infrastructure. Also the survey measured the status of infrastructure and the most famous items of it.

Findings: (mandatory) Positive impact of European Funds in infrastructural investments and development.

Originality/value The research shows the value of investments, which have a significant contribution of EU Funds.

Keywords: European Union Funds, Infrastructure, Rail transportation.

Category of the paper: Research paper.

1. Introduction

A Transportation system is a repository of many diverse, but at the same time related elements, which refer to technology, economics, law or even organization of whole branch of transportation (Kurowski, 2017). Rail transportations have highly expanded in terms of not only organization of transportation process, which is divided into passengers and freight transportation, but regarding to infrastructure, ecology and coming up intermodal solutions. The newest challenges, which must be completed by Polish economy after the change of political system in at the end of XX century, mainly concern each element of rail branch, but particularly the most visible constituents such as: trains, organization of transport and generally known segments of infrastructure. The moment of Poland's entry to the European

Union (Gricer, 2020) as well as an implementation of usage of many European funds, have had a significant influence on country's transportation system. The goal of this article is to breed interest to the transportation area and curiosity to study the different ways of changes perception, which are still coming across rail. The research has been conducted as a survey. The theoretical introduction of general transportation terms as well as the current situation of Poland concerning infrastructure along with the ways to process the investments using the EU funds, had been presented in the first part of the article. Subsequently, the results of the survey had been shown according to awareness of infrastructure and changes, which are taking place with the aid of EU Funds.

2. Rail transportation and market in Poland

While focusing on the transportation in Poland, it's important to cite the definition, which holistically exposes this complex term. Therefore the transportation *is an activity, which relies on providing non-gratuitous (or unpaid) services, which effect is based upon relocation of people and/or freight from a point of sending to a point of collection and then providing additional service, which is directly related to main service* (Stajniak, Hajdul, Foltyński, Krupa, 2008). This definition confirms affiliation of transportation to the term of logistics, but complementary indicates a strong relationship with relocation, which includes transportation of people and goods. It should be noted, that both terms are related to efficient management of information, so the usage of available information serves to creating competitive advantage, helps to penetrate the market and to maintain high level of customer satisfaction (Gricer, 2019). Considering different types of transportation, which are able to distinguish on country premises, it's possible to indicate that rail transportation is one of the main branches. On the rail market in Poland the leading role performs PKP Intercity S.A. as the primary carrier (especially while talking about intercity connections). In case of a transportation between regions or voivodships, it's possible to stand out POLREGIO (formerly Przewozy Regionalne Sp. z o.o.), which provides transportation in each voivodship and guarantees communications between them. There's also a number of other companies, which signify the local governments incl. Koleje Dolnośląskie S.A., Koleje Małopolskie Sp. z o.o., Koleje Śląskie Sp. z o.o., Koleje Wielkopolskie Sp. z o.o., Koleje Mazowieckie Sp. z o.o. On premises of Kuyavian Pomerian Voivodeship stands out private carrier, which is Arriva RP Sp. z o.o. (Report on the functioning of the rail transport market in 2019, 2020). The changes in the number of passengers were indicated across almost every carrier while comparing years 2018-2019. Significant increase of percentage has been reached by Koleje Dolnośląskie, Szybka Kolej Miejska in Warsaw, Koleje Śląskie and POLREGIO (Report on the functioning of the rail transport market in 2019, 2020). Quite big stratification is a result of

an appearance of interesting and competitive connections provided by regional carriers. It is presented on the figure 1. The freight market is visibly more and more divided on many carriers, because on Polish area of goods transportation there are more than 20 companies. As top carriers had been selected the companies with the biggest shares of the market: PKP Cargo S.A., LOTOS Kolej Sp. z o.o., DB Cargo Polska S.A., PKP Linia Hutniczo Szerokotorowa Sp. z o.o. Those players cover almost 65% of market shares. The freight transposition is much more complex in respect of types of goods, which are in transit. In sense of rail passenger transportation it's only possible to talk mainly about people transportation, what is in opposition to freight transportation. However it's important to remember that there are a lot of types of goods to transport, therefore it's obligatory to provide a special type of trucks. The most important groups of freight transportation are (Report on the functioning of the rail transport market in 2019, 2020):

- Hard coal, brown coal, oil and natural gas (27,61% of shares in whole freight transportation market).
- Metalliferous ores and the rest of mining products (28,01%).
- Coke, briquettes, products of refinement of oil (17,01 %).

This division indicates particular domination of energetic goods and heavy metals in freight transportation in Poland.

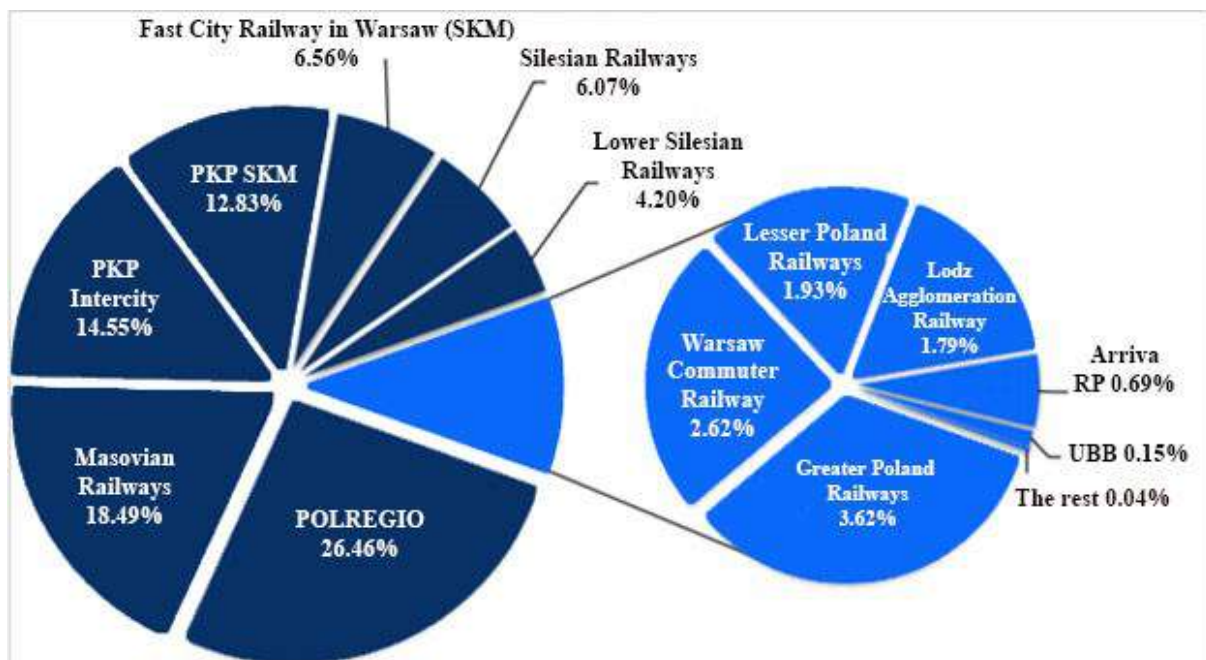


Figure 1. Market shares of passenger carriers acc. to amount of passengers in 2019. Source: Report on the state of the Polish railway transport market in 2019, The Office of Rail Transpiration (UTK), Warsaw, 2020.

3. Rail infrastructure in Poland

At the beginning it is worth drawing your attention to the general outlines of economic and social infrastructure (Wojewódzka-Król, Rolbiecki, 2009). Obviously the infrastructure of rail transportation is included into the economic infrastructure, because it contains different types of devices, which provides stable and effective maintenance of transportation system. The rail infrastructure is divided into 2 additional categories: point and linear. Those terms are quite intuitive and enable easy classification of devices or buildings. The point infrastructure contains: railway stations and all of the devices needed to service and maintain transportation i.e. floats, warehouses, lamps, semaphores, switches, cabins and the rest of rail buildings, which provide transportation services (Stajniak, Hajdul, Foltyński, Krupa, 2008). All of those elements enable functioning of rail transportation and that is freight loading and unloading, modernization, repairs, storage and cleaning of trains and finally maintenance of all of above written elements of point infrastructure. The linear infrastructure includes mainly railway tracks. In our country we can indicate many different types of these tracks: magistral lines, first and second class, lowland and alpine. In 2017 19 209 km of standard gauge (Wojewódzka-Król, Rolbiecki, 2009) tracks had been utilized and 62% of them had been electrified. 2018 was so important for tracks modernization, because it had started works in two important for Poland lines, i.e. E20 (between Warsaw and Poznan) and railroad no. 7 (between Warsaw and Lublin). On the map of 'Figure 2' has been presented a structure of railways, which are adjusted and utilized to passengers and freight transportation throughout the country. Please note, that the director of main rail tracks, point and linear infrastructures, is company Polski Linie Kolejowe S.A. and other subsidiaries of PKP group. A density of railways is not the same in different voivodships due to many different factors incl. historical events (Poland under the possessive, various affiliation of regions to countries before the Second World War), geographical and demographical configuration. According to graphical analysis of the map it may be noticed, that the highest density of utilized railways is in: Silesian voivodship, Opole voivodship and Lower Silesia voivodship. The Poland Statistic Office (formerly Central Statistical Office) monitors length of standard gauge tracks per 100 km². Thanks to that it's possible to confirm graphical analysis. According to Polish Statistics (Local Data Bank of Statistics Poland, 2020) the average for Poland totals 6,2 km per 100 km² and in the big lead are similarly: Silesian voivodship 15,6 km/100 km², Lower Silesia voivodship 8,6 km/100 km² and Opole voivodship 8,4 km/100 km². The lowest density is in Podlaskie voivodship, only 3,7 km/100 km². Additionally it's important to notice, that 9 of 16 voivodships have similar or higher result that country's average.

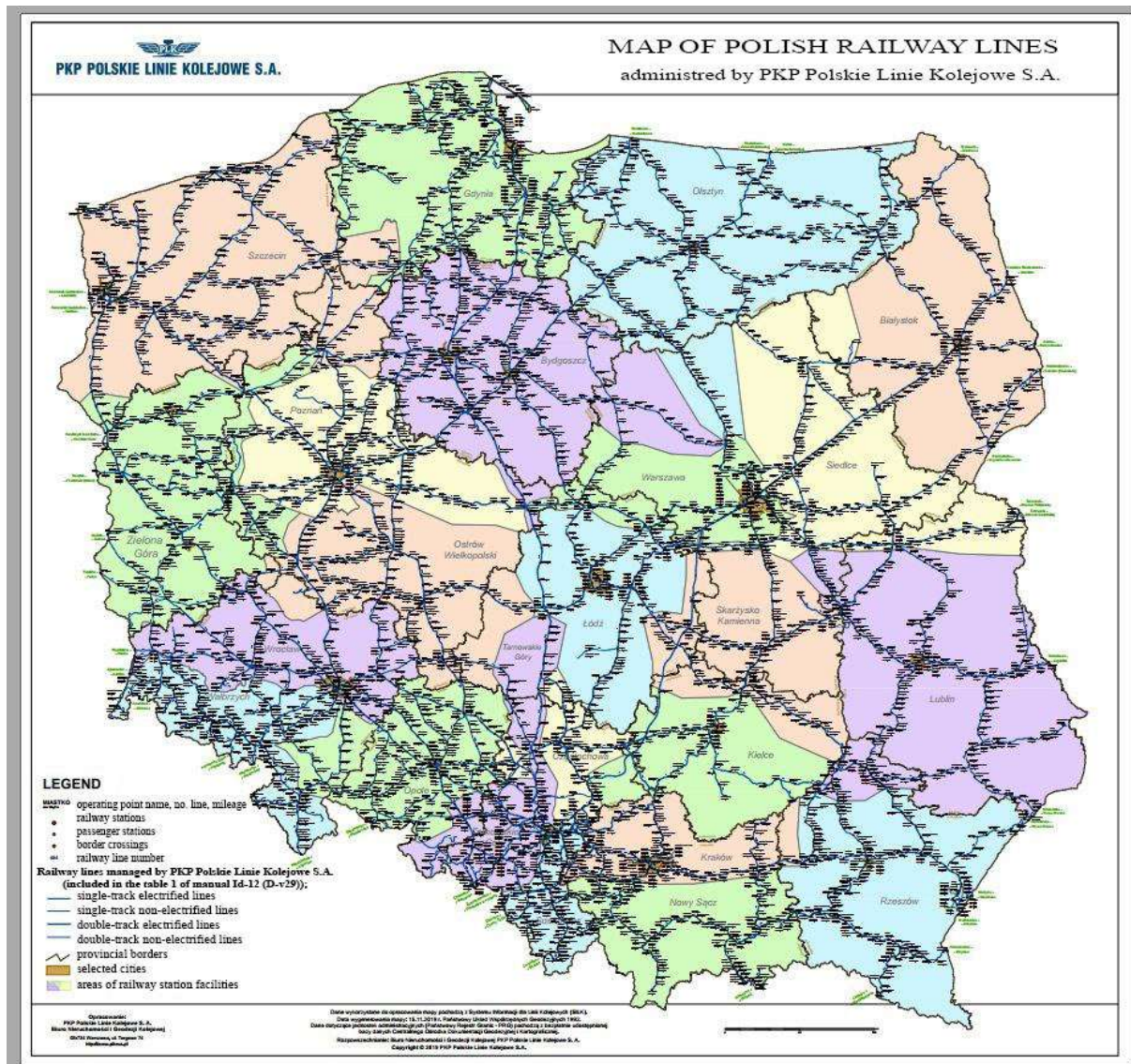


Figure 1. Map of railway lines in Poland managed by PKP Polskie Linie Kolejowe S.A. Source: <https://www.plk-sa.pl/biuro-prasowe/mapy/> (z dn. 22.08.20).

4. Infrastructure and economy development

The infrastructure development is strongly related with the directions of economic development (Wojewódzka-Król, Rolbiecki, 2009), since it might be one of its effects. The economic development doesn't focus only on the state and development of infrastructure, but influences on other parts of whole transportation system (Wojewódzka-Król, Rolbiecki, 2009). One of the important elements is horizontal studying not only whole branch, but exact system. Thanks to that it's possible to indicate synergic effects. Of course every economy indicates different needs according to development and directions. Similarly it's possible to

distinguish three variants of development of transportation system regarding economic development (Wojewódzka-Król, Rolbiecki, 2009):

1. The development of transportation overtakes economic development – that presents the outcome, when supply of infrastructure and transportation development towers domain for such development. In that moments, development of transportation stops until the supply is equal to the demand. It is worth pointing out that the supply will always be higher or equal to the demand of the development. Therefore the development of the transport system will always be ahead of its demand, and thus the development of the entire economy.
2. Variable development of the transport system and economy – means a state when the supply and demand for the development of the economy and the development of the system (including infrastructure) change very often. There is a certain kind of domination of demand over supply, but in such a system there are also moments when supply is above demand (briefly).
3. Delayed development of transport in relation to the development of the economy – means a state when the supply is less or equal to the demand for the development of the system. Most often, the supply for development must, colloquially speaking, "chase" the demand, and thus there is a kind of development necessity caused by the inadequacy to adjust the state of the system (infrastructure) and the location of the entire economy at that time.

Taking into account the current conditions in Poland, but also drawing your attention to the international and even global dimension, it is worth noting that the rail transport infrastructure still fits into the last of the described states. The level of economic development and changes, which are taking place in the economy require thorough reconstruction and expansion of the Polish railway infrastructure, not only in terms of line and point investments, but also in the management perspective.

5. Ways of financing investments in infrastructure in Poland with the use of EU funds. The EU fund and the operational program

It is necessary to take up the topic of funds that support investments in railway infrastructure in Poland. At the beginning it's important to present The Centre for EU Transport Projects (CEUTP) which is the first described entity. It is a unit established in order to efficiently assist in the preparation and implementation of financial investments from European Funds (About CEUTP, 2020) in Poland. Many investments are currently underway in our country, supported by the European Union. An additional goal is the skillful management of the allocated budget to use all funds planned in particular funds for transport (including infrastructure) investments.

From the perspective of the transport system, the European Structural and Investment Funds (ESIF) (EU Funds for modern transportation, 2019) are extremely important. They include 5 main funds of which the following are distinguished (European Structural and Investment Funds, 2020):

- the European Regional Development Fund (ERDF), which supports the development of individual regions in the EU and aims to reduce differences in their development,
- the European Social Fund (ESF), which aims to reduce unemployment and supports the development of human capital in EU countries,
- the Cohesion Fund, which is very important for the development of the transport system. The fund was prepared for selected member countries (with gross national income per capita lower than 90% of the EU average (EU Funds for modern transportation, 2019)). Its goal is to develop transport as well as environmental protection.

Within the given funds, Operational Programs (Newsletter European Funds in Poland No. 49/2018, 2018) are organized, which are intended to implement specific investments in accordance with the assumptions of the funds. For example, many investments in the Polish railway infrastructure are implemented under the national Operational Programme Infrastructure and Environment 2014 - 2020 (OPI&E) (most often in terms of linear (network) infrastructure) (Operational Program POIiŚ, 2017). The main objective of the program is "to support a resource-efficient and environmentally friendly economy that fosters territorial and social cohesion" (Operational Program POIiŚ, 2017). It can be seen that economic development is linked to the development of infrastructure, and thus to the promotion of an ecological approach to the transport. Apart from OPI&E, the Operational Programme "Development of Eastern Poland" (from the ERDF fund) (Eastern Poland Program, 2020) and the Connecting Europe Facility (CEF) (Information on Connecting Europe Facility, 2017) are very important for transport investments. The last of these aims to support the trans-European transport network TEN-T, which are the key transport routes of Europe (not only in terms of particular national). In order for funds to be used by member states, each state must sign partnership agreements with the European Union, which allow member countries to use funds. The contract must include information on how the particular funds will be used within the funds' scope and what is a timeline (European Structural and Investment Funds, 2020). Thanks to the signing of the contract, the above-mentioned Operational Programs are created.

6. Survey methodology

From April 5, 2020 to April 17, 2020, a questionnaire survey had been conducted with 100 respondents. The aim of the study was to check the opinions of respondents on the level of infrastructure in Poland and the changes, which take place with the participation of EU funds.

57 women and 43 men participated in the study. Most of the respondents lived in towns of over 500,000 people (64%). The second largest group were people from towns of up to 50,000 people (23%). The remaining 13% are respondents from localities: from 50 to 100 thousand people (1%), from 100 thous. up to 250 thousand inhabitants (6%) and from 250 thous. up to 500,000 people (6%). Most of the people who completed the questionnaire were between the ages of 18 and 24 (84%) 12% were people between 26 and 40 years of age and 4% between 41 and 55 years of age. The survey took the form of a web questionnaire on Google. It was publicly available and anyone willing could fill in such a form. It contained three types of questions: single-choice questions (yes/no/maybe), requiring the answers according to the Likert scale (0 – I strongly disagree, 5 – I strongly agree) and multiple choice questions, require selecting 3 answers (Likert's Scale, 2020).

7. Results and analysis of the survey

The first question that respondents had to answer related to their opinion on changes in the railway infrastructure over time. As can be seen in Figure 3, the majority of respondents had an opinion that the state of the infrastructure from 2019-2020 is different when compared to the previous years. Both the median (4.00) and the average (3.99) indicate a fairly balanced level of response. To confirm the graphical analysis, it is worth recalling the lower quartile, which is 3. This results indicates that at least 75% of the respondents chose the 3rd answer or higher according to the Likert scale. The data described indicates quite visible changes that took place in the infrastructure.

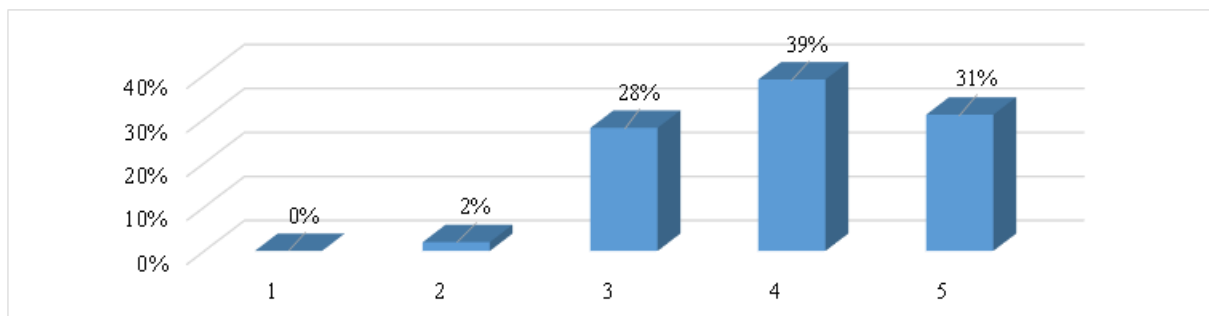


Figure 3. Column chart showing the percentage breakdown of responses to the question "Do you think the railway infrastructure from 2014-2020 is different from the one we had before?" Source: own research.

In order to take a proper look at the changes that have occurred in the railway infrastructure, the respondents were asked to select three most noticeable changes in the infrastructure in 2014-2020. The elements that can be selected in this question were developed on the basis of the guidelines of the Office of Rail Transport (Elements forming the railway infrastructure according to the Office of Rail Transport, 2020). Therefore, the most frequently chosen options include: new/modernized passenger information system, new/modernized platforms,

modernized stops/railway stations, as shown in the Figure 4. It is also essential to draw the attention to a certain relationship between the most frequently selected elements and point infrastructure. It is undoubtedly related to the fact that these infrastructure elements are also necessary to carry out the passenger transport service. Therefore, travelers always have to use the station, platform, and the passenger information system so that they can travel freely within the offered service. The number of investments implemented in these areas in 2014-2020 should also be mentioned here. According to the reports regarding implementation of the Railway Station Investments Program (pol. Program Inwestycji Dworcowych) (Railway station investment program and its implementation, 2020), the National Railway Program (Krajowy Program Kolejowy 2019), as well as reported data from the Center for EU Transport Projects (CEUTP) and the Operational Program Infrastructure and Environment (POIiŚ) for the years 2014-2020, there are many projects that are implemented in the field of a dynamic passenger information system, as well as the modernization and construction of new stations/platforms (EU support for further transport investments in Poland, 2019).

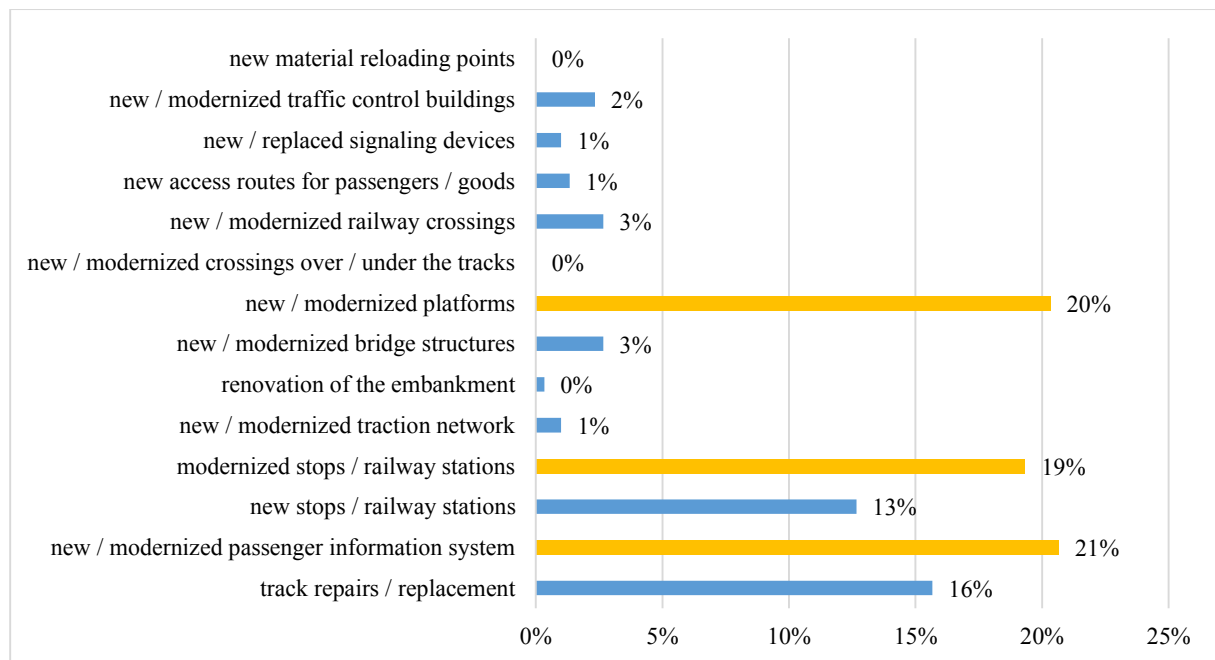


Figure 2. A bar chart showing the most frequently indicated answers to the question: "Choose the 3 most noticeable changes in the infrastructure in 2014-2020". Source: own research.

Referring to the first program, we can talk about almost 200 stations that have been or will be modernized in 2018-2023 (Project "Zmieniamy dworce", 2020). About 75% of the funds that were allocated to the implementation of these investments had been obtained from European Union programs implemented in our country. Also, referring to the reported data by Polskie Linie Kolejowe S.A. from 2018 (Annual report of the company PKP Polskie Linie Kolejowe S.A., 2019), it is worth noting the installation of new 800 passenger information carriers at 600 stations served by the company. As a result, voice announcements are made at 1,344 passenger stations, and some of them contain a system that automatically announces information for travelers. The presented data are intended to confirm the significance of the

projects implemented in the area of stations/platforms, as demonstrated by the respondents. At the same time, 16% of respondents noticed track investments. The number of investments carried out in our country is not always, but to a large extent, associated with EU funds. In the next question, the respondents had to indicate, using the Likert scale, what in their opinion, is the impact of EU funds on investments in infrastructure. Almost half of the respondents (45%) see a strong connection between the funds and the number of projects. Moreover, the average is 4.26, and the lower quartile is 4, which indicates quite high answers given by the respondents. According to data provided by CEUTP, as many as 79 agreements (out of 303) with OPI & E (worth approx. PLN 38.3 billion) and 9 contracts from the Operational Program Eastern Poland 2014 - 2020 (OP EP) (worth approx. PLN 1.6 billion) have been signed for the railroad. Therefore, it can be concluded that the implemented investments have a large share of European funds (EU support for further transport investments in Poland, 2019).

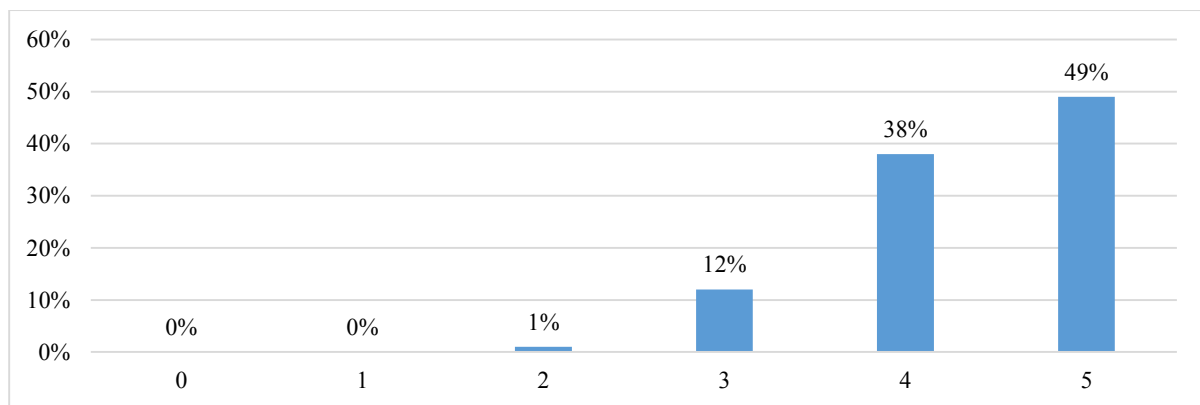


Figure 5. Bar chart showing the percentage distribution of answers to the question: "Do you think that changes in the railway infrastructure with the use of European funds have a positive impact on the comfort and quality of services provided by passenger transport operators". Source: own study.

Another issue lies in checking the direction of European funds impact in passenger transportation, which resulted in showing a positive reception of these investments. As many as 87% of respondents see the positive impact of European funds in infrastructure investments (CEUPT Information Bulletin, 2019). Interestingly, the respondents who in the previous question indicated answers 2 or 3, i.e. did not agree as to the significance of European funds impact on the number of railway investments in Poland, in this question mainly chosen answers 4 or 5, what confirms the positive reception of these investments.

8. The summary

Analyzing the above data, it can be concluded that EU funds have a significant impact on the railway infrastructure in Poland, which is visible to the citizens of our country. The changes and their effects were visible to the respondents, which could also affect the quality of the services provided. Moreover, according to the survey, the changes carried out in individual elements or infrastructure line have influenced their lives positively too. This does not mean that such investments did not take place. For example, one can refer to the construction of a footbridge for the inhabitants of Cracow at the railway bridge (Project of building a footbridge in Cracow, 2018) or at the newly commissioned Warszawa Powązki station (Construction of a footbridge and platforms in Powązki in Warsaw, 2019). However, none of the respondents chose this option in question 2, which may be related to a greater number of changes in other infrastructure elements. It may also depend on how much contact the respondents have had with these infrastructure elements along with the extent to which these elements affected their lives.

References

1. *About CEUPT*. <https://www.cupt.gov.pl/cupt/o-centrum>, 23.08.2020.
2. *Annual report of the company PKP Polskie Linie Kolejowe S.A. for 2018*. https://www.plk-sa.pl/files/public/raport_roczny/Raport_roczny_za_2018_marzec.pdf, 18.04.2020.
3. *CEF Fund*. <https://www.funduszeuropejskie.gov.pl/strony/o-funduszach/zasady-dzialania-funduszy/program-laczac-europe/informacje-o-cef/>, 23.08.2020.
4. *CEUPT Information Bulletin* (2019). No. 2/2019, Warsaw. https://www.cupt.gov.pl/images/biuletyny/marzec2020/Biuletyn_Marzec_2020.pdf, 18.04.2020.
5. *CEUPT's research and evaluation*. https://www.cupt.gov.pl/images/zakladki/badanie_i_ewaluacja/Ewaluacja_wp%C5%82ywu_program%C3%B3w_transportowych-teoria_i_praktyka.pdf, 19.04.2020.
6. *Construction of a footbridge and platforms in Powązki in Warsaw*. <https://www.plk-sa.pl/biuro-prasowe/informacje-prasowe/warszawa-powazki-dwa-perony-i-kladka-w-budowie-4348/>, 19.04.2020.
7. *Eastern Poland Program*. <https://www.polskawschodnia.gov.pl/strony/o-programie/>, 23.08.2020.
8. *Elements forming the railway infrastructure according to the Office of Rail Transport*, <https://www.utk.gov.pl/pl/dostep-do-infrastruktur/dostep-do-infrastruktury/zarzadzanie-infrastruktury/11622,Zarzadzanie-infrastruktura-kolejowa.html>, 18.04.2020.

9. *EU Funds for modern transportation*. https://www.cupt.gov.pl/images/Fundusze_EU_dla_nowoczesnego_transportu.pdf, 23.08.2020.
10. *EU support for further transport investments in Poland*. <https://www.cupt.gov.pl/aktualnosci/1408-1-2-mld-zl-unijnego-wsparcia-na-kolejnej-inwestycji-transportowe-w-polsce>, 19.04.2020.
11. *European Structural and Investment Funds*. https://ec.europa.eu/info/funding-tenders/funding-opportunities/funding-programmes/overview-funding-programmes/european-structural-and-investment-funds_pl, 23.08.2020.
12. Gricer, D. (2019). *The Logistics Customer Service in companies: PKP Intercity, Flixbus and Polskie Linie Lotnicze LOT*. Wrocław: Wrocław University of Economics.
13. Gricer, D. (2020). *Factors influencing the Logistics Customer Service in passenger transport in Poland, Logistics and Transportation*. Student debuts, Wrocław.
14. *Krajowy Program Kolejowy (National Railway Program)*. <https://www.gov.pl/web/infrastruktura/krajowy-program-kolejowy>, 19.04.2020.
15. Kurowski, J. (2018). System transportowy i jego uwarunkowania – aspekty gospodarczo-obronne. *Zeszyty Naukowe Akademii Sztuki Wojennej*. vol. 107, No. 2.
16. *Likert's Scale*. https://pl.wikipedia.org/wiki/Skala_Likerta, 19.04.2020.
17. *Newsletter European Funds in Poland* (2018). No. 49, Warsaw. http://www.fundusze-europejskie.gov.pl/media/63279/Biuletyn_Fundusze_Europejskie_w_Polsce_49_2018.pdf, 19.04.2020.
18. *Operational Program POIiŚ*. https://www.pois.gov.pl/media/93030/POIiS_ver_16_1_17072020.pdf, 23.08.2020.
19. *Project "Zmieniamy dworce"*. <http://zmieniamydworce.pkp.pl/>, 19.04.2020.
20. *Project of building a footbridge in Cracow*. https://www.propertydesign.pl/architektura/104/pkp_plk_wspolnie_z_krakowem_zbuduja_nowa_kladke_na_wisle,28110.html, 19.04.2020.
21. *Railway station investment program and its implementation*. <https://www.gov.pl/web/infrastruktura/program-inwestycji-dworcowych-nabiera-rozpedu>, 18.04.2020.
22. *Report on the functioning of the rail transport market in 2019* (2019). Warszawa: The Office of Rail Transport.
23. Stajniak, M., Hajdul, M., Foltyński, M., Krupa, A. (2008). *Transport i spedycja*. Poznań: Wyd. Biblioteka Logistyczna.
24. *Statistics Poland, Local Data Bank, Transport and communication*. <https://bdl.stat.gov.pl/BDL/dane/podgrup/temat>, 20.01.2019 and 22.08.2020.
25. Wojewódzka-Król, K., Rolbiecki, R. (2009). *Infrastruktura transportu*. Gdańsk: Wyd. Uniwersytetu Gdańskiego.

DETERMINANTS OF THE VAT GAP – PART 1

Beata HOZA^{1*}, Adam ŻABKA²

¹ Department of Finance and Information Technologies, Bielsko-Biała School of Finance and Law, Bielsko-Biała, Poland; bhoza@wsfip.edu.pl, ORCID: 0000-0002-4533-3330

² WSB University, Dąbrowa Górnicza, Poland, azabka@wsb.edu.pl, ORCID: 0000-0001-5461-9317

* Correspondence author

Purpose: The purpose of the paper is to identify the determinants of the gap in Value Added Tax and to assess the measures already taken in order to seal this gap.

Design/methodology/approach: The authors used statistical data derived from CASE reports prepared for the European Commission and numerical data contained in the Supreme Audit Office's (NIK) reports on audits carried out by tax administration authorities.

Findings: A thorough understanding of the VAT gap mechanism will facilitate implementation of appropriate measures to limit the scale of occurrence of tax offences. Systematic data collection, reliable research and interinstitutional cooperation in the field of tax fraud can significantly reduce this phenomenon. Determinants of the VAT gap do not only embrace tax fraud and tax evasion, although these two factors are the most important and are sometimes even identified with the concept of VAT gap. The size of the gap is also affected by other factors such as methodological errors, cyclical factors, grey area, problems with financial liquidity and bankruptcy of taxpayers.

Research limitations/implications: The study is divided into two parts – the first one contains the definition and interpretation of the tax gap phenomenon and shows some tax frauds which are frequently cited as the main factor contributing to VAT gap. The second part contains a presentation of the remaining determinants of the gap such as methodological errors, cyclical factors, the grey area, problems with cash flow and bankruptcy of taxpayers.

Practical implications: The aforementioned considerations were conducted to find the answer to the following questions: to what extent the state can limit the size of the tax gap and whether the factors shaping the size of the gap result only from the structure of this tax.

Social implications: Identification of tax gap determinants can help design a set of effective tools which will reduce the size of this phenomenon.

Originality/value: The article is addressed to all tax services responsible for the architecture of tax system and services responsible for tax collection.

Keywords: tax gap, VAT gap, Value Added Tax (VAT), tax frauds.

Category of the paper: technical paper, case study.

1. Introduction

The VAT gap is a phenomenon that occurs in both developing and highly developed countries, in and outside of the European Union. The consequences of a large tax gap are severe for both public and private sector. From the perspective of the national economy, tax gap hurts the state budget as reduced tax revenues result in reduced expenditure and an increased budget deficit. In the private sector, companies which are not tax compliant may push away from the market law abiding entities who duly fulfil their tax obligations.

Between 2016 and 2017, many legislative initiatives were undertaken in Poland in order to reduce the size of the tax gap. The initiatives include:

- Standard Audit File for Tax (SAF-T)- obligation to report in the standardized format. A package of structured data about business transactions is handed over to the tax authorities in electronic form. The data is downloaded directly from the company's financial and accounting systems.
- Fuel package – only locally registered entities have the right to trade fuel in Poland. Buyers are obliged to make VAT payments for imported fuel within 5 days of its import to Poland.
- Split payment mechanism – the transfer made by the buyer is divided into: net value, which goes directly to the creditor's settlement account and the amount of the Value Added Tax which goes to the taxpayer's VAT subaccount which is permanently supervised by the tax authorities.
- Communication and Information System of the Clearing House (STIR) – a tool used by the tax authorities to control and monitor banking operations carried out by business entities (Hoza, Żabka).

According to reports from the European Commission, between 2006 and 2011, the state budget in Poland lost between 0.4 percent and 1.5 percent of the GDP per year as a result of unpaid Value Added Tax. The biggest VAT gap was recorded in 2012 when it amounted to 43.1 billion PLN (CASE, 2014). The 2013-2015 audits of the Supreme Audit Office (NIK) clearly indicated that the Polish tax authorities had counteracted this phenomenon only to a small extent and the speed and effectiveness of their operations were insufficient.

2. Tax gap – definition and interpretation

The analysis of tax gap should start with the definition of the concept, however, an unequivocal definition of this phenomenon is nowhere to be found in literature. The term 'tax gap' was created, and then the methodology followed as it was needed for the purposes of

reporting, scientific studies and comparative analyses of the OECD. The tax gap can be defined in at least two ways. Firstly, as a gap arising from tax preferences (policy gap) or secondly, as a gap in the compliance of inflows, which is the result of tax revenue lower than revenue from the full implementation of the tax obligation (compliance gap or VAT gap in case of Value Added Tax).

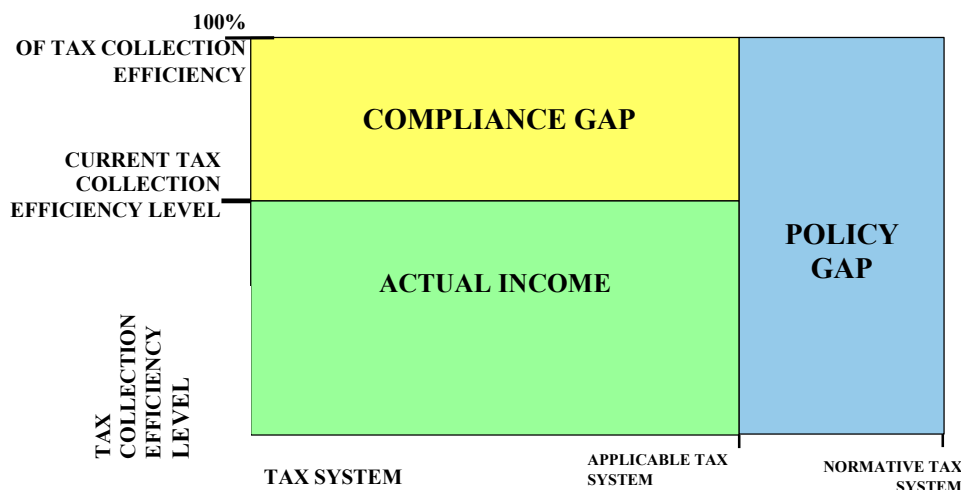


Figure 1. Compliance gap. Adapted from: own elaboration based on CASE 2019 report.

The concept of policy gap includes the potential loss of tax revenue from the application of various tax advantages, exemptions or preferences. In other words, policy gap is the disparity between actual tax revenue and theoretical revenue that would have been gained, had the tax system had neither preferences nor tax advantages. In case of VAT, policy gap includes, among others, reduced VAT rates, exemptions and legal tax optimization. Policy gap is a purely theoretical value and is important from the point of view of the EU as it enables comparison of tax systems of various Member States and facilitates harmonization processes.

The average policy gap in the EU in 2017 amounted to 44.5%. According to the European Commission estimates, the lowest level of policy gap is recorded in Bulgaria (29%) and Lithuania (33.5%), Spain is on the other side of the spectrum (nearly 60%) along with Italy, France and the United Kingdom (53%). In Poland, this figure amounted to 48.4% (CASE 2019).

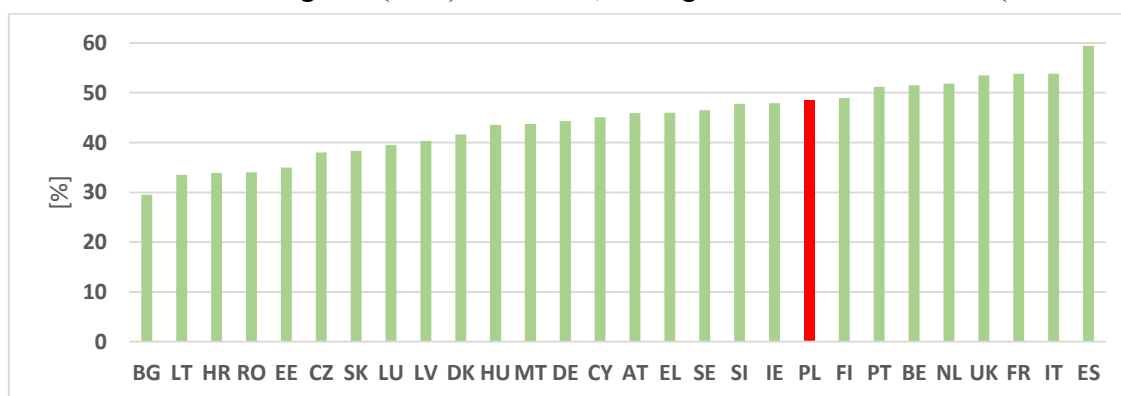


Figure 2. Policy gap of Value Added Tax in European Union countries in 2017. Source: own elaboration based on CASE 2019 report.

The gap caused by VAT exemptions (the exemption gap) averaged at 35% in the EU countries and was highest in Spain (46%) and Great Britain (44%), and the lowest in Cyprus (15.9%). The gap caused by the application of reduced rates (the rate gap) was the lowest in Denmark (0.77%) and Estonia (2.91%), and the highest in Cyprus (29.55%), Malta (16.46%) and Poland (14.61%).

While policy gap and its structure does not constitute a major problem for the EU Member States, compliance gap is a phenomenon that requires both research and action in order to reduce it. According to the most general and thus universal definition used by both the European Commission and entities estimating the size of this phenomenon, such as PWC: *compliance gap is the disparity between tax revenue which should theoretically be achieved assuming full fulfilment of obligations by taxpayers and the revenue actually achieved*. Adopting such a general definition of the tax gap has such an advantage that it does not impose a specific methodology for its measurement and it remains valid regardless of the type of tax in which the gap exists. In the further part of the paper, the definition of tax gap is synonymous with the gap in the compliance of inflows defined above.

In case of Value Added Tax, compliance gap is referred to as **VAT gap** and is defined as follows:

$$\mathbf{VAT\ gap = VTTL - VAT} \quad (1)$$

where:

VTTL – VAT Total Tax Liability – theoretical VAT income resulting from the implementation of the tax obligations,

VAT – actual gained income from Value Added Tax i.e. according to ESA (the European System of National and Regional Accounts).

VAT gap is not a typically Polish problem, most EU countries are struggling with it to a greater or lesser extent. According to data published by the European Commission, in 2017 the EU countries lost 137.5 billion Euro of Value Added Tax revenue. The VAT gap ranged from 35.5% of uncollected VAT in Romania, to 0.6% in Cyprus and 0.7% in Luxembourg. In Poland the gap amounted to 13.7% (CASE 2019).

In absolute values, the largest gap of 33.6 billion Euro was recorded in Italy, 25 billion Euro in Germany. The gap in Poland in 2017 was estimated at 5.7 billion Euro. The European Commission quoted the preliminary estimated value of the gap for 2018 on the level of 9 percent. The countries with notoriously highest tax gap are Romania, Greece, Lithuania, Italy and Slovakia.

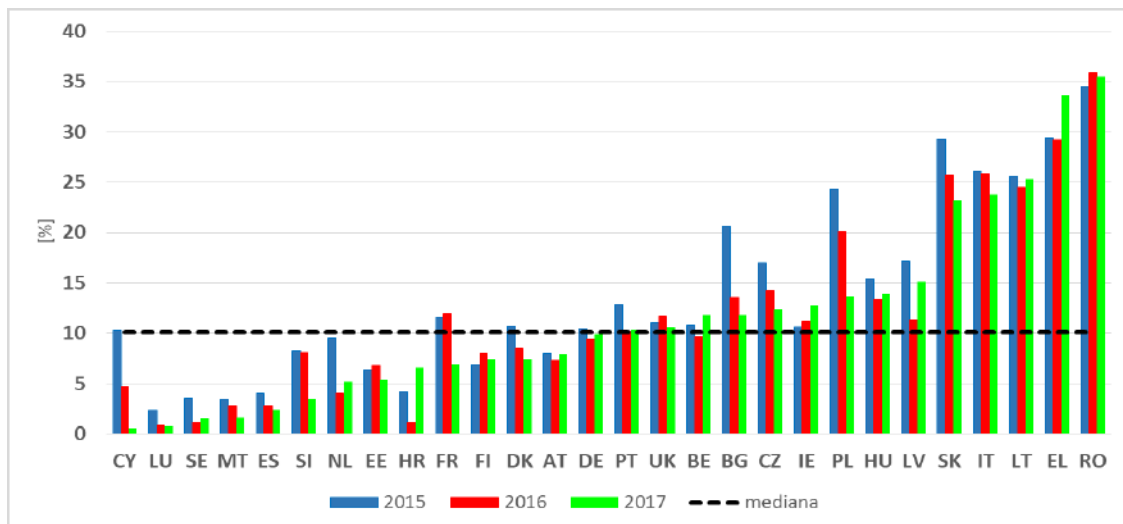


Figure 3. VAT Gap in the European Union between 2015 and 2017. Source: own elaboration based on CASE 2018, 2019 reports.

3. Determinants of the VAT gap

In common view, VAT gap is often synonymous with tax fraud, however, however such perception of the phenomenon is not accurate. In reality VAT gap consists of:

1. fraud and tax evasion,
2. methodological errors – part of the estimated VAT gap resulting from errors and inconsistencies in data or methodological errors, including errors in assumptions, hundreds of which are made in the process of estimation of the VAT gap,
3. cyclical factors resulting, among others, from changes in taxpayers' behaviour depending on the phase of the economic cycle, changes in prices and the demand pattern that are not reflected in macroeconomic data,
4. grey market: activities that are not considered tax crimes, especially in case of VAT, including, for example, neighbourly help, one-to-one tutoring or tips,
5. cash flow issues and bankruptcies of taxpayers who, for financial reasons, are not able to discharge their tax obligations (and to a large extent will never discharge them),
6. other preferences, solutions and mechanisms resulting from the specifics of the VAT system, which cause, for example, shifts in VAT revenue e.g. the option of switching from monthly to quarterly settlement of VAT.

3.1. Tax frauds

Due to its construction, Value Added Tax is particularly vulnerable to attempts of fraud. Tax fraud can take many forms (from conducting undisclosed business to fraud involving fake invoices) and scale (from several fake invoices to organized criminal structures). According to NIK, the most common tax frauds include:

1. Fake intra-community supply of goods, which allows taxpayer to demand a VAT refund or reducing the tax amount due to the state budget, because of the zero VAT rate applicable in intra-community supply. The system of taxing intra-community transactions is based on the model of taxation of transactions in the country of destination. Therefore, the taxpayer delivers the goods and settles it with 0% VAT rate, while the buyer, who has the full right to deduct input VAT, presents this transaction as both purchase and sale, and the tax related to it – as input and output tax. The method of settling intra-community transactions, based on the parties' independent determination of taxation combined with the absence of effective control system on the part of the Member States opens door not only to petty abuses but also to more complex ones such as tax carousels (Michalik, 2017).
2. 'Carousel' fraud is fake flow of goods between several EU countries with the assumption that these goods will finally 'return' to the country of origin and to the first link in the supply chain. The transactions in the carousel are carried out very quickly, they 'pass' through a number of companies in different EU countries within 1-2 days. 'Carousel' is a deliberate and organised crime making use of systems and mechanisms that enable to evade the VAT obligation by either not paying VAT or falsely demanding its return by companies operating internationally (the Chancellery of the Prime Minister of Poland, 2010, p. 82). The tax carousel is a network of a dozen (sometimes several dozen) entities that conclude several hundred transactions of purchase of goods which are immediately resold to another entity. However, the related payments are not reflected in the actual flow of goods (Ozóg, 2017). What is worth mentioning, very often carousel frauds simultaneously operate in several EU countries, creating the so-called 'olympic circle'. This means that fraud is carried out in a selected group of countries where tax regulations are easier to circumvent or inspection authorities are less efficient.
3. Fake exports i.e. deliveries to countries outside the EU, in particular to those with whom cooperation in the field of combating tax fraud is difficult or underdeveloped.

The analysis of the data from reports prepared by CASE for the European Commission, shows the convergence in the shape of the diagrams of the tax gap in various EU countries and makes it possible to conclude which groups of countries appear in this procedure. For example, similar trends can be observed regarding the increase and decrease of the tax gap in the following countries: Greece, Italy, Romania. Particular compliance is noticeable between 2008 and 2010, when the size of the gap in each of the analysed countries first increased by 5% in

Italy and in Romania by 12%, and then decreased by 8% in Romania and by 6% in Italy and Greece (Figure 4).

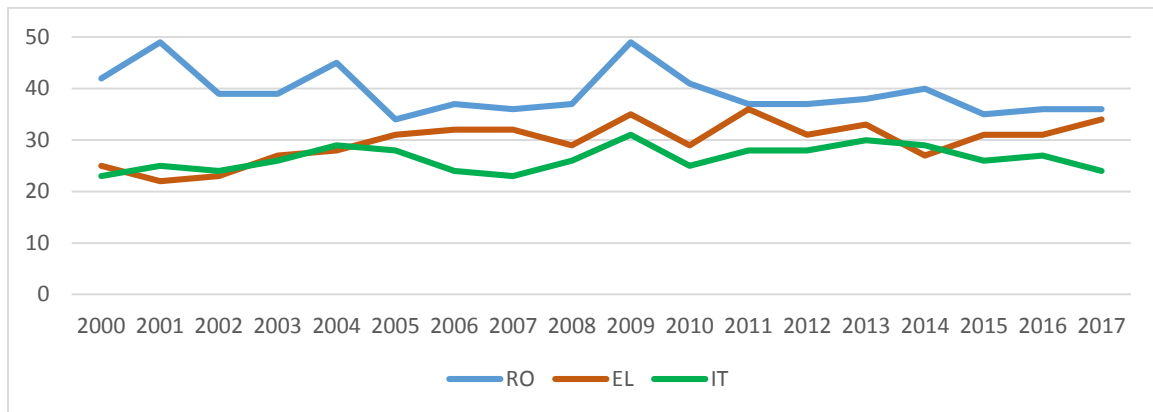


Figure 4. VAT Gap in Romania, Greece and in Italy between 2000 and 2017. Source: own elaboration based on CASE 2018, 2019 reports.

An interesting phenomenon can be observed when juxtaposing three Baltic countries: Lithuania, Latvia and Estonia (Figure 5). Between 2000 and 2006, each of these countries had a different level of VAT gap – Estonia had the smallest gap of 10%, Latvia's gap was between 11% and 23%, while the biggest gap was in Lithuania – between 30% and 42%. Between 2007 and 2009, a dynamic increase in the gap in Estonia could be observed – from 10% to 34%. A similar process could be seen in Latvia in the same period – the gap rose from 10% in 2007 to 42% in 2009 making Latvia the state with the second highest tax gap in the European Union (barely behind Romania). In the following years, Estonia relatively quickly returned to values oscillating around 10%, to finally reach the value of 2-3% in 2016-2017. In case of Latvia, this process was more difficult – between 2011 and 2013 the level of tax gap was very high – over 30%, while in 2015 it fell to 7% levelling with Estonia in 2017. In the same period the gap was also reduced in Lithuania, however, the decline stopped at 25% (Figure 5).

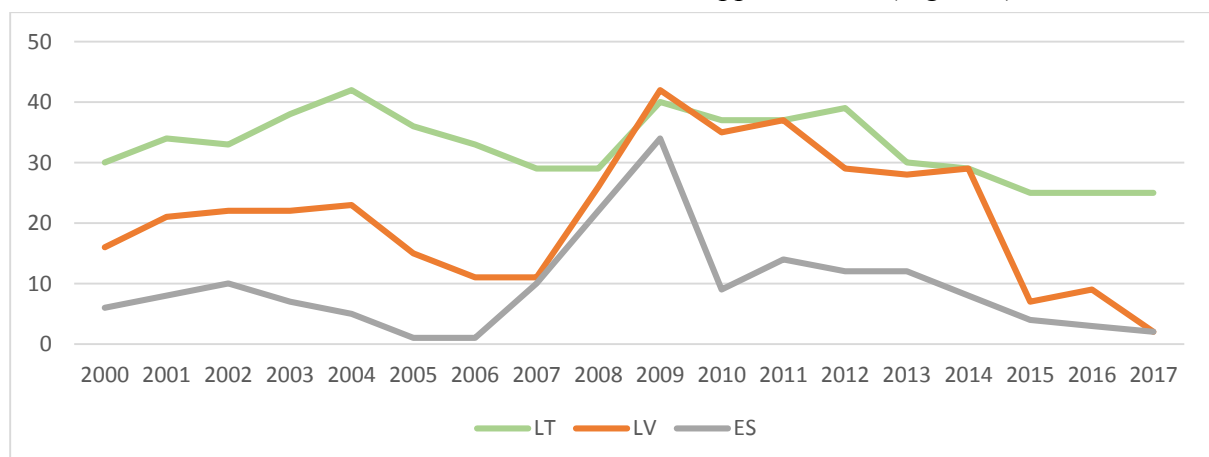


Figure 5. VAT GAP in Lithuania, Latvia and Estonia between 2000 and 2017. Source: own elaboration based on CASE 2012-2019 reports.

When it comes to Poland, there is an observable convergence with Slovakia and the Czech Republic in the period between 2009 and 2017 (Figure 6).

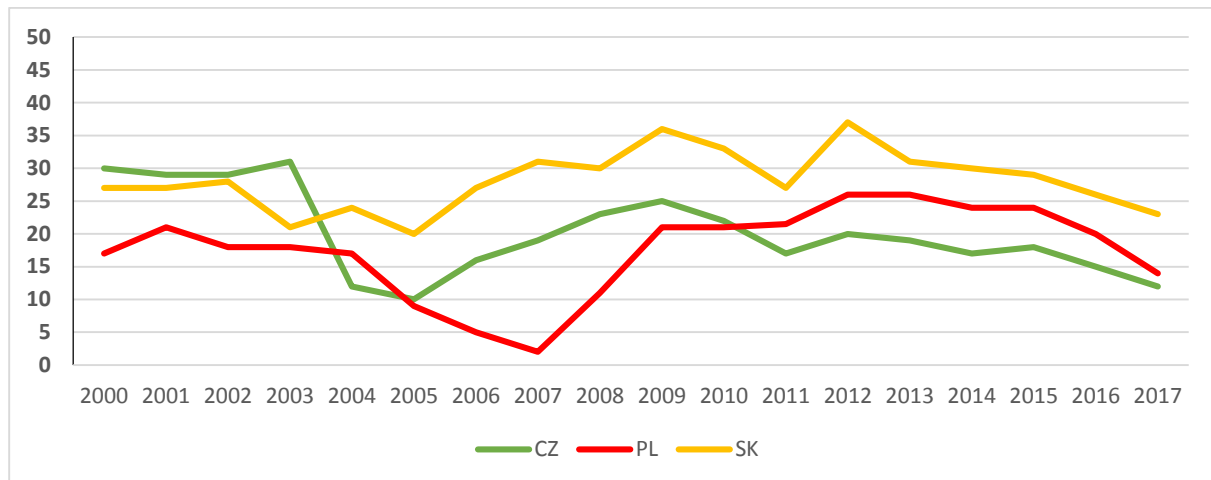


Figure 6. VAT Gap in Poland, Czech Republic and Slovakia between 2000 and 2017. Source: own elaboration based on CASE 2012-2019 reports.

In case of the Czech Republic, the gap started to increase in 2006 and rose gradually by 3-4 percentage points per year. The maximum level of 25% was reached in 2009 and from that moment decreased gradually to 12% in 2017. In Poland, four periods can be distinguished in which the VAT gap was changing dynamically:

- between 2004 and 2007 – a decrease from 15% to 2%,
- between 2008 and 2013 – a steep increase to 26%,
- between 2014 and 2015 – a slowdown of the upward trend – the process of increasing the VAT gap was reversed but it remained at a level oscillating around 25%,
- between 2016 and 2017 – a period of a very strong decrease of the VAT gap (to 14%) which brought Poland closer to the EU average.

Tax criminals modify their "operating technique" in response to the steps taken by the EU Member States to counteract VAT frauds. They increase dynamics of operations by trading goods between entities within a few hours, increasing the value of goods being subject of a single transaction and choosing different types of goods being subject of a transaction. Carousel frauds performed in the form of "olympic circles" are made with the active participation of companies from several countries but the real losses for the budget are recorded only in one country – the one where the carousel fraud begins and ends and where the leading company coordinating the tax fraud procedure is located. The task of companies from other countries is to authenticate the transaction chain and impede access to the leading company. Thus, it is very important to involve all European Union countries in the fight against this type of fraud. Only through cooperation and creation of a unified community information systems will it be possible to really reduce the scope of tax offences. Otherwise, the budgets of affected countries will continue to suffer real losses because criminals always modify their techniques of action and find more weak points in the national VAT systems.

An example of active cooperation between EU Member States to combat tax fraud and to seal VAT gap is using e-invoices. In Poland, the initial concept assumes that an entrepreneur will issue an electronic, standardized invoice in XML format which is sent to an electronic platform, where it receives the approval of tax authorities and only after this approval the contractor is allowed to download the invoice. So far, only a few EU countries have decided to implement mandatory e-invoice reporting in real time. This solution is already in use for example in Italy and, to a limited extent, in Spain and Hungary. In Italy, entrepreneurs send e-invoices in XML format, with an electronic signature to the Sistema di Interscambio (SDI) platform managed by the Italian equivalent of the National Tax Administration. The system is mandatory and paper invoices or invoices issued without the use of SDI are considered invalid. In Spain, e-invoices are reported every four days and this obligation applies to the largest taxpayers with a turnover exceeding 6 million Euro, while for other taxpayers the system is voluntary. In Hungary, e-invoices are transferred to a platform within 24 hours only if their value exceeds 100,000 Forints (approx. 1260 PLN).

In case of e-invoicing, it is highly recommended for all EU countries to cooperate and to establish a uniform format for this document. Only then, e-invoicing could translate into a reduction of VAT frauds committed throughout the EU and in Poland. Otherwise, there will be a need for yet another revolution after the one which already happened in Poland with the introduction of the Standard Audit File for Tax [SAF-T] and split payment, but this new revolution will only bring about limited results because it will still be impossible to cross-check intra-Community transactions and utilise the full potential of the concept of e-invoicing.

A thorough understanding of the VAT gap mechanism will facilitate implementation of appropriate measures to limit the scale of occurrence of tax offences. Systematic data collection, reliable research and interinstitutional cooperation in the field of tax fraud can significantly reduce this phenomenon. In addition, widespread cashless payments, an electronic register of invoices and bills, as well as increased transparency of public institutions' activities can significantly reduce the scale of the VAT gap.

It should be mentioned that higher efficiency of tax collection was not the only cause of an increased VAT revenues in Poland between 2016 and 2019. The good economic situation meant that the tax base and thus the value of taxable goods and services has been raised. It should also be emphasized that the main driver of economic growth in 2017 was private consumption which increased by 4.8% due to good situation on the labour market, increased minimum wage and the implementation of the social welfare programme 'Family 500+'. These factors boosted consumption which translated into an increase in indirect tax revenues.

Determinants of the VAT gap do not only embrace tax fraud and tax evasion, although these two factors are the most important and are sometimes even identified with the concept of VAT gap. The size of the gap is also affected by other factors such as methodological errors, cyclical factors, grey area, problems with financial liquidity and bankruptcy of taxpayers. Effective sealing of VAT gap may result in an increased inflows to the state budgets and the resources can be then redistributed for the benefit of societies and development of national economies.

References

1. CASE (2012). Update Report to the Study to quantify and analyse the VAT Gap in the EU-27 Member States.
2. CASE (2013). Study to quantify and analyse the VAT Gap in the EU-27 Member States.
3. CASE (2015). Study to quantify and analyse the VAT Gap in the EU Member States.
4. CASE (2016). Study and Reports on the VAT Gap in the EU-28 Member States: 2016 Final Report.
5. CASE (2017). Study and Reports on the VAT Gap in the EU-28 Member States: 2017 Final Report.
6. CASE (2018). Study and Reports on the VAT Gap in the EU-28 Member States: 2018 Final Report.
7. CASE (2019). Study and Reports on the VAT Gap in the EU-28 Member States: 2019 Final Report.
8. Hoza, B., Żabka, A. (2018). IT Tools Used to Reduce the VAT Loophole – JPK_VAT, STIR, Split Payment Mechanism. *The Scientific Journal of Bielsko-Biala School of Finance and Law*, No. 3.
9. https://ec.europa.eu/taxation_customs/sites/taxation/files/resources/documents/taxation/tax_cooperation/combating_tax_fraud/reckon_report_sep2009.pdf, 18.04.2020.
10. Michalik, T. (2017). How the European Commission and European countries fight VAT fraud. *CASE Seminar Proceedings/Zeszyty mBank CASE*, no. 147, p. 16, http://www.case-research.eu/uploads/zalacznik/2017-06-27/How_the_European_Commission_and_European_countries_fight_VAT_fraud.pdf, 18.04.2020.
11. Ożóg, I. (ed.) (2017). *Przestępstwa karuzelowe i inne oszustwa w VAT*. Wolters Kluwer, Warsaw.
12. Raport na temat wielkości luki podatkowej w podatku VAT w Polsce w latach 2004-2017. *MF Opracowania i Analizy no 3/2019*, <https://www.gov.pl/web/finanse/no-3-2019>.
13. Reckon, L.L.P. (2009). *Study to Quantify and Analyze the VAT Gap in the EU-25 Member States*. Report commissioned by the European Commission, Directorate-General for Taxation and Customs Union.
14. Szczypińska, A. (2018). Co powoduje lukę w podatku VAT w Unii Europejskiej? *MF Working Papers*, 30. Ministerstwo Finansów w Polsce, ammended on June 14, 2019, <https://www.gov.pl/web/finanse/luka-vat-w-ue-agnieszka-szczypinska>, 18.04.2020.
15. The Chancellery of the Prime Minister of Poland (2010). *Transakcje wewnątrzwspólnotowe ze szczególnym uwzględnieniem transakcji trójstronnych i łańcuchowych oraz dentyfikacja oszustw karuzelowych w handlu wewnątrzwspólnotowym*. Warsaw, <https://dsc.kprm.gov.pl/sites/default/files/f38.pdf>.

BARRIERS TO THE EFFECTIVENESS OF TELEWORKING IN PUBLIC ADMINISTRATION

Adrian IWANIUK¹, Liliana HAWRYSZ^{2*}, Helena BULIŃSKA-STANGRECKA³,
Paweł HURAS⁴

¹ Warsaw University of Technology, Poland; adrian.iwaniuk.stud@pw.edu.pl

² Warsaw University of Technology, Poland; liliana.hawrysz@pw.edu.pl, ORCID: 0000-0002-0357-9930

³ Warsaw University of Technology, Poland; helena.stangrecka@pw.edu.pl, ORCID: 0000-0003-2971-9708

⁴ Warsaw University of Technology, Poland; pawel.huras@pw.edu.pl, ORCID: 0000-0003-3288-5993

* Correspondence author

Purpose: Teleworking under Covid-19 conditions is, for many organizations, a fundamental requirement to ensure continuity of operation. However, it is not a common way of organizing work in public administration entities. In particular, very few studies have examined the effectiveness of teleworking in local administration. The purpose of this paper is to investigate barriers to the effectiveness of teleworking in local administration in Poland.

Design/methodology/approach: Literature analysis in the paper was prepared using VOSviewer software. Empirical research allowing us to achieve our objective was conducted using the CAWI method among 136 communes and cities with powiat rights from the Mazowieckie Voivodeship.

Findings: We have established that the main obstacle in remote work was technological barriers and lack of appropriate technology in the surveyed entities. As a result of our research, we identified challenges related to insufficient digitalization of services in local administration as the main barrier for teleworking.

Research limitations/implications: The paper uses quantitative research, carried out using the CAWI method, on local government entities in the Mazowieckie Voivodeship, on a research sample of 136 entities.

Practical implications: The results of this research provide important guidance for practitioners and managers of public administration. The results indicate the most significant barriers to implementing remote working in public administration. The benefits of remote working for both citizens and public administration employees are also presented.

Social implications: An analysis of the main challenges of remote working enables adaptation to the ongoing changes. Considering the difficulties of remote administration can help improve the functioning of the administration and, as a result, help to achieve widespread benefits for citizens.

Originality/value: The research presented here explores the introduction of remote working to an unprecedented extent in the wake of the COVID19 virus pandemic.

Keywords: teleworking, local administration, effectiveness, effectiveness barriers.

Category of the paper: Research paper.

1. Introduction

Teleworking is a modern and flexible form of work organisation that is growing in scope every year. The first mentions of remote work in public administration appeared in 1997. At that time, the European Commission created the European Telework Development (Choi, 2018). Teleworking is an entirely unique form of employment, which is characterised by high flexibility. To be able to fully leverage its potential, efficient communication and effective management are required. It differs from the traditional form of work in three essential factors: the place of work, the time of work, and the manner of communication. Teleworking breaks with the paradigm that work is tied to a specific location. Teleworking can be done in any place. The condition, however, is the availability of a suitable ICT infrastructure, which is also used as a communication channel. Teleworking enables employees of public sector organisations to work outside the office using appropriate ICT infrastructure. Still, it can also offer a range of opportunities that are not possible under conventional organisational settings. These include the benefits of reduced office costs as less space is required and work can be spread over areas with lower real estate costs (Mahler, 2012). Time and fuel savings from less commuting are also common (Mahler, 2012). Other savings may come from lower parking costs and less air pollution (Mahler, 2012). Teleworking also offers the opportunity to explore alternative organisational processes. It allows managers to experiment with changing workplace design and work technology (Offstein, Morwick, & Koskinen, 2010).

The Covid-19 pandemic has contributed to the increased use of teleworking in organisations. Under current law: "During the duration of the state of epidemic emergency or state of epidemic declared due to Covid-19, and for a period of 3 months after their cancellation, in order to counteract Covid-19, the employer may order the employee to perform, for a specified period of time, work specified in the employment contract, outside the place of its permanent performance (telework) OJ. 2020, item 374.

The new global reality has caused many employers to reach out to this way of organising work, keeping in mind the health and lives of employees. In the first stage of research on teleworking, the most important issue was related to environmental protection resulting from reduced commuting (Andrey, Burns, & Doherty, 2004; Pérez, Sánchez, De Luis Carnicer, & Jiménez, 2004). Over time, analysis of the effectiveness of task completion (Allen, Golden, & Shockley, 2015), new competencies needed for teleworking, employee motivation, and work-life balance have been added to the telework thread of this.

Despite continued interest from both scholars and practitioners in the issue of teleworking, there is limited research in this area in public administration (Kim, Mullins, & Yoon, 2021). Moreover, the literature often emphasizes that teleworking is a more common practice in state entities than in local government entities (Bae, & Kim, 2016; Caillier, 2016; Kwon, & Jeon, 2017; Mahler, 2012). This is probably because the unique character of local government entities

is based on constant and current contact with a broad group of stakeholders. To make it possible also in teleworking conditions, firstly, appropriate infrastructure is needed, and secondly, a large part of services requires digitalisation. Another important issue is the security of data transmission. In Poland, the process of digitalisation of public services started in 2010 and in the last years it has significantly accelerated. The situation of Covid-19 pandemic highlighted the importance of implementing up-to-date technologies in local government entities. Without access to these technologies, the continuity of local government operations may be threatened. Therefore, the purpose of this paper is to examine the barriers to the effectiveness of teleworking in public administration. The article is organised as follows. The first part presents a bibliometric analysis, the dimensions of telework in public administration conducted with the use VOSviewer software. The second part concerns research methodology. The third part presents our research on the barriers to the effectiveness of teleworking in public administration. Finally, the fourth part presents the theoretical as well as empirical implications concerning the effectiveness of teleworking in public administration.

2. Bibliometric analysis

To analyse the dimensions indicated in the literature, we conducted a bibliometric analysis. Based on the bibliometric analysis, the dimensions of telework in public administration were examined. Bibliometric analysis is a method that enables the determination of directions for further research based on statistical evaluation of data (Armfield et al., 2014). Furthermore, the bibliometric method provides insights into existing threads within the given areas (Opejin et al., 2020). It enables the identification of emerging scientific categories.

The bibliometric analysis was based on data from the Web of Science database. According to Clarivate, the Web of Science database is the most extensive database with citation indexing and research intelligence. We conducted the analysis in March 2021 and used the following terms: "teleworking" or "telecommuting" or "remote" and "public administration". We carried out searches of titles, abstracts and keywords for the words mentioned above. As a result, we obtained 260 publications, which constitute the research sample of the bibliometric analysis. We retrieved a list of publications meeting the criteria and then verified the data obtained from a bibliometric point of view: years of publication and

In order to analyse the co-occurring networks of terms in the reviewed papers, we used the VOSviewer software (Yu, Wang, Zhang, & Zhang, 2018). The following bibliometric analysis techniques were used: the method of co-occurrence of words and clustering (cluster analysis) as well as the mind mapping method. We analysed concepts that co-occurred at least 10 times based on their score of relevance. We then created a network map demonstrating the links between the terms.

2.1. Results of bibliometric analysis

The bibliometric analysis of remote work in public administration indicates a growing interest in this concept. Figure no. 1 shows the increasing frequency of publications relating to this topic. In 2001 this was just 7 publications, compared to 27 in 2021. The presented trend line indicates a growing interest in the issue of remote working in public administration.

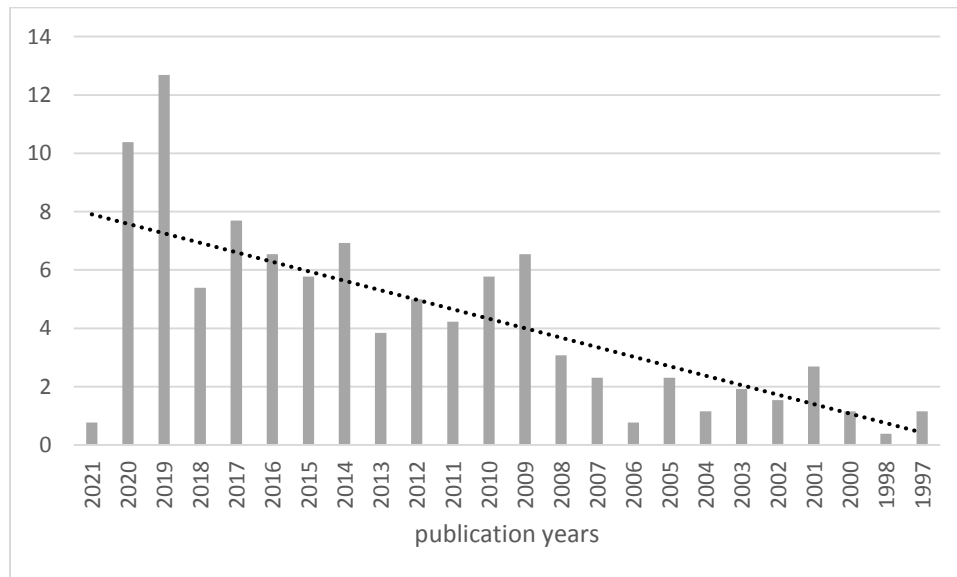


Figure 1. Annual publication trends

Figure 2, on the other hand, shows the regions with the highest number of published papers on work done in public administration. By far the largest number of publications relating to this issue have been carried out in the United States.

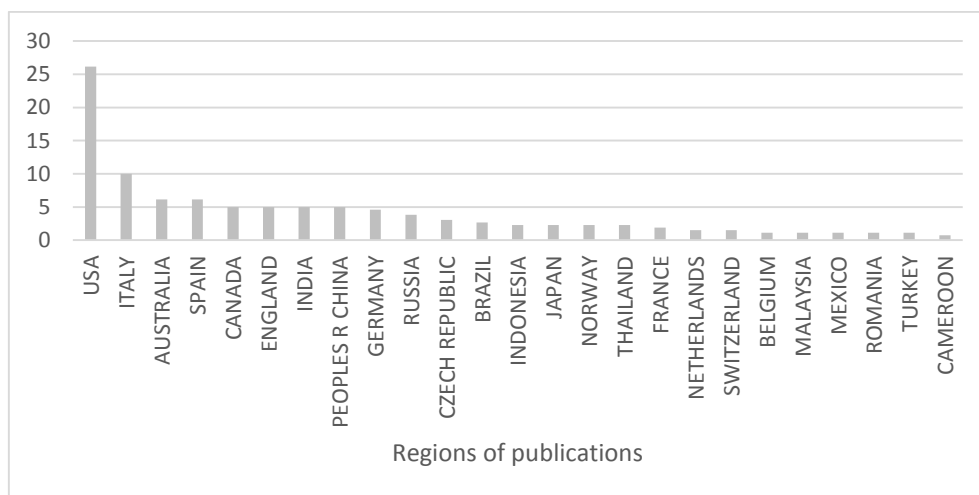


Figure 2. Regions of publication

2.2. Term Co-Occurrence Network Map

The next stage was a co-occurrence analysis of words. Words with less than 10 co-occurrences were excluded. The remaining terms were manually analysed to remove words related to the research process (for example: data, sample, survey). Only terms with

an relevance higher than 60% were taken into account. The analysis resulted in 35 words with 503 associations, which formed 3 clusters. Figure 3 shows the relevant terms within the co-occurrence network.

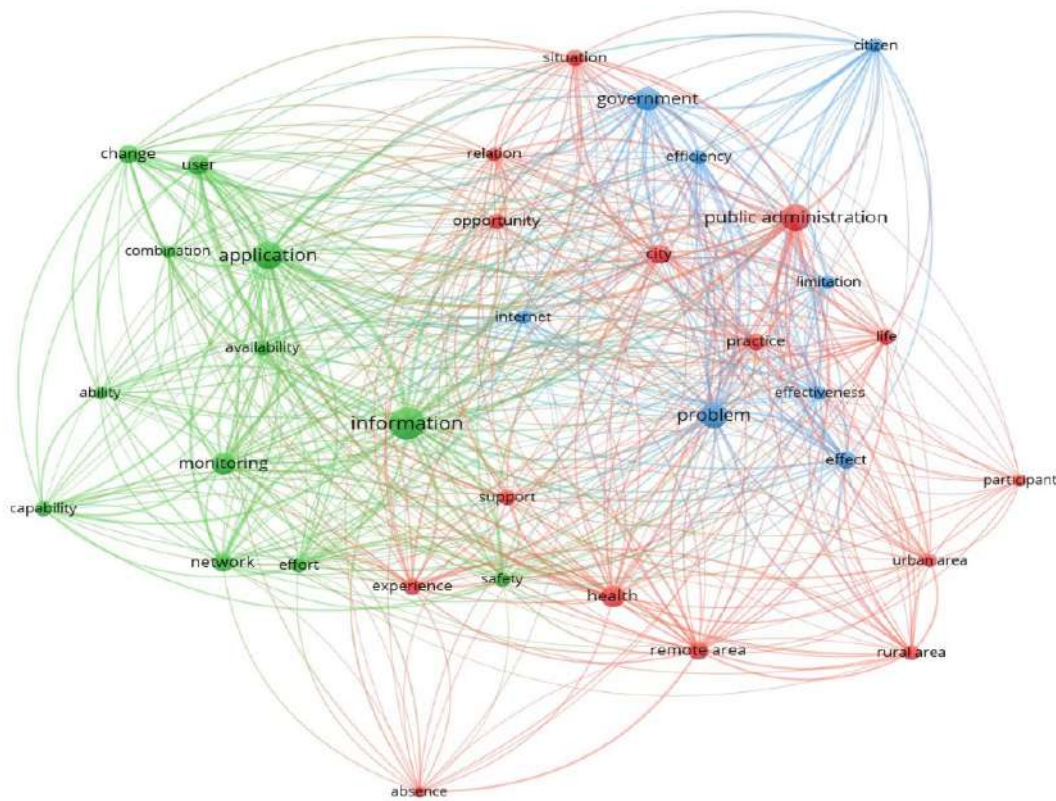


Figure 3. Network of terms from publication abstracts, title and key words. Source: Authors' Vosviewer analysis

The next step was a visual analysis. Verification of the network of terms reveals potential links, clusters themes and identifies research gaps. In the visualisation above, the size of the nodes indicates the strength of the links between the different terms. In turn, the thickness of the threads that connect each node illustrates the number of direct links: publications using both terms. VOSviewer assigns individual nodes to clusters. Clusters are closely related nodes. In Figure Z, the clusters are presented using colours. In this study, the terms were divided into three clusters. VOSviewer assigns individual nodes to clusters. Clusters are closely related nodes. In Figure Z, the clusters are presented using colours. In this study, the terms were divided into three clusters. The **red** cluster is oriented around relationships. Concepts such as relation, network, participation, support, experience are included in this cluster. The relationship cluster refers to the broadly understood relationship level: both in the organisation and in society. It refers to the relationship of a remote public administration to its stakeholders. The next, **green**, cluster contains terms relating to the competence of remote public administration. It includes the following terms: ability, application, capability, effort, information, monitoring and network. The green cluster comprises those aspects of the functioning of the remote public administration that relate to skills and competencies. The **red** cluster encompasses aspects

concerning the effectiveness of public administration. In the third cluster the concepts of efficiency, effectiveness and effects are included as well as problems. In this cluster the factors indicating the effectiveness of remote public administration are highlighted.

By analysing the network map, three areas related to remote public administration were identified: the relationship area, the competence area and the effectiveness area. The **relationship dimension** is concentrated around public administration. Such connections suggest that the relationship between inter stakeholders is a core aspect of the functioning of a remote public administration. Then, in the **competence dimension**, information and application take centre place. This seems to demonstrate the key role of information and data transfer in remote public administration. Whereas in the **effectiveness dimension** the concepts are oriented around the problem. This may indicate that the effectiveness of the work carried out in public administration is oriented around challenges and issues that require effective solutions. The above bibliometric analysis highlights three strands of research on remote work done in public administration.

The efficiency strand is related to the body of research focusing on the analysis of remote working in public administration, such as the study by Allen et al. (Allen et al., 2015) or Park et al. (Park, Kwon, Jun, Jung, & Kwon, 2020). Indeed, such studies address the challenges of ensuring effective outcomes of remote work in public administration (Caillier, 2013). This field examines the optimal management of remote workers in public administration (Kim et al., 2021) as well as organisational culture in shaping teleworker satisfaction (Kwon, & Jeon, 2020). Finally, this dimension of effectiveness also applies to research analysing the consequences of the Covid-19 pandemic on the effectiveness of remote work in public administration (Schuster et al., 2020).

3. Teleworking in public administration

Teleworking offers significant benefits to both employers and employees, as well as to the community and society. Among the benefits of teleworking for organizations are (Overmyer, 2011):

- continuity of operations,
- employee retention,
- real estate cost savings,
- improved employee productivity,
- increased organizational flexibility,
- reduced health care costs,
- accommodation for peoples with disabilities,
- expanded talent pool.

The benefits of teleworking for employees are indicated:

- work-life balance,
- increased personal flexibility,
- employee satisfaction,
- fewer sick days.

Among the benefits of teleworking for society are:

- increase demand for goods and services,
- reduced dependence on foreign sources of oil and reduced greenhouse emissions,
- on-site energy savings.

Teleworking does present unique managerial, organizational, and cultural issues to public administration entities, which often result in challenges facing successful implementation. Early efforts to implementation teleworking in public administration entities was to specifically address barriers to implementation related to the information technology (IT) needed to provide teleworkers with an effective work environment in the home, and to maintain connectivity with the office. It is recommended, therefore, IT support for home-based telework should be addressed at an enterprise level to ensure successful delivery of IT capabilities to employees, and that as telework expands to become an important alternative for most or all employees, IT management must play a greater role in planning and implementation support to ensure these employees have the IT capabilities necessary to perform their jobs.

The most frequently reported barrier in the survey of teleworking was¹:

- data security,
- funding for equipment and information technology (IT),
- management resistance,
- organizational culture,
- office coverage challenges.

In the early period of implementing teleworking public administration entities reported having addressed these barriers in the following ways²:

- provided training to employees and managers on telework,
- increased their budgets for IT support,
- initiated marketing of telework through promotional materials,
- undertook initiatives to gain top management support of telework,
- established regular reporting mechanisms for tracking teleworkers.

¹ <https://www.telework.gov/reports-studies/reports-to-congress/2004-report-to-congress.pdf>.

² Ibidem.

Actions being taken to identify and eliminate barriers in more mature public administration entities included the following³:

- updating policy/guidance,
- improving data reporting and tracking,
- improving program communication efforts,
- improving agency work culture,
- emphasizing telework availability during recruitment/onboarding,
- providing training for managers and/or employees
- encouraging telework when applicable or appropriate.

In summary, the implementation of remote work practices requires both barriers and benefits to be taken into account. The most significant barriers to the implementation of teleworking solutions relate to both technological and organizational aspects.

4. Research methodology

In the article we present the results of research carried out as part of the project Mazovia 2.0 “Sustainable development of the Mazowieckie Voivodeship in the new system of NUTS 2 and NUTS 3 units. Metropolitan, regional and subregional level” (Mazovia_2.0 pt. Zrównoważony rozwój województwa mazowieckiego w nowym układzie jednostek NUTS 2 i NUTS 3. Poziom metropolitalny, regionalny i subregionalnym) financed by National Centre for Research and Development (NCBIR), as part of the program GOSPOSTRATEG. The data collection was conducted with the use of the Computer-Assisted Web Interview (CAWI) method. **CAWI** method is dedicated to the study of the populations or groups of respondents represented by an excessively dispersed sample, characterized by a homogeneous conjunction of socio-demographic features. This method is widely used in social research for many reasons. Firstly, it ensures accessibility to selected groups of respondents with precisely defined predispositions and properties (e.g. e-administration entities). Secondly, online surveys make it possible to use research tools of greater logical complexity. Thirdly, this technique enables tests to be carried out quickly – preliminary results are available even 2-3 days after starting the test. Fourthly, CAWI generates relatively low costs (compared to PAPI or CAPI), which results from the lack of: interviewers and remuneration for them, the need to print and send materials or other additional work indirectly related to the research (e.g. interviewer training). Fifthly, CAWI provides a high degree of control over the research process. The lack of information delays (all data is immediately available, because it goes directly to the server) allows to control the quality, number and type of unit measurements on an ongoing basis, and to determine the

³ Ibidem.

degree of data deficiencies, and to react to any anomalies on an ongoing basis. The CAWI survey was carried out by the Research and Analysis Department of CZLiTT PW in cooperation with the Marshal's Office of the Mazowieckie Voivodeship and the Warsaw School of Economics. The research implementation period is May-June 2020. 314 local government entities from the Mazowieckie Voivodeship were invited to the research. We obtained the completed questionnaires from 136 entities. This means that the level of return obtained by us is 43%.

5. Results

One-fifth of the surveyed entities declared full possibility to perform the teleworking. In the same number of entities, about half of the employees were able to teleworking. In the remaining group of surveyed entities, several employees or none of them had the possibility to perform the teleworking (table 1).

Table 1.
Possibility of teleworking

Most of the employees had the possibility to perform the teleworking	22%
About half of the workers had the possibility to perform the teleworking	22%
Few of the workers had the possibility to perform the teleworking	33%
There was no possibility to perform the teleworking	22%
Hard to say	1%
Total	100%

If there was no possibility to perform the teleworking in a given unit, it was most often due to the need for the physical presence of employees at the workplace, because only in this way they could provide services and carry out tasks. For about 40% of entities, the inability or limited availability of teleworking resulted from a lack hardware and/or software. In 25% of entities, it was pointed to insufficient number of e-services offered to residents and entrepreneurs. This reason was closely related to the aforementioned the need to be physically at the workplace to provide services and carry out tasks. Insufficient number of e-services necessitated the physical presence of employees at the workplace. Behavioral factors such as lack of experience and/or insufficient digital competences and/or reluctance of employees close the list of reasons for the inability or limited availability of teleworking (table 2).

Table 2.*Why there was no possibility or only some employees could perform the teleworking**

Reason	%
The need to be physically at the workplace to provide services and carry out tasks	76
Lack of hardware enabling teleworking	41
Lack of software enabling teleworking	40
Insufficient number of e-services offered to residents and entrepreneurs	25
Lack of the regulation governing teleworking	25
Lack of experience in teleworking	22
Insufficient digital competences among employees for teleworking	7
Reluctance of employees for teleworking	5
Reluctance of the entity's authorities for teleworking	4
Others	5
Hard to say	3

* the respondent had the opportunity to indicate more than one reason.

In 61% of entities, the effectiveness of teleworking was assessed as comparable to stationary work. At the same time, 25% of the entities rated it as lower than during stationary work. A small number of entities claim that the effectiveness of teleworking was much higher or higher than during stationary work (table 3).

Table 3.*The effectiveness of teleworking*

It was much higher than during stationary work	2%
It was higher than during stationary work	2%
It was at a similar level to that of stationary work	61%
It was lower than during stationary work	25%
It was much lower than during stationary work	0%
Hard to say	10%
Total	100,0%

Barriers to teleworking effectiveness were assessed by the entities using a 5-point Likert scale (where 1 = lack of impact, 3 = hard to say and 5 = high impact). No access to documents stored in the unit needed for teleworking was mentioned as the most important barriers to the effectiveness. Another highly impacted barriers was the lack of hardware and software enabling teleworking. As well as insufficient experience in teleworking among employees and insufficient number of e-services provided remotely (table 4).

Table 4.*Barriers to the effectiveness of teleworking*

Barriers	1	2	3	4	5
Insufficient access to software dedicated to teleworking	21%	7%	7%	21%	43%
Lack of hardware enabling teleworking	13%	0%	7%	33%	47%
No access to documents stored in the unit needed for teleworking	0%	0%	0%	27%	73%
Insufficient experience in teleworking among employees	21%	14%	7%	29%	29%
The way in which teleworking was organized	8%	8%	69%	8%	8%
Employees' insufficient skills in operating teleworking software	8%	23%	54%	8%	8%
Insufficient number of e-services provided remotely addressed to residents, entrepreneurs, etc.	7%	7%	21%	43%	21%
No access to the central/internal server of the unit	36%	0%	7%	29%	29%

6. Discussion

This paper explores the issue of remote working effectiveness in public administration. Based on bibliometric analysis and verification of empirical data, several conclusions were drawn.

First, an analysis of the literature examining remote working in public administration confirmed three main strands of research: initially, an analysis of the literature examining remote working in public administration confirmed three main areas of research: one concerning the competences of administration (Kwon & Jeon, 2017), the second related to relationships (Coelho, Faiad, Rego, & Ramos, 2020), and the third focused on the efficiency of public administration (Reina, & Scarozza, 2021; Sousa, 2020). The research presented in this paper is in line with the trend to analyze effectiveness in administration.

Secondly, the presented research indicates the most significant barriers to the effectiveness of telework in public administration. The main barrier to the effectiveness of remote working in the surveyed offices was the lack of telecommuting possibilities. Respondents indicated that technological barriers and lack of availability of appropriate technology were the main obstacle. Moreover, another significant barrier to the implementation of teleworking in the surveyed offices was the absence of availability of e-services. This is in accordance with other studies in this strand showing that not all public administration tasks can be carried out remotely Morilla-Luchena et al. (Morilla-Luchena, Muñoz-Moreno, Chaves-Montero, & Vázquez-Aguado, 2021). The outlined data show the challenges of insufficient digitization of services in the public sector. This is all the more important as previous studies have confirmed the positive impact of digitization on the effectiveness of public administration (Dobrolyubova, Klochkova, & Alexandrov, 2019). Therefore, the strengthening of activities aimed at improving the digitalization of public administration, both by making e-services available and by providing employees with appropriate technology, is a key challenge for public administration.

This enhancement of the digitalisation of existing e-government services will greatly contribute to increasing the availability of remote working for public administration employees. For example, research from 2011 shows that as many as 36% of employees declared that they cannot work remotely because they need to be physically present at work (Mahler, 2012). Thus, the implementation of remote work requires a wide-ranging effort, including changes in public policy.

The third aspect presented in this research is the perception of remote public administration effectiveness by their employees. The majority of the respondents evaluate the performance of tasks during remote work well. Especially in light of previous studies that indicate reduced commitment and negative perceptions of the tasks performed in teleworking (de Vries, Tummers, & Bekkers, 2019), this represents a positive finding. The surveyed civil servants rated their performance in teleworking at a comparable level to that of stationary work.

This is a valuable indication regarding the positive perception of remote work in public administration. The literature emphasizes that willingness to work remotely is a prerequisite for ensuring operational continuity.

The experience of the last year has shown that in order to maintain the continuity of local governments entities need to enable their employees to work remotely, which involves overcoming many technological barriers. However, it is also important to remember that the essence of successful teleworking solutions is more a function of leadership than technology. Teleworking is not simply a new way of assigning work, but creates a new organizational form with different ways of defining tasks, more complex integration problems and different management responsibilities (Offstein et al., 2010).

7. Conclusion

The presented results indicated the most important barriers in the implementation of remote working in public administration. The results also showed the directions of further development of e-administration by increasing the level of digitalisation of services and providing employees with access to technological infrastructure. Public administration should strengthen the digital competencies of its employees, subsidise the purchase of necessary equipment and expand the spectrum of e-services offered. In addition, this article presents a new approach to teleworking performance in public administration by relating the empirical research to the research stream focusing on the effectiveness of administration.

The main limitation of the conducted research was a small research sample limited to units from one province. This research should be extended and deepened. The limitation of the study was also that these results are probably not representative. The survey was conducted in the Mazowieckie voivodship, and according to the government data it is the richest voivodship in Poland. Presumably, the situation in the other voivodships will be even more difficult. However, this requires further investigation.

Teleworking, long practised in the private sector, has a number of advantages, from increased productivity to reduced environmental costs for society. Local governments entities are the first responders in times of any problems of local individuals and communities. The situation with the COVID-19 pandemic and the reduction in personal contacts between people has resulted in a significant reduction in access to services provided by these entities. The limitation in access to these services was a consequence of many factors, but in particular, it was related to the insufficient number of services offered remotely to local individuals and communities, but also to the insufficient preparation of these units to work remotely.

This article aims to inspire discussion on further directions necessary for the effective implementation of remote work in public administration.

References

1. Allen, T.D., Golden, T.D., & Shockley, K.M. (2015). How effective is telecommuting? Assessing the status of our scientific findings. *Psychological Science in the Public Interest*, <https://doi.org/10.1177/1529100615593273>.
2. Andrey, J.C., Burns, K.R., & Doherty, S.T. (2004). Toward sustainable transportation: Exploring transportation decision making in teleworking households in a mid-sized Canadian city. *Canadian Journal of Urban Research*.
3. Armfield, N.R., Edirippulige, S., Caffery, L.J., Bradford, N.K., Grey, J.W., & Smith, A.C. (2014). Telemedicine - A bibliometric and content analysis of 17,932 publication records. *International Journal of Medical Informatics*, <https://doi.org/10.1016/j.ijmedinf.2014.07.001>.
4. Bae, K. Bin, & Kim, D. (2016). The Impact of Decoupling of Telework on Job Satisfaction in U.S. Federal Agencies: Does Gender Matter? *American Review of Public Administration*, <https://doi.org/10.1177/0275074016637183>.
5. Caillier, J.G. (2013). Are Teleworkers Less Likely to Report Leave Intentions in the United States Federal Government Than Non-teleworkers Are? *American Review of Public Administration*, <https://doi.org/10.1177/0275074011425084>.
6. Caillier, J.G. (2016). Does Satisfaction with Family-Friendly Programs Reduce Turnover? A Panel Study Conducted in U.S. Federal Agencies. *Public Personnel Management*, <https://doi.org/10.1177/0091026016652424>.
7. Choi, S. (2018). Managing Flexible Work Arrangements in Government: Testing the Effects of Institutional and Managerial Support. *Public Personnel Management*, <https://doi.org/10.1177/0091026017738540>.
8. Coelho, F.A., Faiad, C., Rego, M.C.B., & Ramos, W.M. (2020). What Brazilian workers think about flexible work and telework? *International Journal of Business Excellence*, <https://doi.org/10.1504/IJBEX.2020.104842>.
9. de Vries, H., Tummers, L., & Bekkers, V. (2019). The Benefits of Teleworking in the Public Sector: Reality or Rhetoric? *Review of Public Personnel Administration*, <https://doi.org/10.1177/0734371X18760124>.
10. Dobrolyubova, E., Klochkova, E., & Alexandrov, O. (2019). Digitalization and Effective Government: What Is the Cause and What Is the Effect? *Communications in Computer and Information Science*, https://doi.org/10.1007/978-3-030-37858-5_5.
11. Kim, T., Mullins, L.B., & Yoon, T. (2021). Supervision of Telework: A Key to Organizational Performance. *The American Review of Public Administration*, <https://doi.org/10.1177/0275074021992058>.
12. Kwon, M., & Jeon, S.H. (2017). Why Permit Telework? Exploring the Determinants of California City Governments' Decisions to Permit Telework. *Public Personnel Management*, <https://doi.org/10.1177/0091026017717240>.

13. Kwon, M., & Jeon, S.H. (2020). Do Leadership Commitment and Performance-Oriented Culture Matter for Federal Teleworker Satisfaction With Telework Programs? *Review of Public Personnel Administration*, <https://doi.org/10.1177/0734371X18776049>.
14. Mahler, J. (2012). The Telework Divide: Managerial and Personnel Challenges of Telework. *Review of Public Personnel Administration*, <https://doi.org/10.1177/0734371X12458127>.
15. Morilla-Luchena, A., Muñoz-Moreno, R., Chaves-Montero, A., & Vázquez-Aguado, O. (2021). Telework and social services in Spain during the COVID-19 pandemic. *International Journal of Environmental Research and Public Health*, <https://doi.org/10.3390/ijerph18020725>.
16. Offstein, E.H., Morwick, J.M., & Koskinen, L. (2010). Making telework work: leading people and leveraging technology for competitive advantage. *Strategic HR Review*, 9(2), <https://doi.org/10.1108/14754391011022244>.
17. Opejin, A.K., Aggarwal, R.M., White, D.D., Jones, J.L., Maciejewski, R., Mascaro, G., & Sarjoughian, H.S. (2020). A bibliometric analysis of food-energy-water nexus literature. *Sustainability (Switzerland)*, <https://doi.org/10.3390/su12031112>.
18. Overmyer, S.P. (2011). *Implementing telework: Lessons learned from four federal agencies*. Arlington, VA: IBM Center for the Business of Government, <http://www.businessofgovernment.org/sites/default/files/Overmyer.pdf>, 8th of May 2021.
19. Park, H.-Y., Kwon, Y.-M., Jun, H.-R., Jung, S.-E., & Kwon, S.-Y. (2020). Satisfaction Survey of Patients and Medical Staff for Telephone-Based Telemedicine During Hospital Closing Due to COVID-19 Transmission. *Telemedicine and E-Health*, <https://doi.org/10.1089/tmj.2020.0369>.
20. Pérez, M.P., Sánchez, A.M., De Luis Carnicer, M.P., & Jiménez, M.J.V. (2004). The environmental impacts of teleworking: A model of urban analysis and a case study. *Management of Environmental Quality: An International Journal*, <https://doi.org/10.1108/14777830410560728>.
21. Reina, R., & Scarozza, D. (2021). Human Resource Management in the Public Administration. *Organizational Development in Public Administration*, https://doi.org/10.1007/978-3-030-43799-2_3.
22. Schuster, C., Weitzman, L., Sass Mikkelsen, K., Meyer-Sahling, J., Bersch, K., Fukuyama, F., Kay, K. (2020). Responding to COVID-19 through Surveys of Public Servants. *Public Administration Review*, <https://doi.org/10.1111/puar.13246>.
23. Sousa, M.J. (2020). HRD as the Epicentre of Governance in Public Administration. *The Future of HRD, Volume II*, https://doi.org/10.1007/978-3-030-52459-3_2.
24. Yu, D., Wang, W., Zhang, W., & Zhang, S. (2018). A bibliometric analysis of research on multiple criteria decision making. *Current Science*, <https://doi.org/10.18520/cs/v114/i04/747-758>.

PROJECT MANAGEMENT AND EMPLOYEES' INDIVIDUAL POTENTIAL

Robert KAMIŃSKI

Wrocław University of Science and Technology, Faculty of Computer Science and Management, Wrocław;
robert.kaminski@pwr.edu.pl, ORCID: 0000-0002-3211-8279

Purpose: Employees' membership of project teams is seen as one of the ways, in which the individual potential is shaped. The objective of the article is to demonstrate the influence of the characteristics of project organizational culture on shaping the characteristics of employees' individual potential.

Design/methodology/approach: The review of the literature served as the basis for identifying the characteristics of project organizational culture. The research hypotheses describing the influence of the characteristics of project organizational culture on striving for perfection, curiosity, perceptiveness, commitment and determination were formulated. The research hypotheses were verified in the course of the empirical studies (questionnaire survey) carried out in December 2019 in 270 enterprises functioning in the USA.

Findings: The positive relationship between the characteristics of project organizational culture with the characteristics of individual potential was indicated. This shows the possibility of making use of project teamwork for the needs of shaping the employee's individual potential.

Research limitations/implications: Both the assessment of the norms and values of the organizational culture and the assessment of the norms and values of the project team were carried out each time by the project manager. Also, the assessment of the potential of employees in the project team and outside it was performed by the same project manager.

Practical implications: Employee participation in the project team can be considered a potential tool for staff development. The socialization of norms and values, that are typical for the project organizational culture, contributes to the growth of the individual potential of employees.

Social implications: The growing importance of projects in the activities of an organization is currently referred to in the literature as projectification, which means institutionalization of projects at all levels of social structures. Once again, the importance of variable project teams (and not stable, e.g. hierarchical, structures) for shaping the employee's high potential is emphasized.

Originality/value: A specific role of a project team for human resources development has been identified. Employee participation in the project team can be considered not only as a potential tool for staff development, but also as factor that shapes employees' individual potential.

Keywords: project team, project organizational culture, organization, management.

Category of the paper: Research paper.

1. Introduction

In the scholarly literature, the employee's individual potential is understood as the ability to adapt and develop in the face of new challenges resulting from a more and more dynamic environment (Fernández-Aráoz, 2014; Hofrichter, Spencer, 1996; van Staden, 2015; Zdonek, Wolny, 2015) or as personality properties, abilities, emotions and talents as well as the employee's attitude, behaviour, readiness to take up new tasks and duties (Hysa, Grabowska, 2017; Zdonek, Wolny, 2015).

The scholars cited above also claim that organisation survival and development will depend on employing employees with high potential or on shaping and developing their potential. For instance, Zdonek, Wolny (2015) present a research model describing the employee's potential consisting of the variables related to competences and psychological and social variables whereas other authors, such as, for example, Szałkowski (2002) or Moczydłowska (2010), focus on the process of developing the human potential of an individual person. This process concerns the regular accumulation of specialised knowledge and professional skills as well the perfection of employees' behaviours and motivation which are necessary for carrying out the present and future tasks of the organisation (Szałkowski, 2002). The effect of this process is the growth of the competences which are useful for the development of the organisation.

The process of the development of employees' individual potential is usually related to training sessions, managerial staff development programmes, mentoring and coaching, funding further studies and foreign language education (Żukowska, 2012). As observed by Kunasz (2007), the number of training methods is quite large. They can be of individual and collective character and can be administered both in a workplace as well as outside it. Furthermore, Kunasz additionally reviews the "on the job" training methods, among which he describes the employee's participation in project work as a training method. Thus, participating in project work involves assigning a trainee to a given task team working on a given project for some time. The trainee, who participates in project work, has the opportunity to gain new specialised knowledge in various fields (by solving specific problems) and to practise his/her interpersonal skills related to communication with other employees in the project team (Kunasz, 2007). Thus, it is assumed that the participation in the project team raises the employee's individual potential and the employees who are the members of project teams are characterised by their higher individual potential than the employees who do not belong to such project teams. While the relation presented above seems to be highly probable, it requires verification on the basis of empirical studies. The empirical studies conducted so far have been related, most of all, to projects in one organisation (e.g. Zhang, Yu, Lv, 2017). This served as an incentive to carry out studies on a larger research sample. Those studies were related, among others, to the

evaluation of the individual potential of the members of project teams as well as to the evaluation of the characteristics of project organisational culture.

The objective of this article is to demonstrate the influence of the characteristics of project organisational culture on shaping the employees' individual potential. In the first part of the article, based on the literature review on this topic, the characteristics of project organisational culture are identified. The second part of this paper presents the characteristics of the employee's individual potential. In the third part, the characteristics of project organisational culture are linked to the characteristics of the employee's individual potential. There, the research hypotheses are formulated. In the final – fourth – part, the research hypotheses are subjected to verification on the basis of the outcome of the empirical studies.

2. Page setup, formatting, notes – first level numbering

Already in 1982 Cleland stated that in the cultural context, project management is a complex entirety which encompasses knowledge, beliefs, skills, attitudes and other abilities as well as habits acquired by people who are members of some project community (Cleland, 1982). Likewise, as observed by, for example, Larson and Gray (2003), project heads have to shape project culture which stimulates teamwork and the high level of personal motivation as well as the ability to identify and solve project work-threatening problems fast. As a result, in the literature on this subject, many authors have attempted to determine the dimensions and characteristics of project organisational culture (Firth, Krut, 1991; Thomas, Marossezeky, Karim, Davis, McGeorge, 2002; Wang, 2001; Zuo, Zillante, 2006; Du Plessis, Hoole, 2006).

In their study, Firth and Krut (1991) contrast project culture with hierarchy culture. Project culture is characteristic of the organisation functioning in a dynamic environment which makes it possible for the organisation to adapt to new conditions in a fast and easy manner. This, as the above-quoted authors state, differentiates project culture from hierarchy culture which works well in a stable environment, when tasks and activities are repeatable and the aim is not adaptation but cost reduction. Thus, Firth and Krut distinguish the following characteristics of project culture: changes are made abruptly, facing challenges is what counts, work is of non-repeatable character, employees have many duties, work is organised around tasks, management covers the employees of various hierarchy levels, future orientation dominates, the position depends on the type of tasks performed, a limited number of principles regulate project team members' work, task teams' meetings dominate, the way of information flow depends on the needs, authority is the result of sharing knowledge with others and is dependent on the ability to cooperate with others.

In the subsequent studies, the authors relied on the competing values framework (Thomas, Marossezeky, Karim, Davis, McGeorge, 2002). While studying the Australian construction industry in terms of quality management, they concluded that the projects which achieve the results higher than average showed strong orientation towards market culture whereas clan culture was poorly emphasised¹. However, as regards quality, the projects which were characterised by the results above the average had more poorly distinguished values typical of market culture and, at the same time, had strong clan culture values. In such project “clan” culture, the emphasis was put on team cohesion, consensus and morale. Moreover, the project heads who were the mentors for project team members or who were described as “facilitators” were preferred.

In his studies, Wang (2001) searched for the key dimension of the professional culture of project management as well as the values and beliefs of professionals dealing with project management (project management culture, as he viewed it, is a set of values and benefits related to work, which are shared by project management specialists). As a result of a statistical analysis, four dimensions of project organisational culture were identified. They include:

- identification with the profession of a project head, which involves the willingness to have a career in the field of project management, identification with other project heads as a professional group, performing tasks related to project management in the time reserved for it,
- project team orientation, which involves the identity of the project team, knowledge-based influence, informal process-based team functioning,
- work flexibility, which involves no description of job positions and employees’ autonomy,
- result orientation and not human relation orientation.

As observed by Wang (2001), the identified dimensions are related to the values which are typical of project management and which have been described in the literature. It means that:

- project management is horizontal management which is significantly different from tradition management typical of highly hierarchised organisations. Thus, employees are more oriented towards tasks than towards their superiors and their status results from what they do rather than from who they are,
- project management is oriented towards teamwork, in which people depend on one another and cooperate; individuality and mutual competition are not preferred,
- project management is oriented towards change – the relations are temporary, uncertainty and change are considered to be something natural; speed and flexibility are stressed,
- project management is oriented towards results – the aim is to execute the entirety of the project.

¹ However, in their study, the above-cited author did not provide any information about how they evaluated projects in terms of quality management.

Du Plessis and Hoole (2006) defined project organisational culture in the following way: [Project organisational culture] *reflects the way projects are conducted as work by interdependent project team members in an organisational setting that supports project principles and practices to ensure focused delivery of results within a set time frame, budget constraints and with customer satisfaction (p. 37)*. Based on the literature review, questionnaire studies and concept mapping session with the participation of project heads, the above-quoted scholars determined the dimensions describing project organisational culture. They are as follows:

- strong orientation towards interpersonal relations – the relations (mutual understanding) among team members, customers and suppliers are seen as essential for the success of the project,
- team orientation – the level of project management and activities related to work is organised around groups and not around units,
- managerial staff's/stakeholders' commitment – stakeholders, including managerial staff, commit themselves, through active participation and support, to strive to complete the project successfully,
- interdependence orientation – the units in the organisations are encouraged to act in a coordinated or interdependent way,
- control and discipline – employees' behaviours are highly supervised and controlled,
- risk orientation – the level to which project environment encourages its participant to be innovative and take the risk in order to be successful,
- learning orientation – projects are seen as a chance to learn and to continually perfect the course of action,
- conflict tolerance – employees are encouraged to express their criticism and solve conflict situations,
- result orientation – the managerial staff and team members concentrate more on achieving the goal rather than on the means and methods of the course of action. For instance, the status in the organisation is less dependent on the organisation role which an individual has and it is more determined by the results which are achieved individually or in a team,
- open-system focus – project team members monitor and respond to the changes in the external environment,
- open communication – stakeholders communicate openly and share the information about the project, its problems, changes, successes and failures,
- the use of project management methodology – project heads adhere to project management processes and make use of project management tools.

According to Zuo, Zillante and Coffey (2006), project culture derives from organisational culture. While organisational culture is developed by higher-level managerial staff, project culture can be established both by higher-level managerial staff, project management office as well as project teams. Project culture affects project processes and relations among project team members. It is based on the attitudes and behaviours of project team members. Finally, the above-cited scholars distinguish five dimensions of project culture. They are as follows:

- integration – various parties participating in the project are included in its execution,
- cooperation – during project execution, there are few conflicts and emphasis is put on directing various project participants towards project goals. Teamwork is popular and project participants willingly cooperate,
- goal orientation – attention is paid, most of all, to performing work while the way in which the goal will be achieved is of secondary importance,
- flexibility – the way of project execution is very flexible; an innovative approach, including risk-taking, is supported and rewarded,
- people orientation – of high priority is developing team members' skills; culprits are not looked for; success is celebrated.

The influence of particular dimensions of project culture on the results obtained by the project was studied with reference to the following four dimensions:

- economics – commercial success, future business opportunities,
- continuous perfection – satisfaction with the course of action of project execution, conclusions drawn from the project,
- relations – satisfaction with relations with other parties,
- overall performance.

The results of the studies carried out by the above-quoted scholars show that the dimensions of project culture such as integration, cooperation or people orientation affect positively the results obtained by the project. Curiously enough, project culture which is oriented towards the goal and which is flexible negatively correlated with the results obtained by the project. Based on the results obtained and in the course of the interviews held, Zuo, Zillante and Coffey (2009) offered a model of project culture. It is composed of the following twelve characteristics: fulfilling the customer's needs (both those overt and covert), good interpersonal relations, readiness to help one another, teamwork, the equality of all parties in the project, shared values and goals, considering other parties' interests, effective communication, rewarding for cost reduction, respect and trust, top management's support, clear division of tasks, rights and responsibilities.

However, Nguyen and Watanabe (2017) identified five dimensions of project organisational culture in construction projects. They include:

- project goal orientation – it includes the clear and unambiguous specification of project goals, task division, consensus, information exchange, support for the project head, mutual trust, project supervisors' commitment,
- project executor's goal orientation – the executor commits himself/herself to meet project quality requirements, completion deadline and budget,
- cooperation orientation – the presence of the benefits resulting from the involvement in the project, interactions during work, openness and mutual trust, the exchange of ideas and support, the unambiguous assignment of responsibility, achievement recognition, customers' adherence to the terms and conditions of the agreement, involvement in decision-making,
- empowerment orientation – awarding the necessary rights to perform tasks, encouraging to make decisions, leaders' support,
- employee orientation – employee training, respecting employees, taking care of employees.

The authors mentioned above determined the influence of the identified dimensions of project organisational culture on the results obtained in the course of construction project management. They concluded that the higher project goal orientation, executors' commitment and employee orientation are, the higher project team members' satisfaction and the overall effectiveness of the project are.

On the whole, the models presented above point, most of all, to the following characteristics of project organizational culture:

- project goal orientation – strong subordination of all activities in the project team to the satisfaction of key stakeholders, timely implementation of the project scope in accordance with the budget.
- project teamwork and cooperation orientation – people depend on one another and cooperate, individuality and mutual competition are not preferred,
- openness and free information flow on the project team level – members of project team communicate openly and share the information about the project, its problems, changes, successes and failures,
- project members' and stakeholders' commitment to project execution – they commit themselves, through active participation and support, to strive to complete the project successfully.

3. The employee's individual potential

In the literature on the topic (cf. e.g. Fernández-Aráoz, 2014; Hofrichter and Spencer, 1996; van Staden, 2015; Zdonek, Wolny, 2015)), scholars have offered various approaches to the issue of the employee's individual potential. On account of the goal of this article, it was decided not to discuss them. The further deliberations are based on the model devised by Fernández-Aráoz (2014) which draws attention to five properties characterising an employee with potential. They include:

- striving for perfection in achieving a given common goal – the employee is ambitious, wishes to be respected by others, is modest and continually invests in developing his/her skills,
- curiosity, standing for the tendency to look for novelties, to acquire new knowledge, to look for feedback as well as openness to learn and changes,
- perceptiveness defined as the ability to collect and draw conclusions from the information which potentially can create new opportunities,
- commitment described as a talent to exploit the knowledge and logic to share his/her vision with others,
- determination which should be understood as the skills to fight for complex goals and to deal with difficulties and obstacles.

Fernández-Aráoz bases the process of development, maintenance and personnel development on those five properties. Interestingly enough, in the case of development, he points to the necessity to confront employees with new challenges which “push them” outside of their comfort zone. Fernández-Aráoz quotes the words uttered by one of HR department managers: “As regards the development of the managerial staff for the needs of future managerial tasks, we constantly strive to find the optimal level of discomfort in the next role or project since it is there that most learning takes place. We do not want people to be extended beyond their limits. However, we want well-rounded, value-focusing leaders who see the world through a wide-angle lens. The appropriate extending tasks help those people get there”. As can be supposed, interpreting the quoted author, the employee's individual potential could be shaped, among others, through his or her participation in different executed projects. Assuming that, by definition, projects generate unique products or services and each time new interdisciplinary project teams can be formed, it may be stated that projects will always constitute some challenges for people involved in their execution. Since projects can be of diverse character, for example, they can be more or less innovative or different in terms of technological uncertainty (cf. e.g. Shenhar, Dvir, 2008), a question can be asked whether the very characteristics of project organisational culture influence shaping particular characteristics of the individual potential. Answering this question is the theme touched upon in the further part of this article.

4. Project organizational culture and the employee's individual potential

The review of the literature on this theme served as the basis for identifying the above-mentioned characteristics of project organisational culture. It might be argued that they have a manifold influence on the characteristics of the employee's individual potential. For instance, in the case of strong project goal orientation, it might be noticed that project organisational culture should positively affect:

- striving for perfection in achieving a given common goal – projects, because of their uniqueness, provide an opportunity for new achievements. It is more probable when the executed project is more innovative or when it is more significant for a given organisation. Additionally, in the case of projects which require acquiring new knowledge (e.g. are based on new technology), there emerges an opportunity for learning,
- determination – it is commonly believed that because of the unique character of projects, there will be some execution-related problems or various risks will become materialised. Many times in the project there are critical issues which strongly hinder work in the project or make it impossible at all. Those problems, however, can be solved only thanks to the help provided from outside. Irrespective of the preparation and planned protective measures, the very moment of risk materialisation or problem occurrence is highly stressful and requires intensive efforts and high motivation. It might be thought that without some deal of determination, the project will not be successful.

On this basis, the following research hypotheses can be put forward:

- H1 – The stronger project goal orientation is, the stronger striving for perfection among project team members is. Furthermore, *vice versa*, the weaker project goal orientation is, the weaker striving for perfection among project team members is.
- H2 – The stronger project goal orientation is, the stronger determination among project team members is. Moreover, *vice versa*, the weaker project goal orientation is, the weaker determination among project team members is.

However, in the case of high team orientation, it might be observed that building project team should foster:

- striving for perfection in achieving a given common goal – project team members appreciate the contribution of particular individuals to the execution of project tasks and showing appreciation is a potent stimulus motivating for further activity,
- thoroughness – the project team enables each team member to obtain a more considerable amount of information as well as lets him/her learn from others,
- commitment – like in the case of curiosity described above, the member of the project team has an opportunity to connect with others and share his/her vision,
- determination – the team will thus support its members in executing project tasks and in overcoming potential difficulties.

On this basis, the following research hypotheses can be put forward:

- H3 – The stronger team orientation is, the stronger striving for perfection among project team members is. Furthermore, *vice versa*, the weaker team orientation and building interpersonal relations are, the weaker striving for perfection among project team members is.
- H4 – The stronger team orientation is, the stronger curiosity among project team members is. Furthermore, *vice versa*, the weaker team orientation is, the weaker curiosity among project team members is.
- H5 – The stronger team orientation is, the stronger commitment among project team members is. Moreover, *vice versa*, the weaker team orientation and building interpersonal relations are, the weaker commitment among project team members is.
- H6 – The stronger team orientation is, the stronger determination among project team members is. Moreover, *vice versa*, the weaker team orientation and building interpersonal relations are, the weaker determination among project team members is.

In the case of openness and free information flow in project organisation culture, it might be thought that it should have a positive impact on curiosity because of the ease of acquiring information. This leads to the formulation of H7 hypothesis: The stronger openness and free information flow are, the stronger the curiosity of project team members is. Furthermore, *vice versa*, the weaker openness and free information flow are, the weaker the curiosity of project team members is.

Finally, the strong commitment of project team members and project stakeholders to project execution should foster determination. The fight for complex goals and dealing with difficulties and obstacles will not be possible without firm commitment. On this basis, H8 research hypothesis can be put forward: The stronger commitment is, the stronger determination among project team members is. Furthermore, *vice versa*, the weaker commitment is, the weaker the determination of project team members is.

5. The verification of research hypotheses

The research hypothesis was verified in the course of the empirical studies carried out in December 2019 in 270 enterprises functioning in the USA. Those enterprises were characterised by the fact that they were executed many (various) projects. However, their primary activity involves routine process activity and not project implementation. This made it possible to distinguish two groups of employees in each enterprise. The first group, i.e. employees who combined work in project teams with work consisting routine activities. And the second group, i.e. employees who did not work on projects and performed only repetitive tasks. The questionnaire survey was addressed to project managers working in those

enterprises. The research company (SurveyMonkey) ensured that one project manager completed the survey questionnaire for each company. He related his answers to members of the project teams he managed or he knew, comparing their characteristics with those of employees who did not carry out project work.

Considering the majority of projects executed so far in the organisation, they were asked to assess:

- to what degree the characteristics of project organisational culture (project goal orientation, project teamwork and cooperation orientation, openness and free information flow, project members' and stakeholders' commitment) were represented in project teams in comparison to the remaining part of the organisation,
- to what degree the members of project teams were characterised by the five characteristics of individual potential (striving for perfection, curiosity, perceptiveness, commitment, determination) in comparison to the employees who were not engaged in the work of project teams.

The occurrence of the characteristics of project organisational culture as well as the characteristics of the employee's individual potential was based on the five-level Likert scale. Thus, the respondents, referring to the norms and values of project organizational culture, had four questions and five answer options to choose from. Namely, project management norms and values exist in project teams: much less than in the rest of the organization, less than in the rest of the organization, same as in the rest of the organization, more than in the rest of the organization, much more in the rest of the organization. On the other hand, in the case of properties characterizing an employee with potential, the respondents also had five questions and five answer options to choose from. Namely, properties characterizing an employee with potential occurred among project team members as compared to people not working in projects: to a much lesser extent, lesser extent, in the same extent, to a greater extent, much more extent.

Table 1 presents the coefficients of the correlation between the characteristics of project organisational culture and the characteristics of project team members' individual potential.

The data included in Table 1 allow adopting all of the formulated research hypotheses. The value of the correlation coefficients is not high but all correlation coefficients confirm the positive relationship between the characteristics of project organizational culture with the characteristics of individual potential. This shows the possibility of making use of project teamwork for the needs of shaping the employee's individual potential.

Table 1.

*The correlation between the characteristics of project organizational culture in project teams in comparison to the remaining part of the organisation and characteristics of individual potential of project team members in comparison to the employees who were not engaged in the work of project teams**

Characteristics of project organizational culture	Individual potential properties				
	striving for perfection	curiosity	perceptiveness	commitment	determination
Project goal orientation	0.502128 (H1)	0.365387	0.427460	0.469013	0.514075 (H2)
Team and cooperation orientation	0.507092 (H3)	0.434271 (H4)	0.435518	0.449429 (H5)	0.463111 (H6)
Openness and free information flow orientation	0.384584	0.386869 (H7)	0.391501	0.425541	0.390839
Project team members' commitment orientation	0.539553	0.493530	0.493818	0.496247	0.540099 (H8)

*All correlation coefficients are statistically significant with $p < 0.01$.

Source: the author's own study.

6. Concluding remarks

The objective of this article was to demonstrate the influence of the characteristics of project organizational culture on shaping the employee's individual potential. This influence was shown in the course of a questionnaire survey distributed in 270 American enterprises functioning in various industries. The studies confirmed that project management can be used in the process of personnel development for creation of employee's individual potential. As you might think, this (higher) employee's individual potential can further lead to not only better project execution but also can have positive influence on routine processes in an organisation. As Nowosielski (2018) writes in his paper, at present processes and projects exist in each organisation and their management should lead to the efficient and flexible functioning of such an organisation. In this case, it is possible to make use of project management for the needs of shaping the employee's individual potential.

References

1. Cleland, D.I. (1982). The human side of project management. In: A.J. Kelly (Ed.), *New dimensions of project management*. Lexington, MA: D.C. Heath and Company.
2. Du Plessis, Y., Hoole, C. (2006). An operational 'project management culture' framework (part 1). *SA Journal of Human Resource Management*, 4(1), 36-43.
3. Fernández-Aráo, C. (2014). 21st century talent spotting. Why potential now trumps brains, experience, and "competencies". *Harvard Business Review*, 6, <https://hbr.org/2014/06/21st-century-talent-spotting>, 1.10.2020.
4. Firth, G., Krut, R. (1991). Introducing a Project Management Culture. *European Management Journal*, 19(4), 437-443.
5. Hofrichter, D.A., Spencer, L.M. (1996). Competencies: The right foundation for effective human resource management, *Compensation and Benefits Review*, 28(6), 21-24.
6. <http://www6.ufrgs.br/norie/iglc10/papers/98-ThomasEtAl.pdf>, 1.10.2020.
7. Hysa, B., Grabowska, B. (2017). Wiedza, umiejętności oraz potencjał pracowników administracji publicznej na przykładzie wybranej jednostki ZUS. *Zeszyty Naukowe Politechniki Śląskiej, Seria: Organizacja i Zarządzanie*, 1992(113), 109-123.
8. Kunasz, M. (2007). Przegląd metod szkoleniowych „on the job”. In: J. Poteralski (ed.), *Przemiany rynku pracy w kontekście procesów społecznych i gospodarczych* (pp. 267-276). Katedra Mikroekonomii Uniwersytetu Szczecińskiego,.
9. Larson, E.W., Gray, C.F. (2003). *Project Management*. Burr Ridge, IL: McGraw-Hill.
10. Moczyłowska, J. (2010). *Zarządzanie zasobami ludzkimi w organizacji*. Warszawa: Difin.
11. Nguyen, L.H., Watanabe, T. (2017). The Impact of Project Organizational Culture on the Performance of Construction Projects. *Sustainability*, 9, 781-802.
12. Nowosielski, S. (2018). Procesy i projekty w organizacji. O potrzebie i sposobach współdziałania. *Studia i Prace Kolegium Zarządzania i Finansów, Szkoła Główna Handlowa*, 169, 109-129.
13. Shenhar, A.J., Dvir, D. (2008). *Nowe spojrzenie na zarządzanie projektami*. Warszawa: APN Promise.
14. Szalkowski, A. (ed.) (2002). *Rozwój personelu*. Kraków: Wydawnictwo Akademii Ekonomicznej.
15. Thomas, R., Marossezeky, M., Karim, K., Davis, S., McGeorge, D. (2002). The importance of project culture in achieving quality outcomes in construction. *Proceedings of the IGLC-10*, 1-13.
16. van Staden, E. (2015). *Identifying and Developing High-Potential Employees and Emerging Leaders Creating a Robust Talent Pipeline*, <https://www.scribd.com/document/373618572/TI-Identifying-and-Developing-High-Potential-Employees-and-Emerging-Leaders-pdf>, 1.10.2020.

17. Wang, X. (2001). Dimensions and Current Status of Project Management Culture. *Project Management Journal*, 32(4), 4-17.
18. Zdonek, I., Wolny, M. (2015), Potencjał pracownika – koncepcja modelu badawczego. *Zeszyty Naukowe Politechniki Śląskiej, Seria: Organizacja i Zarządzanie*, 1946(86), 205-215.
19. Zhang, J., Yu, P., Lv, Y. (2017). Enterprise Employee Training via Project Team Formation. *Proceedings of the 10th ACM International WSDM Conference (WSDM '17)*, Cambridge, UK: ACM.
20. Żukowska, J. (2012). Kształtowanie potencjału rozwojowego pracowników przedsiębiorstw. In: J. Skalik, A. Barabasz (eds.), *Współczesne przeobrażenia procesów zarządczych przedsiębiorstwa* (pp. 255-265). Wrocław: Wydawnictwo Uniwersytetu Ekonomicznego.
21. Zuo, J., Zillante, G. (2006). Project Culture – The X Factor for Achieving Optimum Performance in Construction Projects? *Construction Information Quarterly*, 8(4), 173-177.
22. Zuo, J., Zillante, G., Coffey, V. (2009). Project culture in the Chinese construction industry: perceptions of contractors. *Australasian Journal of Construction Economics and Building*, 9(2), 17-28.

FIT-GAP ANALYSIS AS INTRODUCTION STEP TO BUSINESS PROCESS STANDARDIZATION

Monika KIEĆ

Department of Quality Management, Jagiellonian University in Cracow, Cracow, Poland; monika.kiec@op.pl,
ORCID: 0000-0002-9888-1170

Purpose: The purpose of this study is to identify: (1) business process fits and gaps, (2) gaps allocation to process towers and categories, (3) IT related gaps, (4) IT tools requiring improvement, (4) placement of the IT related gaps on Heat-Map, (5) compliance related gaps.

Design/methodology/approach: The fit-gap approach was to identify a differences between the referential Finance Operational Model, and “as is” processes. Fit-gaps were identified with application of workshops and brainstorming discussions in exemplary finance shared service center, delivering service to 36 independent entities located in 11 EMEA countries. Data collection plan was built based on Finance Operational Model taxonomy and service catalogue.

Findings: Findings of the study are: during this study 4999 fits & gaps were found: (1) 36.2% of activities fully fit to the referential model, (2) 28.8% activities require adjustment of ‘process placement’, and transition from one location to another, (3) 19.5% of gaps are allocated to IT category, where smaller (7.9%) or bigger (11.6%) adjustments of IT infrastructure need to be planned, (4) 15.6% of activities require changes in the way of working. 27.5% of identified gaps impact compliance.

Research limitations/implications: Due to project time frame limitations, the finance processes were reviewed and drill down to the level of single process, not single activity.

Originality/value: The value of this study is presentation of the business areas, which needs to be adjusted to meet requirements of the finance referential model on the organization's way to process standardization.

Keywords: fit-gap analysis, process standardization, finance operational model, IT process gaps.

Category of the paper: Research paper.

1. Introduction

Improvement of the IT technology is one of the fundamental enablers, which is helping to increase processes quality, performance, efficiency and serviceability, understood as speed of service, availability, lowered cost and effective development of a professional relationship between user and supplier (James, 1996). Process design is a key phase of the business process management lifecycle. The resulting models form the basis for process implementation and execution (Pajk, Kovacic, 2012). The company being subject of this study has developed its own finance operational model, which provides the best practices for conducting the business. According to authors of *Fit gap analysis – the role of business process reference models*, the models are having following characteristics (Pajk, Kovacic, 2012):

- Are representing the best practices for conducting the business.
- Are having universal applicability.
- Can be reused as for example blueprints for development of the information systems.

To make the core business processes obligatory for all, an experienced process owners created correct definition of the process as a macro-level model (Rosenkranz et al., 2009). The main focus of the reference model created in exemplary company is a business process, thus the outputs of the model design were detailed process procedures and maps (including main process steps/activities and process participants), created globally for the entire finance organization and for all finance processes conducted in the areas of: order to cash (O2C), procure to pay (P2P) and record to report (R2R). After approval of the global process documentation by the company Senior Management, the referential business model named the *Finance Operational Model*, became future aspiration of this finance organization.

Company being subject of this study is a leading global producer of the special materials used by manufacturers of iron, steel and aluminum. Historically, single manufacturing entities have been acquired and became one big organization, with their diversity in technology & IT infrastructure. Today, the European region is composed out of 36 independent manufacturing entities, located within 11 countries. Each entity is represented by a finance teams, called the Retained Organizations (RO) who is the service receiver, and a single Shared Service Centre (SSC) of EMEA, delivering financial services to these 36 manufacturing entities, who is the service supplier. Shared service of EMEA employs over 100 employees and was selected as a pilot area for implementation of the new Finance Operational Model.

After Finance Operational Model development and approval, organization focused on installation of the model. As the entire venture was complex and multidimensional, the project management structure was put in place, project was divided into smaller sub-project tracks, led by individual Project Managers, reporting to Program Manager. The Chief Financial Officer & Senior Management of the company were assigned as the Steering Committee for the entire project and had signed off project plan with its due dates for individual project activities.

Fit-gap analysis described in text below, was part of the project dedicated to process standardization & process improvement, where following steps were defined:

- Detailed project planning.
- Identification of business process fit gaps.
- Process standardization, by implementation of the improvement recommendations aiming minimalization of the identified.

Diagnose of IT infrastructure was critical to the Board of Senior Management as based on fit gap analysis certain budget & resources allocation as well as business decisions need to be made, with respect to the further process standardization objectives and project timelines.

The aim of this study is presentation of the business areas, which needs to be adjusted to meet requirements of the finance referential model on the organization's way to process standardization.

In order to achieve the purpose of this study (and the objective of the fit-gap analysis) following items needs to be identified:

1. number of fits and gaps,
2. gaps allocation to process towers and categories,
3. ratio of the IT related gaps,
4. find scope of the IT related improvement opportunities, in the meaning of ERPs and IT tools kinds, which needs to be improved as part of the future process standardization,
5. assess impact and complexity if IT related gaps, to prioritize actions,
6. identify number of compliance related gaps.

In order to fulfill the purpose of the study, following questions can be posted:

- How many processes from all run processes do not meet the requirements of the targeted finance model?
- How many gaps are allocated in IT gap category and other categories?
- What is a gap placement: process tower?
- What is the complexity/impact of changes required for IT technology area?
- What ERPs/ IT tools require improvement?
- How many compliance related gaps are within IT category gap category?

The output of the fit-gap analysis: the full list of process fits and gaps, together with the improvements recommendations was used for preparation of the process standardization roadmap. Roadmap became a tool useful in further installation of a referential process model on a planned and agreed level of standardization, which has been established as sufficient to create already a strong foundations of the process driven organization.

2. Literature review

As per literature review, gap analysis is a recognized tool, used in variety of disciplines, such like: service, IT, engineering, finance, human resources (Koripadu, Subbiah, 2020), medical or biological branches. As per author of *Fit Gap analysis Methods for ERP Systems* (Ancveire, 2018), the ‘fit-gap analysis’, also named ‘gap analysis’ is a method used in projects requiring the comparison of enterprise business processes with standard system processes. Paul James in his book of *Total Quality Management*, in chapter *Why Plan?*, wrote that planning is preparation for change, and in this context planning means: evaluating the past and present in order to ensure the best possible future (James, 1996). Authors of *Gap analysis of the Online Reputation* (Rodriguez et al., 2018) inform, that gap analysis can be used as a tool, which facilitates identification of the main problems of the organization. The gap model, used to achieve the total quality in the management of services, is based on reducing the differences between the expected and perceived service by customer (Rodriguez et al., 2018).

According to authors of the *Methods of Fit Gap Analysis* (Pol, Paturkar, 2011), who were working on identification of gaps in ERP system, there are four methods widely used to conduct fit gap analysis:

- Simulation based, where all the stakeholders are attending the workshop to understand and compare system requirements with offered functionalities.
- Brainstorming discussion based, where highly skilled and knowledgeable system consultants are analyzing and presenting system features at the open forum discussion, later noted as fits or gaps.
- Questionnaire based, where questions are matched and compared with system functionalities and features in order to arrive with system fits and gaps. Questionnaire is used for probing of requirements and prepared by highly experienced system consultants.
- Hybrid type, where all three forms from above are utilized.

The following advantages were presented next to the above methods (Pol, Paturkar, 2011), simulation based methods enables to get full view of system functions and capability, brainstorming helps to get 360 degree overview of enterprise requirements by using problem skills and methods, questionnaire is faster method to execute comparing to other methods, and hybrid helps to achieve most desired output as best of all methods.

The requirements prioritization and traceability play an important role in the identification of functionality gap (Ancveire, 2018). The author of *Fit Gap Analysis Methods for ERP Systems Literature Review* (Ancveire, 2018), focuses on three levels of the fit-gap framework, which in ERP (SAP) context, are as follow: application requirements, process requirements and design requirements. ERP system integrate standard business practices that suggest an effective and validated way to perform business operations (Pajk, Kovacic, 2012). These days ERP systems

need to offer a lot of functionality in order to cope with a large number of business requirements. This functionality needs to be aligned with the business in order to create value for the organization (Pajk, Kovacic, 2012).

As an outcome, gap analysis estimates and demonstrates gaps (or fits) in many areas (Ancveire, 2018) of business operation. The fit-gap analysis yields a list of gaps identified, and also discuss methods for reducing the gaps (...) and are identifying gap groups, for example (1) ERP modification, (2) business process modification, (3) traceability & prioritization of requirements, (4) use of third party application software and (5) training of customer or project team (Ancveire, 2018). As per author of article Gap analysis, if expected outcomes from the business fit-gap study exceed aspiration, the objectives can be revised upward. When aspirations substantially exceed possible performance, it may be necessary to revise the objectives downward (Sammut-Bonnici, Channon, 2015).

Authors of publication *Beyond cost efficiencies in shared service centers (...)*, results of the fit-gap analysis can be used for improvement of the organizational business processes performance, and become trigger to process standardization. Processes are at the core of business operations. They enable interactions between stakeholders to effectively fulfill activities with specific purposes. Organizations need to be consistent and coherent as to how they structure and provide their services, as this can demonstrate a key differentiating capability from those of competitors. Processes have different standardization capacities and this needs to be clearly understood when defining whether and how these services should operate through shared service centers (Gonzalez et al., 2019).

According to author of publication *Standardization as a key issue in shared service organization* (Marciniak, 2012), standardization means framework of agreements to which relevant parties in an industry or organization must adhere to ensure that all processes associated with the creation of a good or performance of a service are performed within set guidelines. This is done to ensure the end product has consistent quality. Business standardization means establishing uniform business processes across various organizational units or locations. When thinking about shared service model, following aspects should be considered, before starting (Marciniak, 2012):

- Examination of concerned services in the organization and improvement of process at the current process placement.
- Examination of possibility for economic improvement.
- Examination of IT solutions that could elevate the future improvement of process efficiency.

Organization must be able to understand how each of their processes are embedded throughout, and given their specific nature, make required decisions for those processes to operate optimally (Gonzalez et al., 2019). According to Lillrank Paul, the author of *Quality of Standard, Routine and Nonroutine Processes* (Lillrank, 2003): Perrow (1967) has classified organizations and their technologies by the number of exceptions they have to handle,

and by degree to which a search for a solution to an exception is analyzable. Organization in which there are few exceptions and problems are analyzable Perrow calls routine (typically high-volume services, with processes involving identical repetition of standardized tasks). The opposite type, nonroutine organizations, handles a lot of exceptions that are not analyzable. The concept 'routine' has been used in organization theory to describe the stability that comes from repeating the currently best-known practices (Lillrank, 2003). According to author of article: *Shared Services – Standardization, Formalization, and Control: A structured Literature Review*, by identifying trends, as well as differences, in organizing shared services in different domains — for example in terms of standardization, centralization, or control — one can nuance ideas and recommendations for future shared services and related research. Throughout the literature identified, standardization was reported as a key feature of shared services and one of the main reasons for establishing shared services in the first place. This was because it was seen as achieving many desired objectives such as maximum efficiency, customer satisfaction, and cost savings through economies of scale (Bondarouk, Friebe, 2014).

According to authors of the article: *The coming Commodization of Processes*, firms seek to standardize processes for several reasons. Standardization can facilitate communications about how the business operates, enable smooth handoffs across process boundaries, make possible comparative measures of performance, allow easier outsourcing of process capabilities. Since information systems support processes, standardization allows uniform information systems within companies as well as standard systems interfaces among different firms (Davenport, 2005). Standardization however, depends on variety of factors, such as existing IT capabilities, available standard frameworks, existent knowledge, business strategies, market situation, and competitors, as noted by authors of *Towards a framework for business process standardization (...)* (Rosenkranz et al., 2009).

3. Research methodology

3.1. Fit-gap approach and method

The fit-gap approach, used by company being subject of this study, was to identify a differences between the referential processes, represented by the Finance Operational Model, and "as is" situation, means the way the processes are conducted within the organization at the moment when fit-gap analysis was conducted. Fit-gaps were identified mainly with application of 'simulation based methods' (workshops) and 'brainstorming discussions' (Pol, Paturkar, 2011):

- Workshops: conducted between global process owners, of the: order to cash (O2C), procure to pay (P2P) and record to report (R2R) areas, the main creators of the reference model in indicated process areas, and process participants, such like accountants, team leaders and cluster leaders. During the workshops the “future state” model map of the process was compared with today’s “as is” process and based on that comparison, fits and gaps were identified.
- Brainstorming discussion, were applicable during fit gap analysis, when the root cause of certain gap was discussed in order to propose solution and improvement recommendation.

As outcome of the fit gap analysis following fit-gap categories have been defined and listed in (Table 1) below.

Table 1.
Fit-Gap categories and special characteristics

Fit-Gap category/special characteristics	Category/special characteristic name	Description of the Fit-Gap category/special characteristics:
category 1	IT-1 group of gaps	IT-1 gap category is dedicated for such kind of activities, where functionalities of the existing IT tool or infrastructure leads to misalignment versus the referential model requirements, and when a small change within existing tool is required to meet the model process expectations.
category 2	IT-2 group of gaps	IT-2 gap category is dedicated for such kind of activities, where due to missing IT tool functionality or IT infrastructure, activity is performed either manually with poor quality or is not performed at all, what creates incompliance, or when a complex change within existing tool is required in order to meet the model process expectations.
category 3	Incorrect process placement	Incorrect process placement category is dedicated to such tasks or activities which are performed by a different team in a different location, than assigned by the model (for example detectable when comparing both: current process placement with future/model process placement).
category 4	Incorrect way of working	Incorrect way of working category is dedicated to such tasks or activities which are performed in a different way, in different order or incorrectly, than assigned by the model.
category 5	Full Fit	Full fit is dedicated to such tasks or activities, which are performed in line with model assignment, and fully meet model requirements (full fit means, that no gap was found in the process or activity).
Special characteristic	Compliance related gap	Compliance related gap is such sub-group of the gaps, where process compliance, understood as alignment to the internal company requirements (internal audit, risk and control matrix) is significant.

Note: Author’s own research source.

3.2. Definition of process taxonomy

A process taxonomy document is a list of all processes included in the reference finance model, ordered sequentially, by a process towers of O2C, P2P and R2R, main processes and their sub-processes. Such document is defining scope of activities, being in responsibility of SSC, and structure of all conducted processes: their level, number, title, group.

Table 2 presents the example of process taxonomy list in area of ‘P2P – procure to pay’. In a first column, there are numbers assigned to: process tower, main processes and sub-processes. The next few columns, from Level 1 to Level 4, are reflecting process level within process tree and containing processes names (titles). The last column contains process placement for selected country and country site, so the place (or team), where process should be run (as per referential process model). Expression “SSC” means, that process placement, as per new finance model, is assigned to shared service center (service supplier), “RO” means that process is assigned to the retained organization (service receiver).

Table 2.

Illustrative table of service catalogue & process taxonomy

No.	Level 1	Level 2	Level 3	Level 4	Process placement
1	Procure to Pay (P2P)				
1.1.	Accounts Payable				
1.1.1.	Invoice Receive & Archive				
1.1.1.1				Send invoice	SSC
1.1.1.2				Invoice sorting (prep. for scanning)	SSC/RO
1.1.1.3				Request digital / electronic invoice for future	SSC
1.1.1.4				Return to vendor: incomplete document	SSC
1.1.1.5				Scan document	SSC/RO
1.1.1.6				Archive hardcopy	SSC/RO
1.1.1.7				Archive Work Object	SSC
1.1.2.	Invoice Indexing				
1.1.2.1				Validate document	SSC
1.1.2.2				Send to proper recipient	SSC
1.1.2.3				Reclassify to ‘no invoice’	SSC
1.1.2.4				Return to vendor	SSC
1.1.2.5				Reroute to proper company code operator	SSC
(...)				(...)	

SSC – Shared Service Centre (service supplier), RO – Retained Organization (service receiver).

Note: Author’s own research source.

Generally, document type: “Service catalogue and process taxonomy”, should list all financial processes run within the entire SSC EMEA, and is a very useful document not only for gathering all in-scope activities but also as a starting point for preparation of the documentation governance system, planning of process standardization or creation of the service agreement level, a document which defines the relationship between two parties, the nature of the services each parties provides to the other, and the measures to monitor the level of service provided against the agreed level of service (Gonzalez et al., 2019).

3.3. Design of fit-gap data collection plan

Fit-gap data collection plan, should deliver following data:

- covering the objectives of this study and delivering answer to the questions (posted in ‘Introduction’ chapter of this paper),
- assuring gap traceability in respect to internal document of ‘Service Catalogue & process taxonomy’,
- deliver a standard method of data collection, by creation of standard definition and common understanding of process level groups and gap categories.

The fit-gap data collection plan framework, presented in table 3, was designed to consolidate all above objectives and deliver following set of detailed information, and prepared in a form of an excel table.

- “Gap no.” – to assure traceability and unique identification of each process gap (for example: “ES_01” corresponds to “country code_gap number within Spain country”).
- “Gap size” – to estimate size of the problem, from 0 to 100% (interval: 10%), where full fit = 0%, full gap = 100%, partial gap = 50%.
- “Process tower”, level -2/ -3/ -4 – to assure gap traceability and placement (1. P2P, 1.1. Accounts Payable, 1.1.2. Invoice Indexing, 1.1.2.3 Reclassify to ‘no invoice’).
- “Current/future process placement” – to indicate the actual and the future, process placement assigned by new finance model (for example: SSC).
- “Gap description” – to indicate what is not in line with objectives of the referential process model, represented by the Finance Operational Model, where short description of findings is put based on workshops discussion or questionnaires (for example: 1.1.2.3 _there is no reclassification to ‘no invoice’; process does not exist).
- “Improvement recommendations” – to propose solutions, helping minimizing the gaps (for example: change the way of working, add missing process step: reclassification to ‘no invoice’).
- “Gap category” – to group the gaps into categories for statistics purposes (for example: Incorrect way of working).
- “ERP/ IT tool” – to identify IT tool linked with Improvement recommendations (for example: system used for document workflow).
- “Compliance” – to indicate areas where gaps are related with internal requirements of key controls and internal audit, and where action plan creation and execution is mandatory (for example: left <empty>).
- “Heat map placement” – see detailed explanation in point 3.6 below.

Table 3.*Fit-gap data collection plan framework with examples*

Column name:	Example:
Gap no.	ES_01
Gap size [%]	10%
Process tower	1. P2P
Level 2	1.1. Accounts payable
Level 3	1.1.2. Invoice indexing
Level 4	1.1.2.3 Reclassify to 'no invoice'
Current process placement	SSC
Future process placement	SSC
Gap description	1.1.2.3_ there is no reclassification to 'no invoice'; process does not exist
Improvement recommendation	change the way of working, add missing process step: reclassification to 'no invoice'
Gap category	Incorrect way of working
ERP/ IT tool	Workflow
Compliance	<empty>
Impact on process	High
Complexity of implementation	Low

Due to limited space on the page in Table 3, columns were switched with rows.

Note: Author's own research source.

3.4. Define scope of the fit-gap analysis

Design phase of the fit-gap framework, is a good opportunity for the project team to discuss how deep and wide processes should be analyzed, and what level of details should be aimed during conduction of the fit-gap workshops. Such corrections of the approach will help with data collection method leveling and delivering of the comparable outputs. As per results of this study, the project team has proposed to limit fit-gap analysis down to the 'level 4' processes only, and Steering committee has approve it.

3.5. Improvement recommendations

Every gap found during the fit-gap analysis was considered in order to identify improvement opportunity. The future target is to align all business processes to the Finance Operational Model, thus improvement recommendations should enable realization of that objective. Majority of the improvement recommendations was already defined and listed during workshop's discussions between global process owners and workshops participants. Gap analysis contributes to improving organizational effectiveness in many different areas, categorized as "gap categories", with a special focus on IT category.

3.6. Impact on process and complexity of implementation – Heat Map placement

In addition to presented in table 3 data collection framework, two additional assessments per gap/process line were conducted.

Impact on process (graded as: low, medium, high), where:

- **LOW** – small impact on process or benefit, low priority of implementation, low gravity of gap in model, low impact on compliance.
- **MEDIUM** – medium impact on process or benefit, dependencies, medium priority of implementation, medium gaps gravity in model, big impact on compliance.
- **HIGH** – high impact on process or benefit, significant dependencies, high priority, significant gap gravity on model, significant impact on compliance.

Complexity of implementation (graded as: low, medium, high):

- **LOW** – technology exists, new activity needs to be implemented, extra workload for SSC but with low impact on resources, missing report or missing KPI.
- **MEDIUM** – technology exists, but it requires involvement from IT and their medium workload, extra workload for SSC with medium impact on resources.
- **HIGH** – new technology intro required or technology exists, but it requires significant workload and involvement of IT, extra workload for SSC and extra resources.

Both impact and complexity were used as input to process Heat Map, being helpful in navigating priorities and preparation of action plans in a form of process standardization roadmaps.

As per author of publication: Heat Map and Map Chart using TIBCO Spotfire® (Gupta, 2020), heat maps use colors to communicate numeric data by varying the underlying values. Heat maps are extremely versatile and efficient in drawing attention to trends, and it's for these reasons they have become increasingly popular within the analytics community.

In our study each zone color corresponds to change implementation complexity and has a following meaning: green: easy, yellow: moderate, red: complex change introduction:

- **Green zone** (where following combination of impact and complexity appears: high impact on process and low complexity of implementation, high impact on process and medium complexity of implementation, and medium impact on process and low complexity of implementation).
- **Yellow zone** (where following combination appears: high impact on process and high complexity of implementation, low impact on process and low complexity of implementation and medium impact on process and medium complexity of implementation).
- **Red zone** (where following combination appears: low impact on process and high complexity of implementation, low impact on process and medium complexity of implementation, medium impact on process and high complexity of implementation).

3.7. Fit-gap analysis progress tracking

Once fit-gap workshops started, teams have spent over 10 weeks, being fully dedicated to completion of the fit-gap task. The progress of fit-gap analysis was verified every week. Data for process towers and every process included in taxonomy list per country per country' site, were analyzed and tracked. The exemplary figure 1 is presenting overall weekly fit-gap process progress, after the 5th week of fit-gap analysis duration. The overall fit-gap analysis score at the time was 38% of processes reviewed.

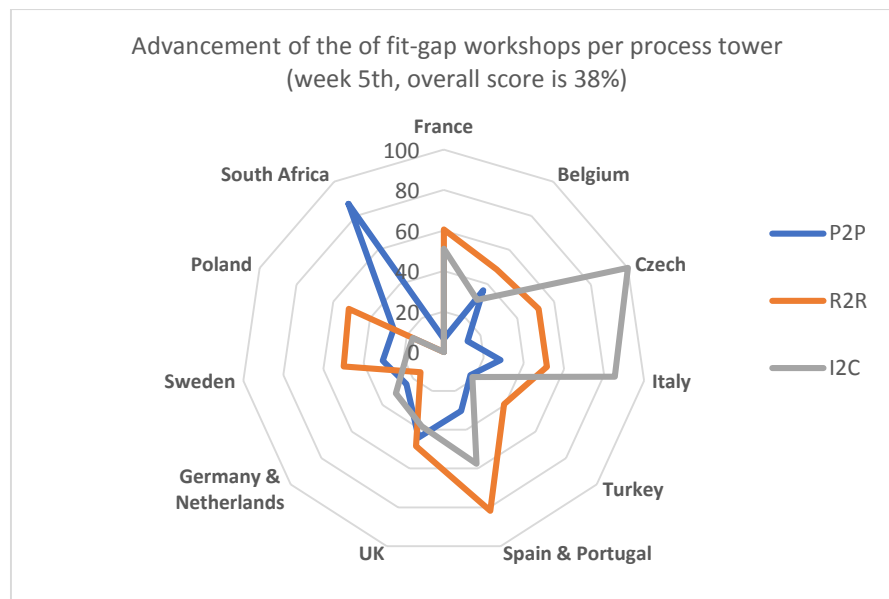


Figure 1. Tracking the progress of fit-gap workshops. Note: Author's own research source.

3.8. Process standardization roadmap

Process standardization roadmap is a document, prepared for needs of the project conducted within company being described in this study, where next to the details described in fit-gap framework (Table 3), few additional columns were added:

- Actions list (actions defined based on improvement recommendations).
- Action owner(s) (person responsible for action leading or implementation).
- Action due date (to know, when action is planned to be completed).
- Action Status (to know if it is: planned, in progress, pending, withdrawn, delayed or completed).
- Placement on Heat Map (gap impact on process and complexity of implementation).
- Gap size "after" [%] (to indicate gap size after implementation of the improvement actions).

4. Results

In order to meet objectives of this study, answers to the study's questions, set in introduction chapter, were found and presented below. The process' specific details of fit-gap analysis, conducted in the company being subject of this study, are confidential. Summary statistics are presented in this chapter.

During the fit gap analysis the total number of 4970 processes were reviewed, and 3191 gaps and 1808 fits were found, what gives total of 4999 fits & gaps. The overall result of fit-gap study can be interpreted in a different ways (Table 4, Table 5):

- as 63.8% gaps found among all fits & gaps,
- as index of 0.64 gap found in each process,
- as 41% of process non-conformance level, when taking into consideration the estimated gap size [%].

Table 4.
Fit-gap analysis summary -1

Fit-Gap analysis summary	[count]	[%]
Total number of analyzed processes	4970	na
No. of process fits and gaps	4999	100
No. of process gaps found	3191	63.8
No. of process fits found	1808	36.2

Note: Author's own research source.

Table 5.
Fit-gap analysis summary -2

Fit-Gap analysis summary	[%]
Overall estimated gaps size [%]	41
Estimated level of process conformance [%]	59
Estimated level of process non-conformance [%]	41

Note: Author's own research source.

The largest category of all fits & gaps was "Ful fit" – 36.2%, what means that tasks or process activities are performed correctly, as assigned in the model, and no corrective action at the moment is required.

The next big category of all fits & gaps was "Incorrect process placement" – 28.8%, what means that there are 28.8% of tasks or activities which are performed by a different team in a different location, than assigned by the model, for example are performed by retained organization and not by shared service or by shared service and not by retained. As a future corrective action, transfer of some activities between RO and SSC will need to be considered.

Both IT categories: IT-1, where small change on existing tool is required and IT-2, where bigger change on existing tool or introduction of new tool is required, are consuming in total 19.5%, where smaller IT changes takes 7.9% and bigger takes 11.6%.

The last group is “Incorrect way of working” – 15.6%, what means that 15.6% of tasks or activities are performed in a different way, in a different order or incorrectly, than assigned by the model, and for example instead of double control we have in place only single controls or instead of double monthly reconciliation, only single reconciliation is performed. As a future corrective action, process change or change the way of working needs to be implemented.

See results enclosed in table 6.

Table 6.
Fit-gap categories split

Fit-Gap categories	Sum [count]	Sum [%]
Full Fit	1808	36.2
Incorrect process placement	1438	28.8
Incorrect way of working	779	15.6
IT-2 group of gaps	580	11.6
IT-1 group of gaps	394	7.9
Total:	4999	100

Note: Author's own research source.

When analyzing all gap categories per process tower, as per table 7 below, we can conclude, that the biggest number of gaps (excluding process fits) have been identified in Procure to Pay area (P2P) – total of 1423 gaps, in Order to Cash area (O2C) 979 gaps have been found, and for Record to Report (R2R) 789 gaps have been found.

Table 7.
Fit-gap categories split per process tower

Fit - Gap categories	O2C	P2P	R2R	Total [count]	Total [%]
IT-1 – existing tool/small change	128	249	17	394	7.9
IT-2 – not existing tool/big change	27	347	206	580	11.6
Full fit	956	419	433	1808	36.2
Incorrect way of working	133	385	261	779	15.6
Incorrect process placement	691	442	305	1438	28.8
Total [count]	1935	1842	1222	4999	100
Total [%]	38.7	36.8	24.4	100	-

Note: Author's own research source.

As presented in figure 2, the largest gap group of 24% belongs to “Incorrect process placement”, 23% of processes full fit to the referential model, 21% are assigned to category of “Incorrect way of working”, and 32% of activities belong to IT category, where: 19% is IT-2 – not existing tool. Big change, and 13% IT-1 – existing tool/ small change.

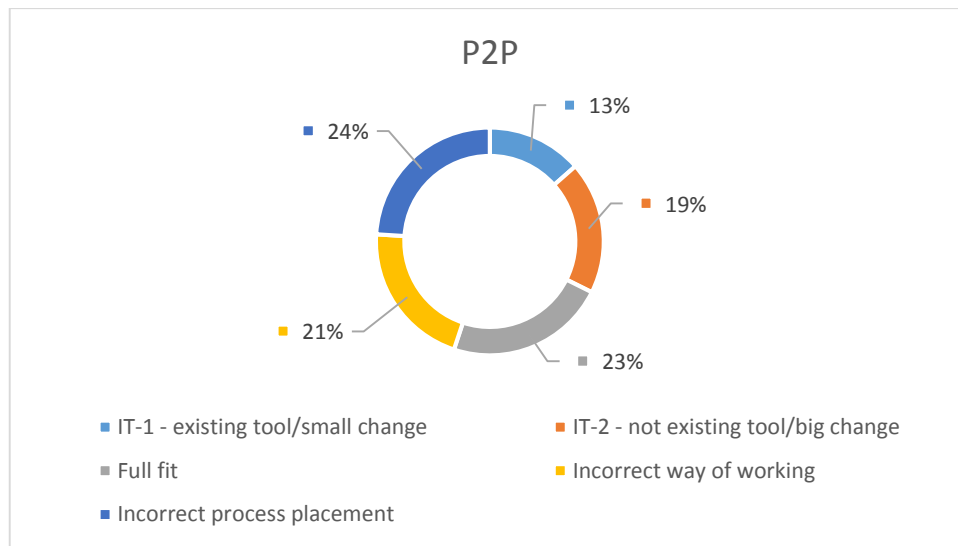


Figure 2. Fit-Gap categories in P2P process tower. Note: Author's own research source.

As presented in figure 3, in O2C process tower, the largest gap group of 49% belongs to processes full fit to the referential model, 36% of activities are assigned to category of "Incorrect process placement", 7% belongs to "Incorrect way of working", and 8% were assigned to IT category, where: 1% is IT-2 – not existing tool and 7% belongs to IT-1 – existing tool/small change.

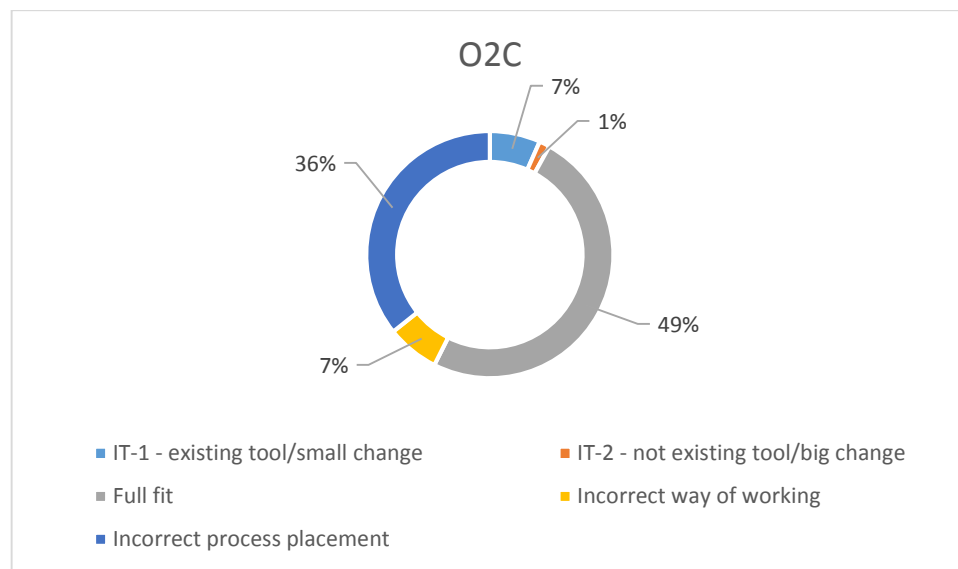


Figure 3. Fit-Gap categories in O2C process tower. Note: Author's own research source.

As presented in figure 4, in R2R process tower, the largest gap group of 36% belongs to processes full fit to the referential model, 25% of activities are assigned to category of "Incorrect process placement", 21% belongs to "Incorrect way of working", and 18% were assigned to IT category, where: 17% is IT-2 – not existing tool and 1% belongs to IT-1 – existing tool/small change.

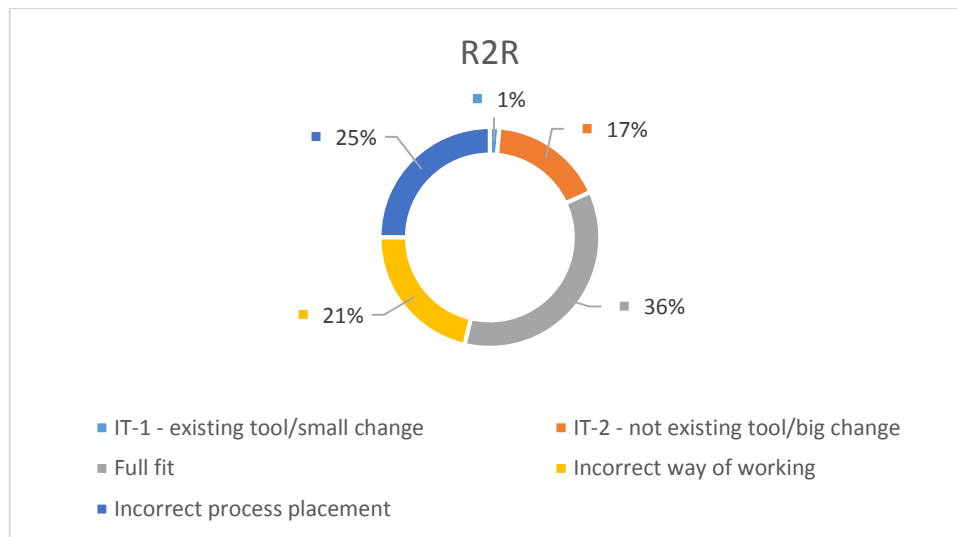


Figure 4. Fit-Gap categories in R2R process tower. Note: Author's own research source.

The overall conclusion of Fit-gap categories split per process tower is, that the largest amount of IT related gaps are appearing in process towers of P2P and R2R. The “Incorrect process placement”, takes more than a quarter of all processes in all process towers, but O2C has the largest amount of process placement issues. Incorrect way of working playing a big part in P2P and R2R and is in minority for O2C.

In order to prioritize improvement actions, all gaps categories were additionally assessed vs. gap impact on business process and complexity of improvement action implementation. Results of the heat map placement study for IT category is presented in table 8 below.

Table 8.
Heat map zones for IT category

IT category “heat zones”	Impact vs Complexity	IT-1 – existing tool/ small change	IT-2 – not existing tool/ big change	Total IT category [count]	Total IT category [%]
GREEN ZONE	High impact vs. Low complexity	18	0	276	26.7
	High impact vs. Medium complexity	185	10		
	Medium impact vs. Low complexity	47	16		
YELLOW ZONE	High impact vs. High complexity	1	231	293	28.3
	Low impact vs. Low complexity	3	0		
	Medium impact vs. Medium complexity	58	0		
RED ZONE	Low impact vs. High complexity	1	0	465	45
	Low impact vs. Medium complexity	82	3		
	Medium impact vs. High complexity	3	376		
All zones	Total [count]	398	636	1034	-
	Total [%]	38.5	61.5	100	100

Note: Author's own research source.

Changes required in IT technology area and their placement on Heat Map, are presented above (Table 8, Figure 5). Heat map placement is created based on two dimensions: impact of on business process and complexity of change implementation and assumptions listed in chapter 3.6. above. Generally, there are more complex IT changes– 45% allocated to red zone, than the easy one changes – 28.3% in yellow zone, and 26.7% in green zone (Table 8).

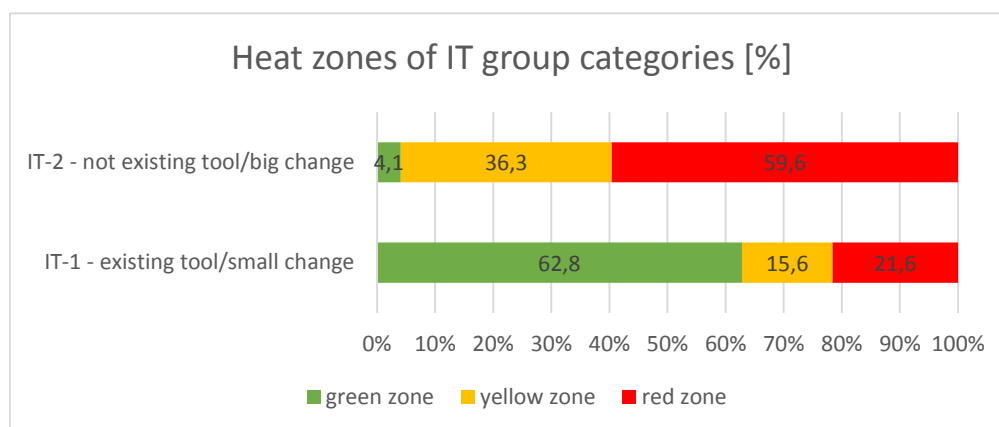


Figure 5. Heat zones for IT category in [%]. Note: Author's own research source.

Based on the study data (Figure 5), we can conclude, that 62.8% of changes in IT-1 gap category (small change on existing tool required) are allocated to green zone, where there are: high impact on process and low or medium complexity of implementation, or medium impact on process and low complexity of implementation. 21.6% are within red zone, where there are: low impact and high or medium complexity or medium impact and high complexity. 15.6% are allocated to yellow zone (with high-high, low-low and medium-medium impact vs. complexity). In reference to IT-2 gap category, where new tool introduction or big change in existing tool is required, majority of 59.6% of gaps are allocated to red zone, and 36.3% to yellow zone and 4.1% to green zone of the heat map.

Table 9.

Compliance related gaps per gaps category

Fit - Gap categories	Total number of 'compliance related gaps' [count]	Total [%]
IT-1 – existing tool/small change	107	12.2
IT-2 – not existing tool/big change	171	19.5
Full fit	0	0
Incorrect way of working	515	58.7
Incorrect process placement	84	9.6
Total [count]	877	100
Total [%]	100	-

Note: Author's own research source.

In table 9 above, there is distribution of compliance related gaps within gaps categories. The largest number of incompliance was detected in gap category “Incorrect way of working”. Within IT category, there are 31.7% of all compliance related gaps, 19.5% within IT-2 and 12.2% within IT-1 category. In general, when comparing number of all process gaps – 3191 with number of all ‘compliance related gaps’ – 877, we can say, that 27.5% of process gaps are impacting compliance.

5. Conclusions

Based on data collected during fit-gap analysis of the exemplary Shared Service Centre of EMEA, among all reviewed process 63.8% of gaps and 36.2% of fits were identified. In general the amount of actions, which needs to be planned and implemented in order to meet the requirements of the new Finance Operational Model need to cover 3191 different gaps. Improvement actions are mandatory for 27.5% (877) of all identified gaps, due to their relations with compliance and internal requirements. It is already visible, that involvement of the entire organization in this complex change is required, as 28.8% of activities will require transition from one place/location to another, 19.5% of activities will require improvement of IT infrastructure and technology, including automatization, and 15.6% of activities will require changes in the way of working or some process changes.

As per presented results, fit-gap analysis was considered as adequate tool for diagnosis of process alignment to the referential finance model, and it has delivered satisfactory and very detailed performance overview of the SSC organization. The company being subject of this study, is one global organization, which historically grew up by acquisition of individual manufacturing entities of different EMEA countries, with their unique technology & IT infrastructure. Today's organization attempts to manage multiple ERP systems, such like: SAP: A1/B1, JDE: XE/World/One, sometimes applied under different revision number, and in addition many 'country specific' IT tools. Currently company uses: 4 different ERPs, minimum 13 other IT tools, and 1 newly implemented ERP, within a pilot country. Integration of financial model requirements with such an amount of IT tools is very complex, diverse and time consuming. As per table 10 and results of conducted fit-gap analysis, 50.2% of improvement actions will require upgrade of ERP' functionalities, 44.5% are allocated to systems used as document workflows, enabling to count volumes, track status of financial processes, and 5.4% improvements actions are expected from tools, which are used for maintenance of data or as data import/exports portals (between internal reporting systems, banks or ERPs via cubes).

Table 10.
IT tools requiring improvement

IT tools	No. of the improvement opportunities	[%] of the improvement opportunities
ERP	571	50.2
Non-ERP tool (documents workflow)	506	44.5
Data exchange tools	61	5.4
Total	1138	100

Note: Author's own research source.

Majority of improvement actions defined to minimize number and size of identified gaps, will for sure enable to align business processes to the requirements of the Finance Operational Model, but there are also some individual cases, where current practices will have to be accepted “as they are”. For example: according to the model, when mismatch between invoice and purchase order is found during already started invoice booking process, process is stopped and put on-hold, until goods receipt action will confirm: the real number of delivered goods/service, the price and the fact of delivery. As for ‘today’, in some countries existing ERP systems do not support such a process sequence, so changed process order will need to be accepted, until future ERP system upgrade, and once installed functionality will enable investigation of goods receipts prior to process of invoice booking.

Next steps need to focus on preparation of the detailed action plans, setting priorities and process standardization level objectives, what could be next research objective and continuation of this study.

References

1. Ancveire, I. (2018). *Fit Gap analysis Methods for ERP Systems*. IEE 12th International Symposium on Applied Computational Intelligence and Informatics, May 17-19, Timisoara, Romania, SACI 2018.
2. Bondarouk, T., Friebe, C-M. (2014). Shared Services – Standardization, Formalization, and Control: A structured Literature Review. *Emerald Insight, Advance Series in Management, Vol. 13*, 39-65.
3. Davenport, T.H. (2005). The coming Commodization of Processes. *Harvard Business Review*, 83(6), 100-8, 149.
4. Gonzalez, A., Schreiber, B., Farah, A.J. (2019). *Beyond cost efficiencies in shared service centers. Alternative focus to maximize shared service center value generation*. Arthur D. Little.
5. Gupta, A. (2020). *Heat Map and Map Chart using TIBCO Spotfire®*. Conference paper.
6. James, P. (1996). *Total Quality Management*. An Introductory Text. Prentice Hall Europe.
7. Koripadu, M., Subbiah, K.V. (2020). *Skill Gap Analysis for Improved Skills and Quality Deliverables*, <https://www.researchgate.net/publication/343975701>, 06.05.2021.
8. Lillrank, P. (2003). *The Quality of Standard, Routine and Nonroutine Process*. Organization Studies.
9. Marciniak, R. (2012). *Standardization as a key issue in shared service organization*. Conference Paper.
10. Object Management Group, Inc. OMG. (2008). *Business Process Maturity Model (BPMM)*.

11. Pajk, D., Kovacic, A. (2012). Fit gap analysis – the role of business process reference models. *Economic and Business Review*, vol. 15, no.4, 319-38.
12. Pol, P., Paturkar, M. (2011). *Methods of Fit Gap Analysis*. Infosys – White Paper, Building Tomorrow's Enterprise.
13. Rodriguez-Diaz, M., Rodriguez-Voltes, C.I., Rodriguez-Voltes, A.C. (2018). *Gap Analysis of the Online Reputation*. Sustainability, MDPI.
14. Rosenkranz, C., Seidel, S., Mendling, J., Recker, J. (September 2009). *Towards a Framework for Business Process Standardization*. Conference paper in Lecture Notes in Business Information Processing.
15. Sammut-Bonnici, T., Channon, D.F. (2015). *Gap analysis*, <https://www.researchgate.net/publication/272353121>, 06.05.2021.

INDUSTRIAL TWINS AS AN EFFECTIVE TOOL FOR THE IMPLEMENTATION OF LABORATORY CLASSES

Arkadiusz KOLKA^{1*}, Maciej KAŻMIERCZAK²

¹ Silesian University of Technology, Machine Technology Department; arkadiusz.kolka@polsl.pl,
ORCID: 0000-0002-5713-4670

² Silesian University of Technology, Machine Technology Department; maciej.kazmierczak@polsl.pl,
ORCID: 0000-0003-4382-1602

* Correspondence author

Purpose: The main aims of the article is to present a solution to the problem that has arisen in connection with the pandemic and the need for distance teaching of vocational subjects

Design/methodology/approach: The proposed methods of solving the problem are based on the use of digital twins created by integrating existing components by developing hardware and software solutions.

Findings: An effective solution was obtained that allows to improve the availability of workshop resources during remote learning and use them in the educational process. The development of techniques combining the virtual and real world seems to be a necessity. The developed solution is a step towards modernizing the approach to the teaching process in the discussed area.

Practical implications: The technical university will have to develop the availability of techniques integrating virtual reality and the real world, which results from the solutions imposed by the development of Industry 4.0. The creation of digital twins for most laboratory equipment will be necessary.

Social implications: Working in a hybrid mode with the use of digital twins in the case of student groups allows for effective development of awareness of responsibility in team work.

Originality/value: An effective methodology for teaching the operation of advanced machine tools was implemented. Tools of this type are new solutions in the field of education, necessary from the point of view of education for employees of the future industry.

Keywords: pandemic time, remote education, virtual reality, digital twins, industry 4.0.

Category of the paper: Technical paper, General review.

1. Introduction

The education system in Poland is customarily based on various forms of education, however, it is mainly based on contact and interaction between the lecturer and the student. Despite the existence of different platforms for non-contact learning, so far in most areas of education, little use has been made of them. On the other hand, in the case of vocational education, which in principle puts the main emphasis on acquiring practical skills, these paths were not used in practice. It should be noted the fact that in the framework of vocational education there is a division on the direction in which education can be successfully based on remote forms of training provide the necessary content, as exemplified by the computer science in the area of programming in the selected language, for example. Python. At the same time, there are areas where contact with the trainer and the equipment is necessary, and the acquisition of the appropriate scope of knowledge is impossible without contact training, e.g. machine tool operator or metrologist. At the turn of 2020/21, the situation changed radically, as education in Poland and around the world faced new challenges related to the growing number of SARS-CoV-2 virus infections, which ultimately led to the declaration of a pandemic. The difficulty in this situation was raised by the dynamics of the entire process, because at the turn of less than a month, the forms of classes had to be radically changed. In the Polish case, more specifically, Silesian University of Technology, the situation was as follows (Iwińska, 2020):

- On March 4, 2020, the first laboratory-confirmed case was found in Poland.
- March 11, 2020 The World Health Organization (WHO) recognized the SARS-CoV-2 epidemic as a pandemic.
- On March 20, 2020, the state of the epidemic in Poland was announced.
- On March 25, 2020, suspension of contact forms of education (full-time classes) at the Silesian University of Technology based on the decision of the Ministry of Science and Higher Education.

This condition applies to the present day, with a few exceptions where for short periods with the consent of individuals supervising attempts to return to the forms of contact with hybrid education, which enabled a reduction in class sizes and the total number of students residing in the college.

2. Educational requirements in the context of remote learning

The result of the situation, the sudden change of educational units from contact to non-contact form of education, was the necessity to develop appropriate ordinances and regulations by managing bodies. In the case of the Silesian University of Technology, a number of Rector's ordinances can be cited, e.g. No. 104/2020 (Monitor Prawny, 2020); No. 200/2020 (Monitor Prawny, 2020), which formalized the rules of conducting classes and verifying the achieved learning outcomes with the use of distance learning methods and techniques. Among the many entries contained in them, attention should be paid to:

- allowing synchronous and asynchronous forms of classes,
 "... learning outcomes covered by the study program may be obtained during classes conducted with the use of distance learning methods and techniques ... synchronous and asynchronous interaction between students and teachers ..." (Legal Monitor of the Silesian University of Technology, item 901),
- determining the form of transferring knowledge concerning, in particular, laboratory classes of a practical nature,
 "... it is allowed to conduct laboratory classes using the remote education platform used at the University, where the teacher discusses the instructions referring to previous exercises and results obtained by students...
 ... conducting laboratory classes on methods and techniques of distance learning that enable conducting various kinds of experiments...
 ... using audio and video recordings showing the course of measurements, simulations, experiments, etc. and providing measurement results via the platform for remote education...
 ... conducting real-time measurements in the laboratory by the tutor and their presentation using ... a platform for remote education. During the measurements, students prepare a measurement report...
 ... use of computer equipment, it is recommended to conduct remote classes or use audio and video recordings showing the operation of the program ..." (Legal Monitor of the Silesian University of Technology, item 901),
- determining the form of crediting and verification of obtaining the desired learning outcomes,
 "... verification and assessment of learning outcomes achieved during the classes are carried out ... in written or oral form ... it is in the form of ... electronic...
 ... proceed to pass ... have a device that supports information technology chosen by the teacher, and prepare a room in which he will test ... so that there will not be another person in it, there are not ... multimedia or telecommunication devices ... materials and

utensils must not be present either auxiliary ..." (Legal Monitor of the Silesian University of Technology, item 901),

- enabling verification of the conditions in which the passing test or exam takes place, ... the person conducting the exam in case of doubts as to the identity of the student ... has the right to verify his / her data ... student ID...
... has the right to verify the conditions of their passing, in particular the room in which the student is staying ...
... at the request of the person conducting the test or examination, the student or doctoral student is obliged to provide the screen of his device ..." (Legal Monitor of the Silesian University of Technology, item 901).

In conclusion, the lecturers obtained the necessary tools and clear guidelines regarding the acceptable form of classes, as well as the organization of credits and exams. It should be particularly emphasized here that there are clearly defined requirements, i.e. the obligation to use devices that enable image and sound transmission, which enables full interaction and control of the test or exam being conducted. At the same time not so clear rules formulated in the context of its regular activities, in particular laboratory and in such a situation often interact with the participants of the course was difficult, and the cameras were running only good will on the part of students.

The provisions cited above included the obligation to obtain learning outcomes within individual subjects. And here some problems related to the possibility of obtaining fully selected effects in subjects such as Programming and operation of machines and production systems, due to its practical nature, were revealed. The learning outcomes assigned to operating the devices, as in the case of other subjects, were divided into three groups: knowledge/skills/competences.

The group of skills constituted the biggest problems or doubts in the context of the possibility of obtaining the full educational result. Examples of skills closely related to the practical side of service, i.e. .:

After completing the course (lecture, laboratory exercises), students should:

- have knowledge of available CNC programming techniques,
- have detailed knowledge of the use of machines used during laboratory classes and techniques of preparing numerical programs for these machines,
- be able to practically develop technological documentation for the implementation of tasks,
- analyze a technological problem, develop an NC program,
- arm the machine, simulate and start the NC program,
- be able to organize the work of several people during the implementation of tasks,
- be able to prepare a team final report on a laboratory exercise.

Mastering the theoretical principles in the context of the above-mentioned skills that students are to acquire as a result of participating in the course does not seem to be sufficient. Even a perfect knowledge of the theoretical foundations regarding the principles of operating machines or CNC controllers will not ensure the correctness of actions using it. In this case, the lack of access to actual production equipment makes it impossible to fully verify the effects of the decisions made.

3. Virtual models limitations

Let's analyze the available tools for the implementation of laboratory classes within the course, e.g. operation and programming of CNC machines. There are both standalone software products as well as simulation software for industrial controllers. Since in non-pandemic conditions we have real machines available, solutions based on simulators dedicated to these machines seem to be appropriate. The basic tool in this case is the simulation environment, consisting of an interactive text editor and a graphical visualizer of tool paths (Figure 1).

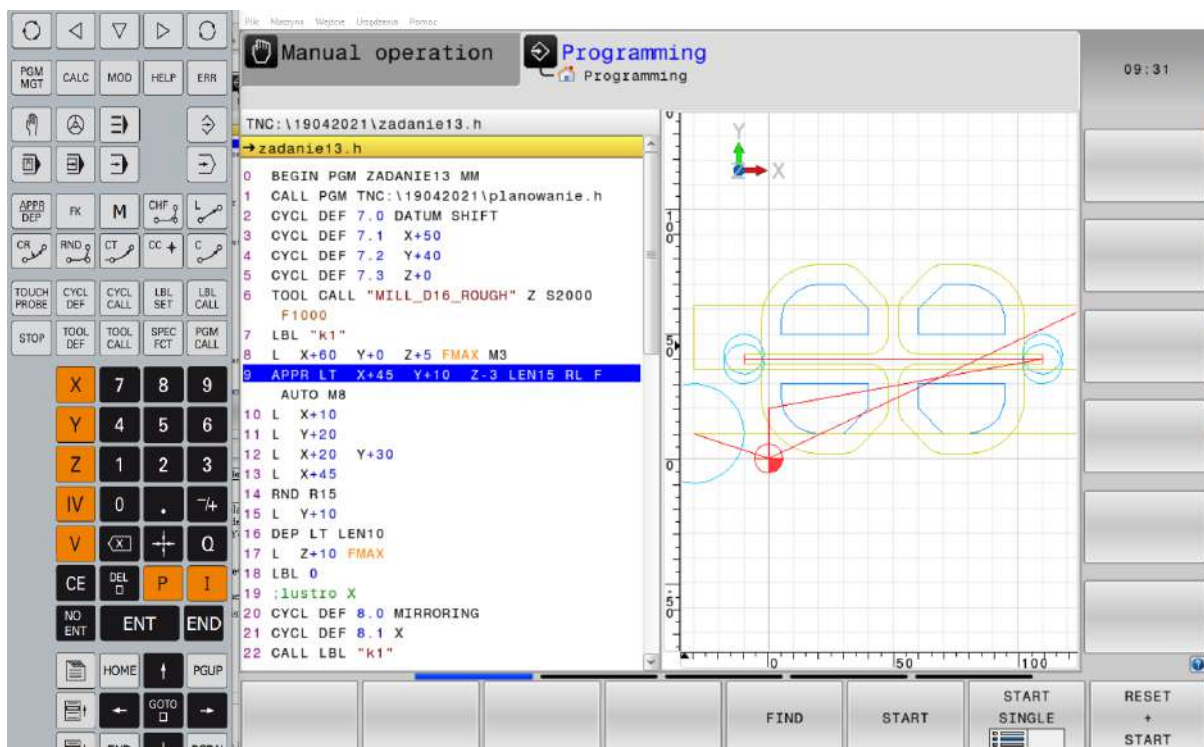


Figure 1. Interactive editor with graphical visualization.

In this case, the student carrying out programming tasks can observe the effects of the decisions made and the program instructions used. This solution allows you to learn syntax of the language used, the methodology of entering coordinates, cutting parameters, etc. The 2D visualization of the paths themselves is not sufficient to evaluate the all required effects. Therefore, another tool in this type of software is 3D visualization of simulation, in which the workpiece and tools are visible. The workpiece is shaped during the operation of the individual cutting tools. In many cases, at this stage, it is possible to evaluate the obtained effects as a result of a color map and workpiece measurement. This case is shown in Figure 2. The color of the area makes it easier to identify the tool that was working there. When working with multi-axis machines, the limitation is the fixed position of the workpiece. In such a machine, the workpiece can rotate, and the tool axis does not change, unlike in the simulator.

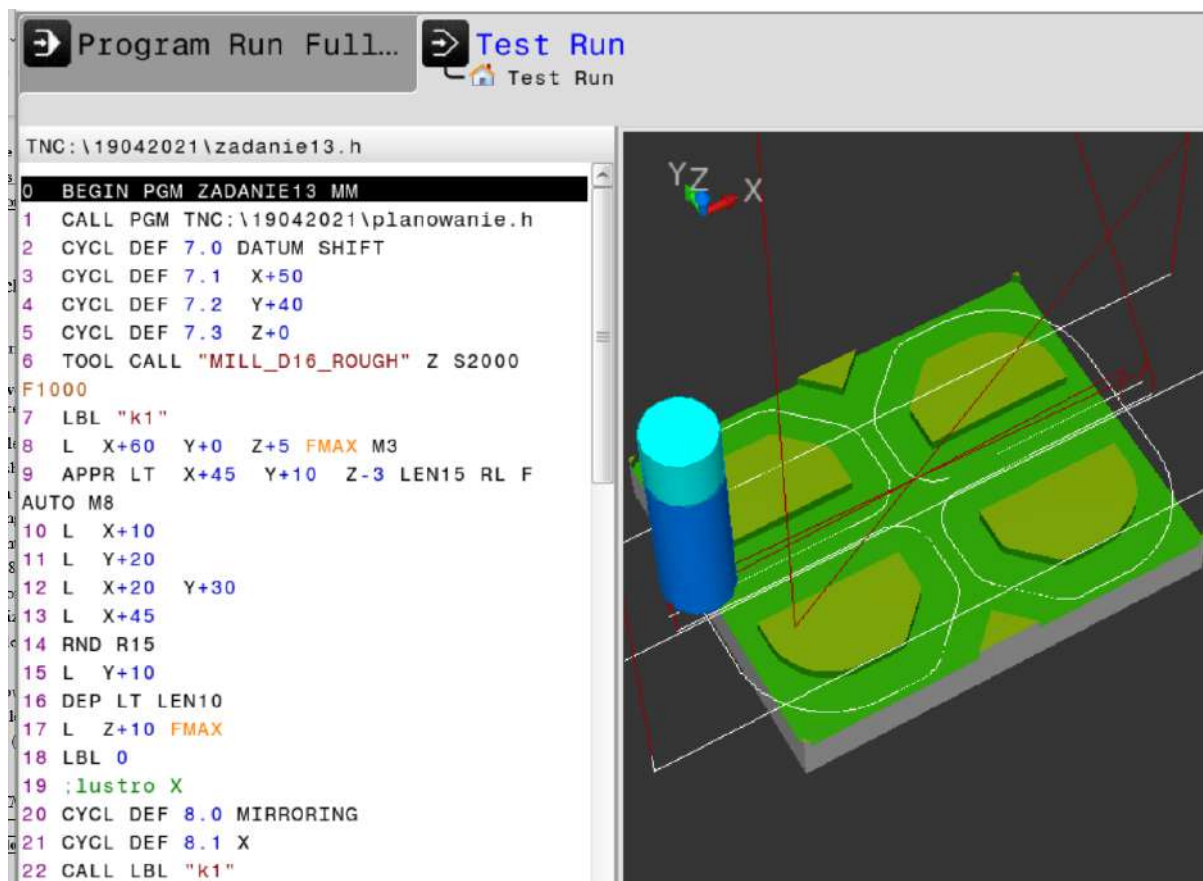


Figure 2. Example of 3D model workpiece simulation with toolpaths.

The next step is to use the virtual machine model (Figure 3). In this case, the process takes into account the kinematics of the machine model. In this way, the mismatch that occurred in a typical simulator is eliminated. In this case, we get complete access to the real CNC controller software, including all its settings. The software operator can describe all important parameters and simulate the process as in a real machine. All machine operations are simulated by a 3D model of the machine with a visible working space. Additionally, in this case, the software can control the collisions of machine units. Both a virtual and real control panel can be used to operate the machine. Such a panel contains switches and keys that are located on the desktop of real machines. Such software brings the student closer to the operation of the real machine, because it has to perform basic maintenance activities, but still the relationship with the real machine requires appropriate imagination. In this form, simulation software seems to be sufficient for learning programming, but only partially meets the requirements for operating real machines.

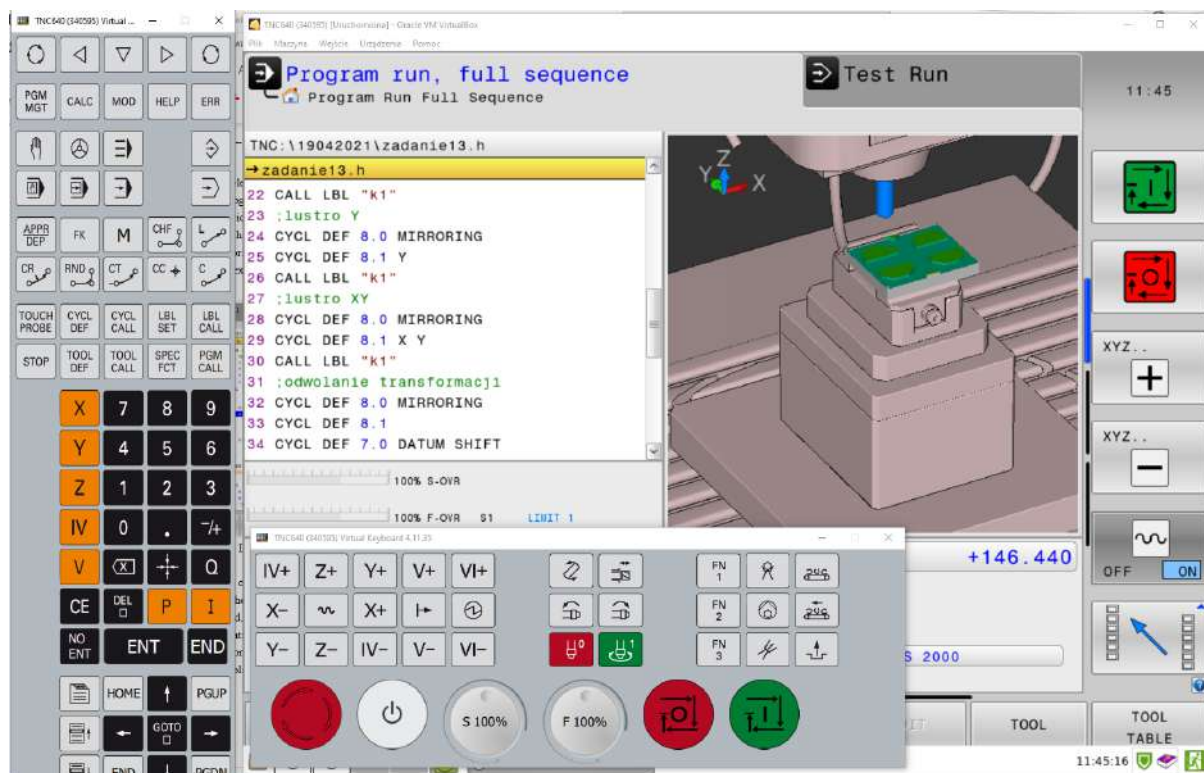


Figure 3. Screen view of virtual machine simulator with complete virtual keyboard.

4. Industrial twins as teaching device

The industrial twin, also known as the digital twin, is an important solution used in Industry 4.0. Thanks to it, it is possible to combine the virtual world and reality, which gives you huge and completely new opportunities. A digital twin is a digital replica, a mathematical model of a given object / product, process, systems or service. It derives from the concept of the virtual equivalent of the physical world, which was created at the beginning of this century at the University of Michigan. The very idea of creating virtual models of devices was introduced by NASA. The space agency created replicas of space capsules and installed hardware and software in them, and in this way was able to test them. With time, when appropriate possibilities and tools appeared, physical models began to be transferred to virtual reality.

The digital twin model consists of: a physical object, digital representation, and linking them through real-time data exchange and processing to continuously update the mapping. Due to the advancement of technology, the collection of data and its transmission is no longer done manually as well as offline and in real time.

The existing infrastructure and software were used to build the teaching device. In the laboratory of Technopark Gliwice there is an advanced multi-task machining center by OKUMA (Figure 4) The MULTUS B200II machine is equipped with the OSP-P300S control by OKUMA. It is an advanced control system, well integrated with the machine, offering many special functions. The CAS (Collision Avoidance System) is an extremely important part of the software. It uses a virtual machine that allows for complete mapping of the actual content of the workspace, including clamping devices, tools, workpiece, measuring instruments, etc. During direct classes, students can perform all maintenance activities on this machine. In particular, activities related to the launch of previously prepared programs. For this purpose, they must equip the machine with tools and equipment, modeling and position all elements of the machine's working space. In such a case, the implementation of numerical programs requires them to be run in compliance with all safety rules. During the implementation, it is sometimes necessary to return the machine from collision positions, restart programs from different places, and change settings. All these task are supervised by the CAS system, which allows for collision-free operation. Since the CAS system settings are critical, they are directly controlled by the supervising teacher. After approving the critical settings, the students themselves cannot change them in further work.



Figure 4. Multitasking machining center OKUMA MULTUS B200II at Technopark Gliwice.

On a remote station, it is possible to run a twin software in the form of a virtual OSP-P300S control simulator (Figure 5), which enables virtual execution of all activities performed on a real machine. It is an environment that allows both programming and testing of programs, which can then be transferred to the MULTUS B200 machine. As a rule, this software works separately from the machine. When the simulation computer and machines are connected to the network it is possible to transfer files between them.

In order to achieve the desired educational results, access to both the machine tool and the software is necessary. This is usually done in separate classes. Work with the simulator takes place on individual computer stations, which enables individual problem solving. Access to the simulator is also possible outside the classroom on the student's own computers when they can perform homework.

Access to the machine tool is limited to workshop activities. Group access to the machine is not effective. Usually, the most active students perform direct maintenance activities, while the rest are only passive observers. It is also influenced by the limited possibility of observation resulting from the space available around the machine. As a result, in terms of the requirement to operate machinery and equipment, achieving the desired educational effect is difficult. It seems necessary to increase the number of hours of access to the machines.

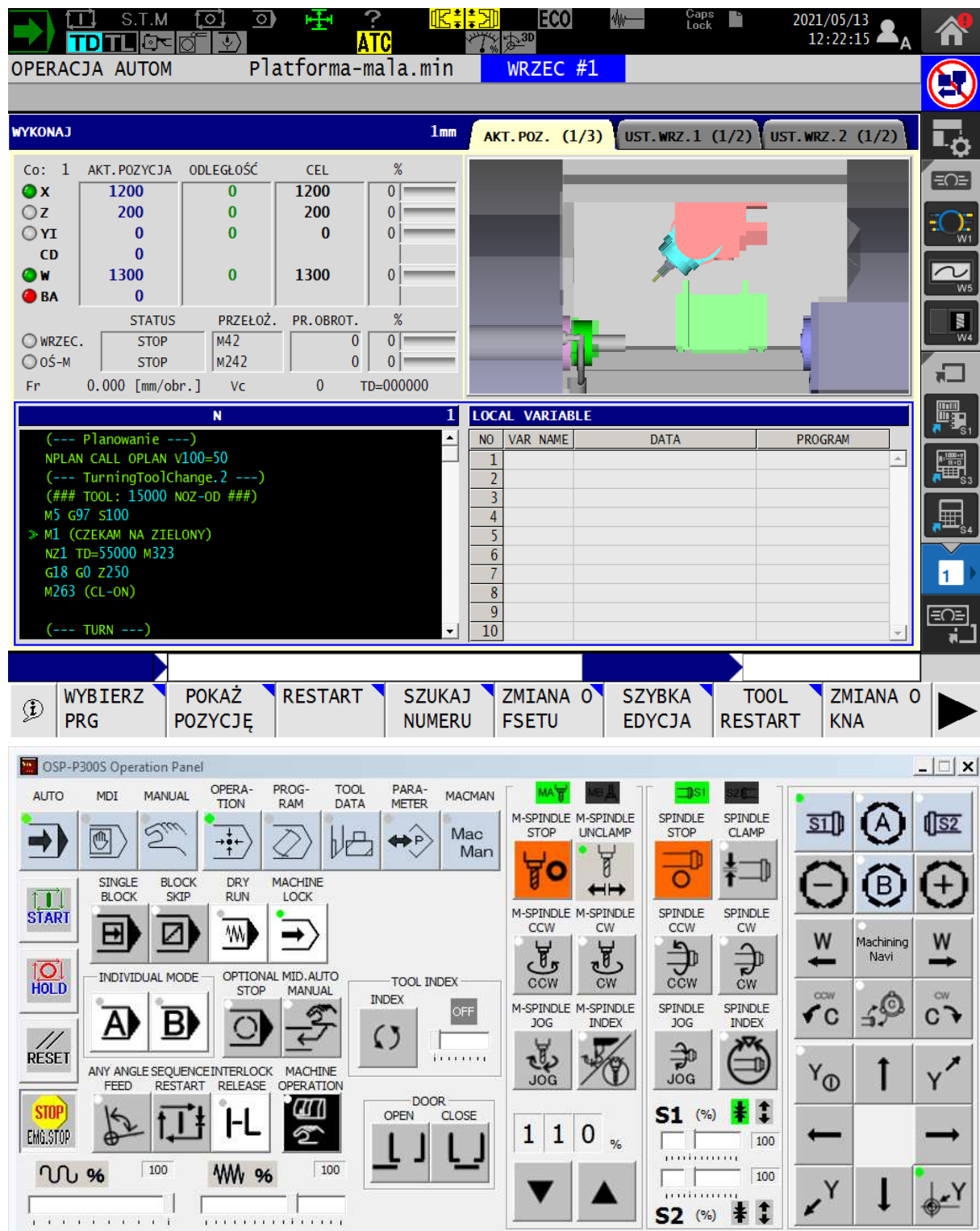


Figure 5. Okuma OSP-Visualisation software with complet virtual controll keyboard.

Due to the lack of direct access to the machine, an attempt was made to use the digital twins technique. For this purpose, special communication software was developed based on the technology OPC UA as data transmission protocols. Okuma's controls allow programmer to use the API to build own applications. This allows to develop software that runs directly on the controller. The software can access the current machine settings, and also allows to change

these settings. It is possible to read, for example, the current position of the machine's mechanisms, cutting parameters such as rotational speed, the amount of working feed, information about the tools used, the states of auxiliary systems and other inputs and outputs.

Figure 6 shows a schematic presentation of the group work during distance learning. The trainer has direct access to the machine tool, where he can make critical settings and take maintenance actions when necessary. It was assumed that he could perform standard educational tasks in parallel with the use of a camera and a microphone. The video image is transmitted to students in real time, both from a blackboard and from the machine's working space. At the same time, students have access to the desktop and digital screen of the machine tool twin. As can be seen in Figure 5, the current operating states of the machine tool are displayed on the top bar of the screen in the form of pictograms that change color depending on the activity. The virtual keyboard is equipped with keys with control LEDs, which allows students to easily identify their status. The programs prepared by the students are sent to the machine control. The machine must be prepared for work, i.e. the workpiece is placed in the holder, appropriate tools are put in the magazine. These activities must be performed directly in the workshop. They are performed by a designated person or trainer. The remaining activities are performed remotely by students under the supervision of a trainer. The trainer selects a person from the group of students who has the operator status. The selected person has the ability to manipulate a digital twin. The other participants can observe the current status of the machine tool on individually personalized screens. The exchange of information between users can be done either by voice or via chat.

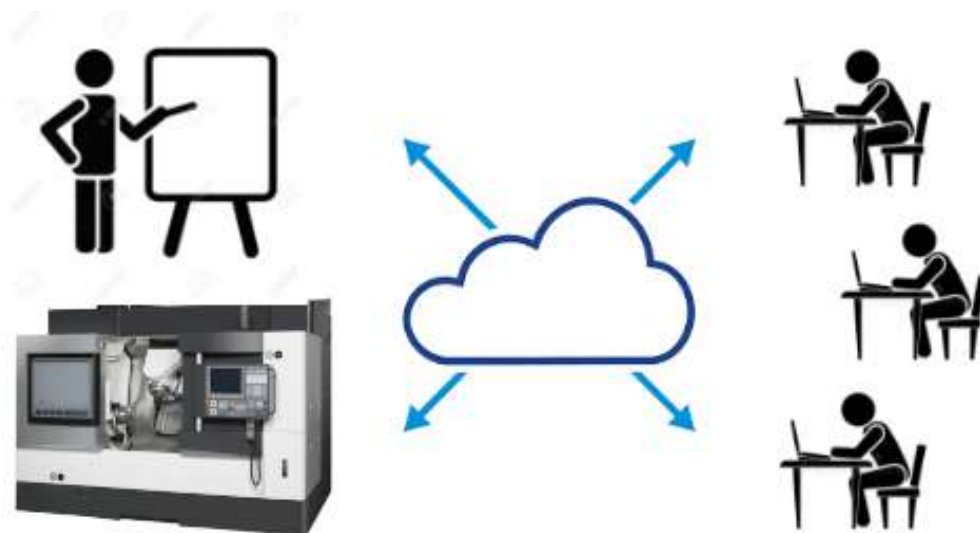


Figure 6. Cloud based learning with digital twin of machine tool.

This form of group collaboration has been tested and has demonstrated the limitations of remote control tasks. In the first place, the problem was the inability to remotely control the start/stop button. Okuma OSP control in terms of simulation is based on the machine lock mode. The activation of this mode causes the complete blocking of the working systems, but CNC controller, together with the virtual machine, works normally. To start automatic operation (even for simulation) it is necessary to press the cycle start button. For security reasons, the API library does not provide direct access to handle this button. In this case, the remote operator can perform all settings, activate most of the keys responsible for displayed screens and basic functions, but cannot execute commands in automatic mode. As a result, the trainer has to do the pressing of the start button. The same problem applies to pausing the machine tool with the feed hold button. For safety reasons, the biggest problem may be the inability to quickly press the Emergency Stop button.

A suggested method of solving the problem of accessing the functions of special keys is to develop a special adapter that interacts with the machine. A design of a special adapter for communication with the machine and external system has been proposed. This adapter is a software and hardware solution based on a microcomputer, eg Nvidia Jetson Xavier NX, which is designed to enable the implementation of tasks requiring operation at the level of electrical signals. It is necessary, for example, for the implementation of tasks related to the operation of critical functions such as automatic cycle start, feed hold, and emergency stop. This adapter will work connected directly to the machine control, but it will be operated with virtual keys implemented in a digital twin available in the cloud. Thus, it will be possible for the remote operator to run programs and perform other tasks in automatic mode. At the same time, persons supervising the process carried out by the machine will have access to the emergency stop button.

The proposed agent, as a separate computer, could also take over additional tasks related to the teaching process. It is possible to equip it with additional cameras, sensors, etc. Probably new applications and needs will arise in the course of further development.

5. Summary

The remote work mode forced by the pandemic may contribute to faster implementation of IT technologies, which will soon become standard solutions in industry 4.0. The proposed methodology of the teaching process with the use of a digital twin allows to combine the potential of software simulators and real workshop equipment. On the one hand, it cannot replace completely direct contact with laboratory equipment, on the other hand, in the case of group work, it gives more individual access to it at the same time for many people.

References

1. Biesinger, F., Weyrich, M. (2019). *The Facets of Digital Twins in Production and the Automotive Industry*. 23rd International Conference on Mechatronics Technology (ICMT) IEEE, Salerno, Italy.
2. Iwińska, M. (2020). *Wyzwania edukacyjne podczas pandemii w opinii studentów pracy socjalnej*. Biblioteka Instytutu Spraw Społecznych 13 Uniwersytetu Pedagogicznego im. Komisji Edukacji Narodowej w Krakowie, p. 135. Retrieved from https://iss.up.krakow.pl/wp-content/uploads/sites/13/2021/01/biss_13_e-book.pdf, 03.04.2021.
3. Koludo, A. (2020). Strategie kształcenia na odległość. In: J. Pyżalski (ed.), *Edukacja w czasach pandemii wirusa COVID-19. Z dystansem o tym, co robimy obecnie jako nauczyciele* (pp. 43-50). Warszawa: EduAkcja.
4. Stark, R., Freseman, C., Lindow, K. (2019). *Development and operation of Digital Twins for technical systems and services*. CIRP Annals – Manufacturing Technology.
5. Umedaa, Y., Otab, J., Kojimac, F., Saitoc, M., Matsuzawac, H., Sukekawac, T., Takeuchib, A., Makidaa, K., Shirafujib, S. (2019). *Development of an education program for digital manufacturing system engineers based on 'Digital Triplet' concept*. Retrieved from <http://www.elsevier.com>, 10.05.2021.
6. Zacher, S. (2020). *Digital Twins for Education and Study of Engineering Sciences*. International Conference on Life Sciences, Engineering and Technology. Retrieved from <http://academia.edu>, 10.05.2021.

SOLVING PROBLEMS IN HOSHIN KANRI SYSTEM APPROACH USING QUALITY MANAGEMENT TOOLS – CASE STUDY

Kinga KONIECZKA

Instytut Inżynierii Bezpieczeństwa i Jakości, Politechnika Poznańska; kinga.konieczka@doctorate.put.poznan.pl,
ORCID: 0000-0001-8539-5774, Phd student

The article was created thanks to participation in program PROM of the Polish National Agency for Academic Exchange. The program is co-financed from the European Social Fund within the Operational Program Knowledge Education Development, non-competitive project entitled “International scholarship exchange of PhD students and academic staff” executed under the Activity 3.3 specified in the application for funding of project No. POWR.03.03.00-00-PN13/18.

Purpose: The main goal of the article is to present quality management tools that help solve problems in the functioning hoshin kanri system.

Design/methodology/approach: In this article described practical aspects of quality focusing on solving problems in foundation system of hoshin kanri. Operation of this system means a systematic process of planning and achieving long-term goals, by developing organization's strategy for all its departments and units. In addition, the article discusses analytical research in relation to Toyota Motor Corporation. This analysis included evaluation of the most popular quality tools for solving problems such as DMAIC, 8D, A3, 5-Why and Ishikawa diagram.

Findings: The case study presented in the article showed that the most applicable and useful is A3 Report but it is possible to use 8D and 5-Why however, the results are less useful than in the case of previous ones.

Originality/value: The results of the considerations are very useful for small and large companies. The application of the presented method in article is mainly for better strategic planning and as a tool in quality management systems and management of complex projects.

Keywords: hoshin kanri, quality management, quality tools, solving problems.

Category of the paper: literature review.

1. Introduction

Nowadays, companies are constantly competing with each other to attract as many customers as possible. To this end, they must ensure the highest quality of products and services and constantly improve their processes and strategy of operation. They can do this using different methods, techniques and tools used in management.

Quality management in manufacturing enterprises has its foundation in quality theory, which deals with building systems of general definitions, theorems and models describing and explaining qualitative phenomena. Uses the achievements of broadly understood management, uses cost accounting. It is based on the methods of such fields of knowledge as management sciences, computer science, economics, sociology, psychology, statistics and other systems related to the functioning of human behavior, etc. This knowledge is a pillar for the correct use of quality management instruments. This article focuses on quality management tools that are used to solve problems not only at the management and executive level of enterprises. These tools support activities by providing properly processed data and information, enriching knowledge of processes, are characterized by some universalism, but at the same time they must be properly selected (Hamrol, 2008).

A key problem for enterprises is also the effective translation of strategies, including vision, mission, values and strategic goals into a simple language, so that they are understandable to all employees and can be cascaded effectively down the organization and linked to daily management. One concept that explains this issue in a systemic way and proposes effective problem solving is hoshin kanri – a 7-stage lean system for implementing coherent strategic goals in an organization (Głowicki, Kowalewski, 2016).

As part of this article, the individual steps of the hoshin kanri system were presented with an indication of the operation of the system based on the PDCA cycle and planning. The PDCA cycle is its basic mental model and gives structure to activities at every level of management. After a long part of planning in HK system comes time to achieve goals, which is not easy, because that is where problems arise. Hoshin kanri is patience and the right resources. Instead of frustrating and bothering companies should use proven, valued, standard quality tools to solve these problems.

2. Characteristics and applicability of hoshin kanri system

The hoshin kanri method was developed in Japan by Yokogawa Hewlett-Packard in the early 1970s. Some western companies in the mid-1980s began to implement their own versions of HK (Hewlett-Packard, Porter and Gamble, AT&T, Xerox Corporation, IBM, Florida Power

and Light and Texas Instruments). Furthermore, different authors have given different literal interpretations of HK, but the following is considered to be the most accurate definition (Dale, Bamford, 2016).

“hoshin” = a compass, a course, a policy, a plan, an aim

“kanri” = management control of the company’s focus

Hoshin kanri is a 7 steps process used as part of strategic planning in which goals are communicated and shared throughout the company, and then put into action (Jolayemi, 2008). The steps below:

Establish the Vision and Assess the Current State – analyze current mission, vision and values, review existing processes and procedures to achieve future goals.

Develop Breakthrough Objectives – requirement for organization to be open to new and demanding ways. It usually takes three to five years.

Define Annual Objectives – state what needs to happen this year to ensure that three to five years old goals are achieved.

Cascade Goals Throughout the Organization – set goals should be measurable, detailed with specific key performance indicators, monitored by management.

Execute Annual Objectives – actions to achieve the goals for the year. It is advisable to use problem solving techniques, including DMAIC, 5WHY, A3.

Monthly Reviews – monthly checking of each person's progress in achieving goals to ensure that progress is maintained.

Annual Review – comprehensive assessment of organization's progress, adjusting goals or time estimates, ensuring adequate resources to achieve goals in the following year.

The purpose of hoshin planning **is to improve communications throughout the company, whilst also reducing the waste created by poor direction or bad management** at any level. The key to acquiring organizational knowledge is ability to discover problems and solve them. Hoshin kanri helps meet this requirement by using the Deming cycle (Plan-Do-Check-Act, PDCA) to manage and improve every detail in company. PDCA is an abbreviation for management method based on the scientific method, which includes four successive stages:

- Plan – developing a better method of operation and planning its implementation.
- Do – testing a new method.
- Check – verification of the results of the experiment.
- Act – introducing the tested method as a new standard of work.

Thanks to the systematic use of PDCA, hoshin allows to combine planning and implementation at all levels of organization. This can be achieved by means of a complex information exchange process called “catchball”, which results in interconnection and interlocking of subsequent PDCA cycles as well as transfer of the strategic plan to the next levels of the organization (Watson, 2005).

The application of the presented method is mainly for better strategic planning and as a tool in quality management systems and management of complex projects. It also serves to motivate employees and join in the process of change. The hoshin kanri facilitates the understanding of strategic goals by the entire enterprise community and the creation of what can be described as strategic awareness, i.e. a shared vision of the future. Supports the creation of short- and long-term plans. Thanks to it, the company is able to produce products that meet the individual needs of customers and steadily increase its profits. The hoshin kanri method is also used to manage and integrate supply chains.

3. Quality management tools for solving problems in the theoretical concept

Quality management tools help to improve the quality of products, services and processes. Quality tool is a tool designed to perform a specific task, according to a defined procedure. It enables direct and support the activities of improvement and change. The complementary tools are less used or are used only to solve a specific problem.

Based on analysis of the functions of extensive set of tools, those that correspond to the assumed problem solving were selected. These are: Ishikawa diagram, 8D report, A3, 5-why and DMAIC.

The first of these quality tools to solve problems is the tool 8D (Eight Disciplines). The 8D report is a systematic form of problem solving and continuous improvement of the organization. The standard 8 points of analysis allow to effectively find the cause and determine corrective actions. The 8D report follows the logic of Edwards Deming or PDCA. It is an extensive tool that uses some of the other well-known quality assurance tools. It corresponds to their readiness to solve complex problems for continuous improvement of a product or a process. The tool is processed in eight disciplines and emphasizes the synergy of the people involved. It was originally developed by Ford Motor Company, where it combined various elements of other techniques for problem solving to shape the eight disciplines, which it was introduced in Ford manual titled: Team Oriented Problem Solving. The 8D tool can be represented in steps as in Table 1.

Table 1.
Steps 8D

Nr	Step	Explanation
D1	Initial Data	Establish a small group of people with knowledge, time availability, authority and competence to solve the problem and implement corrective actions. The group must select a team leader.
D2	Description of the problem	Describe the problem in measurable terms. Specify clearly and objectively the problems that occurred both internal and outside the company.
D3	Immediate countermeasures	Define and implement actions that will provide protection for the customer to faulty, not causing a significant loss of the same, until permanent corrective action is implemented. Check with the data of the effectiveness of those actions.
D4	Root causes	Identify all potential causes that could explain why the problem occurred. Apply and test each potential cause against the problem description and data. Identify alternative corrective actions to eliminate the root cause.
D5	Corrective and preventive actions	Confirm that the corrective actions implemented will solve the problem for the customer or supplier and will not cause undesirable side effects. Define other actions, if necessary, based on the potential severity of the problem.
D6	Effectiveness of actions	Define and implement the necessary corrective actions for the permanent elimination of the root cause of the problem. Choose controls to ensure that the cause is eliminated. Monitor the long-term effects and implement additional controls, if necessary.
D7	D7. Updating of standards	Modify the specifications, training of employees, work flow, improve practices and procedures to prevent recurrence of this and all similar problems
D8	D8. Closing	Recognize the collective efforts of the staff. Promote your accomplishment and share knowledge and learning with the whole team, to assist in possible failures or similar errors that may occur.

Note: source Broday E.E., Andare P.P., 2013.

The Ishikawa diagram is another quality tool analyzed that helps focus energy on the root cause of the problem, rather than dealing with and wasting time on symptoms. Ishikawa is cause and effect diagram, allows to rank the causes of occurring irregularities and to link these causes to each other using the chart. Its essence is a graphical presentation of the analysis of interrelationships of causes causing a specific problem. (Smith, 1998). Perfect for team work, in combination with other quality management tools and techniques, such as brainstorming. It is referred to as a hierarchical tool whose main purpose is to help locate the causes of the problem that bothers us. The Ishikawa diagram is also often called the herringbone diagram or the fish bone diagram, because it resembles its shape. The Ishikawa cause and effect diagram should be constantly updated depending on how many and which of the causes of current errors have been removed or resolved.

Problems can be grouped based on several principles. For the less experienced working groups, the 5 M rule is the most popular of those used. Other rules used are: 5M + E, 7M, 8M, standards.

Grouping problems based on the 5M rule. The 5M rule is to use the (5M) system when performing the analysis. Five groups of reasons are proposed here:

Manpower (people, workforce) – qualifications, habits, satisfaction with work, internship, well-being, etc.

Method – procedures, instructions, scope of duties, specifications, standards, law, rules, know how, technology etc.

Machine – license, durability, modernity, efficiency, precision, security living, working conditions etc.

Material – input materials, semi-finished products, elements, substitutes, etc.

Management – organizational structure, work organization, change work conditions, etc.

Ishikawa is cause and effect diagram has many uses, the main one is to solve quality problems in which there is an extensive chain of causes. It is also considered one of the basic quality tools used in the analysis phase of Six Sigma's DMAIC approach to problem solving.

DMAIC is an acronym from the words Define-Measure-Analyze-Improve-Control. This method is based on process improvement according to Deming cycle. It is a process improvement of many different areas in the enterprise. DMAIC cycle consists of five stages which are connected with each other (Smętkowska, Mrugalska, 2017):

Defining the goal and its requirements. The main purpose of this stage is to verify if the actions, which should be taken in order to solve the problems, are connected with the priorities in the organization and that there is support from management and availability of required resources.

Measuring the current process. The measure stage concerns gathering information about processes which are going to be improved. It focuses on information which is needed in order to better understand all the processes in organization, customers' expectations, suppliers' specifications and identification of the possible places where a problem may occur.

Analysing the results of measurements, determining the causes of process imperfections and possible solutions for them. In the analyse stage different tools and methods are used to find root causes, assess the risk and analyse data. To confirm the analysis some samples should be performed and potential problems have to be proven to be real problems.

Improving the process, implementing the changes, which eliminates the imperfections. The goal of this stage is to take necessary information to create and develop an action plan in order to improve the functioning of the organization, financial aspects and customer relationship issues.

Controlling of the improved process, monitoring the results in a continuous way. The control stage is about confirmation if changes implemented at the improve stage are sufficient and continuous by verifying the quality of the improved process.

The next tool analysed is A3 Report – the simplest and most effective method of communicating what is important in an enterprise in a structured way. The A3 report took its name from a 297 mm by 420 mm sheet of paper. The report is based on the PDCA principle – Plan (Do), Do (do), Check (verify), Act (improve, act). The Deming Wheel is used in many methods of problem solving or continuous improvement. Therefore, the main recommendation of this method is primarily to solve problems where they occur (Shock, 2020).

The A3 Report usually consists of multiple steps following a PDCA structure of Plan, Do, Check, Act. The number of steps can vary due to the different formats being used for the A3 Report. The exact number of steps used is not as important as the end result. The A3 Report

can utilize various forms depending upon the organizations needs and preferences. The following paragraphs provide information regarding the basic steps and some tools used to complete the A3. One thing that all of the forms seem to have in common is that they follow the PDCA problem solving process. The basic steps and where they fall into the PDCA structure are listed below (Bassuk, Washington, 2013):

Plan – the first step is to define the problem or identify the need for improvement. Define the ideal state, the operational standard or the desired condition, describe the current situation or status and identify the Gap or problem.

Containment – in some A3 formats, a section is included for immediate countermeasures or containment actions. The purpose of containment is to prevent further problems from occurring or prevent the current problem from causing negative effects to other processes, products or departments.

Breakdown the problem – may be more than one issue contributing to the problem or more detail required to properly address the problem. Prioritize the issues and identify the point of occurrence or escape point.

Define goals – set goals regarding the improvement desired as a result of the exercise. This could include a percentage of improvement in process throughput, reduction in number of defects per unit or processing time. The goals should be specific, measureable, realistic, achievable and timely.

Root Cause Analysis of the problem by using various quality tools. Whatever method selected, it is important to get past the symptoms of the problem and down to the root cause.

Countermeasures – determined to address the root cause. The countermeasures must be clearly defined, achievable by the person responsible and have a due date. Corrective actions that do not have an owner or due date are seldom achieved.

Implementation of the corrective actions should be developed. The plan should include the team members, resources and time required to complete each task. In some cases, support from outside resources or test facilities are required. Some countermeasures may require repair or replacement of tooling or other capital expenditures. Therefore, proper levels of management should be kept informed throughout the process to assure adequate resources are available for implementing any corrective actions.

Monitoring and Validation the A3 team should next confirm the effectiveness of the countermeasures. This can be accomplished in many ways, including but not limited to additional quality checks, Statistical Process Control (SPC) data, process or product audits and customer feedback.

Standardize and Improve – during this phase of the A3, the team should take action to standardize the process changes or improvements. The team must update all standard work, work instructions and process control plans, etc. The management team should also promote continuous improvement of the A3 tool within the organization.

The last of these problem-solving tools is the 5-Why tool, which allows to find out the causes of a given problem. It is a method that raises two aspects. The first concerns the causes of the problem – why did the problem arise? The second aspect concerns the detection of the problem – why our current system/process control/supervision methods did not detect the problem once it appeared. Diagram 5-Why, also called the why-why diagram is one of the methods used to check and control the production process. It is based on the assumption that each subsequent statement is determined by asking the question "why?". The tool is very similar to a cause and effect diagram. It is helpful when assessing the network of problems and the relationship between these causes. By using the diagram, organizations can develop short- and long-term solutions.

4. Tool verification for solving problems in the hoshin kanri system on the example of Toyota Motor Corporation

One of the companies using hoshin kanri is Toyota Motor Corporation, which is currently the largest and one of the most technologically advanced car manufacturers in the world. Toyota currently sells almost 11 million cars a year and is famous for developing the concept of cars that guide the development of the global automotive market. In the last 70 years, Toyota has developed one of the most effective management and production systems, and concepts such as the Toyota Production System, Toyota Way, Toyota Philosophy or Lean Management. Toyota is also an excellent exemplification of the integration of the lean management concept and the hoshin kanri method (Głowicki, Kowalewski, 2016).

Indicators driving problem solving and supporting process orientation are important for Toyota. Most important educational measures track progress in achieving stretch improvement goals, which is the process described above – hoshin kanri (Choi, Liker, 1995).

The hoshin kanri systematically uses the PDCA cycle, also called the Deming cycle. PDCA is a management method aimed at discovering problems, solving them and constantly improving every aspect of the organization's functioning. Each of the analyzed problem-solving tools is also based on the Deming cycle. Quality tools for solving problems in system hoshin kanri are used in step 5, to enforcement of annual targets.

Summary of results from the analyzed quality management tools for solving problems in hoshin kanri system in Table 2.

Table 2.
Quality tools for solving problems in HK

Quality tool for solving problems			Hoshin Kanri System	
Name	Purpose	Results	Input	Output
Ishikawa diagram	Pointing out and grouping the causes of the problem.	Graphical presentation of the relationship between factors that affect a given problem and effects	The causes of problems that annual goals have not been met.	Corrective and preventive actions against similar problems.
DMAIC	Improving process productivity, project finances, quality and time.	Analysis of the current state and the desired state.		
5-Why	Inspect a certain problem in depth until it shows the real cause.	Finding the answer to the cause of the problem.		
A3 Report	Document the learning, decisions, and planning involved with solving a problem, facilitate communication with people in other departments, provide structure to problem-solving so as to maximize learning.	The report tells the whole story, the details, description of the situation, objectives, problem analysis, plan further action.	Completed data sheets in accordance with the guidelines in the reports.	Solving problems in a standard and systematic way, very detailed data, a systematic approach to solving emerging problems and stimulating the process of continuous improvement of the enterprise. The analysis is based on standard steps. They provide the opportunity to determine the cause of the problem and the required corrective actions.
8D	Effective finding the cause and establishing corrective actions.	Problem analysis in the form of a report.		

Note: source – own study.

The analysis showed that the best way to solve problems in hoshin kanri is to report A3. This report appeared at Toyota Motor Corporation as a method combining two important management processes: hoshin kanri and problem solving. At the enterprise's macro-scale, hoshin kanri leads to setting operational goals and actions in line with higher organizational goals, at the micro level, at the individual level, the formalized problem-solving process provides the organization with the possibility of continuous learning. The A3 process combines both scales. Therefore, companies that are looking for a way to discipline the hoshin kanri process and an effective problem-solving process, can find a great challenge and powerful possibilities in A3. Organizations use this tool to make decisions, achieve goals and implement actions, ensure proper understanding of team goals, and above all to teach for better efficiency, efficiency and improvement. A3 is both a problem-solving tool and a structured process of educating employees in solving these problems. It helps to promote a scientific method that forces to observe reality, present specific data, determine feasible remedies geared to achieving the previously set goal, and describes ways to check later whether the selected remedies really do the job.

Using the 8D tool allows to identify the cause of the problem and apply effective measures to prevent it from reoccurring. The popularity of 8D is associated with a long list of measurable benefits of its implementation. On the advantages side, the 8D method should include a simple and logical structure showing the next steps of the procedure and a wide range of application.

In case of 5-Whys technique is an effective way to sort through a wide range of problems. Keep in mind that some problems have more than one root cause, so for complex issues, it may need to be repeated by asking several different starting “why” questions.

The DMAIC cycle can be quick and easy for simple problems with clear root causes, or it can involve many improvement tools and cross-functional collaboration for more difficult challenges. In either case, it requires discipline and attention to detail, two very important elements of continuous improvement. Organizations that get very good at DMAIC put themselves in the position to respond quickly to problems and achieve benefits that last but usually works for a relatively short time. Often, DMAIC is an ideal starting point to solving problems, but is hardly a substitute for a personalized and well-thought-out manufacturing strategy.

5. Summary and conclusions

In summary, presented in the article troubleshooting methods used in system hoshin kanri are unique and useful mainly because of its scientific basis. This is confirmed by example of Toyota Motor Corporation, which uses solutions based on the key PDCA cycle. The tools discussed in the article were divided into two groups, those more useful for solving problems occurring in the HK system and those less helpful. Those from the second group are used and it is recommended to use them as components of Report A3 and 8D, which are more complex.

The choice of the most accurate tools was determined by their relevance and complexity. One of the arguments was to focus on multifaceted root causes instead of the problem or selected first order cause. Another argument was a significant and stable improvement effect due to multi-faceted analysis and elimination of root causes. The last advantage was the ease of use at every level of the organization. These tools are simple, logical, fast and clearly define next steps in solving problems. What is more, they are transparent and understandable, making communication easier. In this way, A3 and Report 8D most accurately entered the subject matter analyzed in the article.

References

1. Bassuk, J.A., Washington (2013). The A3 Problem Solving Report: A 10-Step Scientific Method to Execute Performance Improvements in an Academic Research Vivarium. *PLoS ONE*, 8(10), e76833.
2. Broday, E.E., Andare, P.P. (2013). Application of a quality management tool (8D) for solving industrial problems. *Independent journal of management & production (IJM&P)*, v. 4, n. 2.
3. Choi, T.Y., Liker, J.K. (1995). Bringing Japanese Continuous Improvement Approaches to U.S. Manufacturing: The Roles of Process Orientation and Communications. *Decision Sciences*. Vol. 26, No. 5, September-October.
4. Dale, B.G., Bamford, D. (2016). *Managing Quality*. John Wiley & Sons Ltd, p. 81.
5. Głowicki, P., Kowalewski, M. (2016). *Metoda hoshin kanri w przedsiębiorstwach wykorzystujących koncepcję lean management*. Wrocław, Research papers of Wrocław University of Economics X. 424.
6. Hamrol, A. (2008). *Zarządzanie jakością z przykładami*. Warszawa: PWN.
7. Jolayemi, J.K. (2008). Hoshin kanri and hoshin process: A review and literature survey. *Total Quality Management & Business Excellence*, Vol. 19, Iss. 3.
8. Łańcucki, J. (ed.) (2006). *Podstawy kompleksowego zarządzania jakością TQM*. Poznań: Akademia Ekonomiczna.
9. Łuczak, J., Matuszak-Flejszman, A. (2007). *Metody i techniki zarządzania jakością*. Poznań: Kompendium wiedzy, Quality Progress.
10. Shock, J. (2020). *Managing to Learn: Using the A3 Management Process to Solve Problems*. Gain Agreement, Mentor and Lead. Lean Enterprises Inst Inc.
11. Smętkowska, M., Mrugalska, B. (2018). Using Six Sigma DMAIC to improve the quality of the production process: a case study. *Procedia – Social and Behavioral Sciences*, 238. Elsevier Ltd.
12. Smith, G.F. (1998). *Quality Problem Solving*. Milwaukee: ASQ Quality Press, pp. 110-112.
13. Watson, G.H. (2005). Design and Execution of a Collaborative Business Strategy. *Journal For Quality & Participation*, Vol. 28, No. 4, pp. 4-9.
14. Witcher, B. (2002). Hoshin kanri: a study of practice in the UK. *Managerial Auditing Journal*, Vol. 17, Iss. 7.

PERFORMANCE MANAGEMENT SYSTEM FOR PRIMARY HEALTHCARE SERVICES PROVIDERS

Piotr KORNETA

Warsaw University of Technology, Faculty of Management, Warsaw; Piotr.Korneta@pw.edu.pl,
ORCID: 0000-0003-2726-8309

Purpose: The purpose of this paper is to identify critical areas of primary healthcare services providers and to develop a performance management framework for these organizations.

Design/methodology/approach: Firstly, 12 semi-structured interviews with decision makers experienced with management of primary healthcare services providers are being conducted. Next, based on obtained results, holistic conclusions and the performance management system for primary healthcare services providers are being provided.

Findings: Performance management of primary healthcare services providers is highly reliant on significant stakeholders, namely: patients, medical doctors, nurses and midwives, stockholders and National Healthcare Fund. Failure to include any of stated stakeholders would result in considerable underperformance. The proposed framework postulates to focus on the performance management of the following 3 areas: (1) operations management, (2) risk and compliance and (3) development so that stated stakeholders are satisfied and provide, in exchange, their contribution to the organization.

Research limitations/implications: The scope of this paper has been limited only to small and medium sized clinics located in Poland.

Practical implications: Proposed in this study performance management framework, due to its simplicity, should be a useful tool for practitioners to adapt and apply in their organizations.

Originality/value: The first performance management framework for primary healthcare services providers in Poland is being proposed. Since, the proposed framework acknowledges wider society, the developed concept should provide sustainable solutions for organizations willing to implement it.

Keywords: Primary healthcare, performance management, performance management systems, SME.

Category of the paper: Research paper.

1. Introduction

The role of a primary health care is increasingly growing. Countries with developed primary health care enjoy lower health care expenditure, fewer hospital admissions and overall better outcomes of patients treatments (Starfield et al., 2005; Bresick et al., 2019). The key objectives of primary health care are: (1) improvement of the patient care, (2) improvement of the population health and (3) reduction of the per-capita cost of healthcare (Haj-Ali and Hutchison, 2017, p. 70). The achievement of aforementioned objectives is not an easy task, as healthcare service providers must: meet the needs of senescent society, overcome significant shortages of medical doctors and nurses, perform within limited funds and follow the changes in IT and telemedicine, (Haczyński et al., 2017; Borkowska, 2018; Haczyński and Buraczyńska, 2018; Korczak and Karlińska, 2018; Kwiatkowska and Skórzewska-Amberg, 2019). In order to approach aforementioned challenges primary healthcare services providers could implement and use performance management systems (PMS), which have already proved to be very successful in other industries and are considered to improve the performance quickly and significantly (Chau, 2008; Cocca and Alberti, 2010; Robson, 2005). PMS are defined as dynamic and balanced systems, aimed to support the decision-making processes by gathering and evaluating relevant information (Korneta, 2018; Taticchi et al. 2010). The implementation and further using of PMS is not a straightforward task. The organizations willing to implement such system should be prepared to meet and overcome considerable difficulties relating to technical or people related issues (Korneta, 2019). It should be noted that it is widely acknowledged that PMS should be designed for specific organizations with particular attention being paid to their individual strategies (Wouters and Sportel, 2005; Amaratunga et al., 2001; Leandri, 2001). Since, successful PMS cannot be generic but designed for specific organization, the objective of this article is to identify critical areas on which, primary healthcare services providers should focus while designing such systems and to develop a practical framework for primary healthcare services providers. In this paper, it was assumed the number of significant areas of performance measurement should be considerably reduced, so that the proposed concept is practical and straightforward to implement by primary Healthcare services providers (PHSP). The scope of this paper has been limited only to small and medium sized companies, as these companies, conversely to larger ones possess less resources and frequently less experienced management, hence require more attention from scholars. The choice of PHSP in Poland stems from the fact, that to the best knowledge of author, no PMS has already been published for contemplated industry in Poland. Additionally, it should be noted that primary healthcare is subject to many local legal regulations, specific for different countries. Hence the framework suitable for one country might require adjustments to be suitable for another one.

The rest of this paper is organized as follows: in Section 2 a literature review regarding key aspects of performance measurement and management and its recent developments for healthcare industry are being provided. In Section 3 methodological approach, based on 12 semi-structured interviews conducted with industry decision makers, is being described. In Section 4 results obtain from the empirical part are being provided. In section 5 The concept of performance management system for primary healthcare services providers followed by the discussion are being disclosed. The paper ends with discussion, conclusions, managerial implications, limitations of the study and indications for further research.

2. Theoretical background

Performance management has become considerably popular among scholars and practitioners since early 1990s. That popularity was primarily driven by several successful performance management frameworks, which were published at that time. Among these concepts considerably popular were: balanced scorecard (Kaplan and Norton, 1992, pp. 71-79), Sink and Tuttle model (Tangen, 2004, pp. 726-737), performance pyramid (Cross and Lynch, 1988; McNair et al., 1990), Malcolm Baldrige model (Garvin, 1991) and others. Although aforementioned frameworks contributed highly to operations improvement, they were significantly criticised, mostly because they were not properly linked to strategy (Atkinson et al., 1997) and because they ignored significant stakeholders (Nita, 2016). Criticism relating to ignorance of significant stakeholders was were quickly addressed by Neely, who published performance management framework which was utterly focused on various stakeholders – performance prism. This concept begins with identification of significant stakeholders to organization, next aims to address their needs and contribution through proper organization of strategies, processes and possessing adequate capabilities (Neely et al., 2001). Since this concept is profoundly based on stakeholders, performance prism is supposed to be superior to other performance management models at organizations with numerous and powerful stakeholders. Pursuant to Neely et al. other researches begun to include stakeholders at performance management systems. Among modern performance management systems, which include stakeholders, are: Kanji's Business Scorecard (Kanji and Moura, 2002, pp. 21-23), Holistic performance management framework (Andersen et al., 2006), Total Performance Scorecard (Rampersad, 2004) or Flexible strategy game card (Sushil, 2010).

As for performance management systems for healthcare industry, significant work has already been done for hospitals. Weiner et al. (2006) developed hospital-level quality indicators, Curtright et al. (2000) proposed performance measurement system aimed to support the strategy of clinic, Lilford and Pronovost (2010) studied the relationship between mortality rates and the performance of a hospital, Tyagi and Singh (2019) proposed a multi-criteria

decision-making approach for performance management of hospitals, Shiva and Vish (2019) proposed performance measurement system for hospitals.

Considerably less research has already been done relating to performance management at PHSP, with many scholars claiming, yet a lot to be done in this area (Bresick et al. 2019). Rogan and Boaden (2017) postulate the use of principal-agent theory as to understand the relationships underling for performance management in PHSP. Bresick et al. (2019) measured performance of South African primary healthcare providers, from patients and managers perspective. The study used descriptive surveys and concerned mostly quality and operations aspects like accessibility, coordination of information, comprehensiveness and others. Silava and Ferreira (2010) studied performance management systems of public PHSP in Portugal and found these systems are poorly designed, lacked consistence and coherence, which confirms further studies are required.

The study on the perception of the quality attributes in primary health care industry was undertaken by Chmiel M. (2019) , who found that quality plays a predominant role. She also noted the increasing role of functional quality relating to courtesy, politeness, punctuality and other attributes as easier noted by patients than the technical quality based firmly on medical knowledge.

Considerable literature of performance management for primary healthcare is focused on a system level. The most frequently measured areas are: access and timelines, including regular access to PHSP, but also access to after-hours and none face-to-face care and home visits for target populations; integration, understood as information sharing between other health care service providers; efficiency; effectiveness; patient-centeredness; safety; appropriateness of resources and equity (Kates et al. 2012; Haj-Ali and Hutchison, 2017). Noticeably less papers are focused on performance management of PHSP on an entity level.

3. Methodological approach

Given very little attention paid by scholars to performance management of primary healthcare services provides, and because, to the best knowledge of the author, no research has been undertaken in this area in Poland an exploratory, qualitative approach was employed in this study. Qualitative approach is relevant for this study as it allows to focus in depth on issues important to the researcher, is pragmatic, interpretive, and grounded in the experiences of people (Marshal and Rossman, 2011, Lincoln and Guba, 1985).

3.1. Design

This study employs 12 interviews with industry experts possessing significant experience with management of primary healthcare clinics. Structured interviews have not been employed in this paper, as they leave very little room for flexibility and because they are more suitable for larger samples (Fontana and Frey, 1998; Sandy and Dumay, 2011), than the one selected for this study. Unstructured-interviews have not employed either, as to avoid the risk of changing the interviews into informal chats or conversations. Therefore, a semi-structured interviews have been selected for this study, aimed to direct the discussion toward the areas the study should explore, acknowledging however, the key objective of the interview is to access the interviewee perspective. Semi-structured interviews allow, therefore the interviewer to modify the pace, its style, and ordering of questions as to obtain the fullest responses from the interviewee.

The interviews were continued until the information become saturated, defined as no or little new information were obtained in the following interviews (Hennink et al. 2017, Bowen, 2008). The saturation for this study was achieved after 8 interviews.

3.2. Participants

The interviews were carried out with decision makers from primary healthcare services providers industry. The inclusion criteria for the interview comprised at least 5-years of experience on managerial position in a PHSP, which provides services to more than 4 thousand patients and which employs at least 3 general practitioners, of which at least 2 are full-time employed at the clinic. Additionally, representatives from the largest national chains of PHSH has not been invited, since they differ greatly from small and medium size clinics. Table 1, provides a summary of interviewees for this study.

Table 1.
An outlay of interviewees

Position	Location	Description	Managerial experience in the industry
Owner*	Warsaw	A graduate of Warsaw School of Economic, son of a medical doctor. He runs the company in a legal form of sole proprietorship, providing primary healthcare services to around 9 thousand patients. Additionally, his outpatient clinic provides other medical services, both financed by NFZ (National Health Fund) and paid by patients.	25 years
Manager*	Warsaw	She runs an outpatient clinic with primary healthcare (4,5 thousand of patients). PHSP also provides additional services to patients, mostly medical specialties, which however remain secondary to the clinic.	18 years

Cont. table 1.

Manager	Radom	This is her third employment in healthcare industry. Since 5 years she has been a general manager for small limited liability company a PHSP, whose owner operates in restaurant business, appointing her to be fully responsible for the medical business. The company provides services to around 4 thousand patients, which contributes to around half of the company sales revenues. The remaining half of revenues come from medical doctors with specialities.	12 years
Owner	Kielce	A son of medical doctors, who graduated from 2 faculties: management and IT. He run the business as a civil company together with his brother who is a medical doctor, providing medical services within the company. The company provides primary healthcare services to around 5,5 thousand patients. The clinic recognize also considerable revenues from medical specialities.	20 years
Manager*	Warsaw	A graduate of administration. He runs a state owned primary healthcare clinic, providing services to around 8 thousand patients. Additionally the clinic provides, financed by NFZ, the following services: dermatology, laryngology, cardiology, neurology and several minor ones.	23 years
Owner*	Michałowice	She, together with her son runs a major regional primary healthcare clinic in a suburbs of Warsaw for around 5 thousand patients. Additional services comprise gynecology, cardiology and rehabilitation.	20 years
Manager*	Warsaw	He is responsible for the management of 1 major primary healthcare clinic providing services to approximately 7 thousand patients. The clinic is a part of a chain of 7 other clinics, focused primarily in primary healthcare services. Formerly he was a manager at retirement house.	8 years
Manager*	Piaseczno	She has been a manager at PHSP for 6 years, following her promotion from reception of the clinic. The clinic provides services to 8 thousand patients and is one of the most well recognized in Piaseczno. Around 40% of clinic revenues are from rehabilitation services.	6 years
Owner	Grójec	A general practitioner (GP), who following completion of his GP specialty opened a clinic from where he comes from. The clinic provides services to 8,5 thousand patients, employs on a full time 2 others GP and 3 more on an hourly basis. Revenues from other medical specialties are considerably smaller and are fully financed by NFZ (the government).	12 years
Owner*	Warsaw	A general practitioner, former employee of the clinic (since 2004), who together with his wife (a dentist) purchased a clinic 7 years ago. The clinic provides primary healthcare services to around 6 thousand patients. The clinic operates also in dentistry industry.	7 years
Owner	Radom	Former head of orthopaedic surgery ward in the hospital, who quit provision of surgery services and set up 5 years ago his own business based primarily on primary healthcare, orthopaedic, rehabilitation and aesthetics medicine services.	28/5 years
Owner	Kielce	A GP who runs the clinic together with his 2 colleagues other GP's. The company provides primary healthcare services to around 7 thousand patients. Other revenues are insignificant and account for less than 15% of the clinic revenues.	17 ears

3.3. Conducting interviews

The 12 semi-structured interviews were carried out in a period between 7 October 2019 and 10 January 2020 in a PHSP premises. Before the interviews, the respondents were informed in advance, by the phone, the subject of the interview session, so they could prepare better and improve the quality of obtained results. In each of conducted semi-structured interviews the following 4 issues were discussed:

1. Primary healthcare services market description.
2. Strategy and goals of PHSP.
3. PHSP experience with performance management systems.
4. Critical factors for the performance of PHSP.

Many issues mentioned by the interviewees, if recognized relevant to the study, were immediately followed up with the questions, such as: “could you please comment more on...”, resulting frequently in the obligation to go back to the initial question later. The duration of the first three interviews were over 2 hours, while the following ones reduced to almost an hour.

4. Results

4.1. Primary healthcare services market description

In due course of conducted interviews, the following information, regarding considered market, were obtained:

- Sales revenue from PHS have been growing several percent per year. This growth, however is primarily price driven, i.e. NFZ (National Health Fund) 3 times per year increases the fees paid to PHSP, whereas the number of patients is stable.
- Sales margins, calculated as sales revenues less all medical variable costs, as a percentage of sales, ranged between 25% to 50%. These costs include: the salaries of medical doctors and nurses, outsourced examinations like roentgen or blood test and medical materials.
- Start-ups of PHSP in recent years has largely been unsuccessful. PHSP established 10 or more years ago operate well and poses firm positions in the market. Large private chains like Medicover, LuxMed (Bupa Group) or PZU Medycyna, although entered PHSP market poses only an insignificant market share and, at the moment, and are not considered as significant competition.
- There is a great shortage of medical doctors and nurses on Polish market. PHSP experience difficulties with hiring new medical staff.
- The fast development of IT is noticeable. Despite, many PHSP in Poland are small, one location clinics, with limited funds available to be invested in IT, it become no longer

possible to run PHSP without sound IT support. On the one hand it refers to fulfilment of the duties imposed by the NFZ, like electronic receipts, or electronic reporting to NFZ, but on the other, the more patients expect to book a GP (general practitioner) visit online, or to see their results on-line. This shift in patients behaviour is especially noticeable in younger and middle aged patients generations.

- Telemedicine is also very quickly developing. The interviewees stated that for the moment large chains of healthcare service providers are not considered as competition to PHSP, primarily because the patients expect these services to be provided nearby their locations. However, if larger competitors continue with telemedicine development and introduce it to primary healthcare, local PHSP might very quickly lose its proximity advantage and begin to lose their clients to larger competitors who can provide services more quickly and with lower variable costs, on-line.
- The political environment is volatile and unstable. The interviewees recon the risk related to the fact, that the sales revenues from PHS are primarily obtained from only one client – NFZ, and that if an unfavourable law is passed the PHS market might change drastically.

4.2. Strategy and goals of primary healthcare services providers

The goals of the first group of PHSP were focused around the health of the patients: quick provision of primary healthcare services to as much patients as possible, provision of high quality services within primary care, provision of more complex primary healthcare services in cooperation with other specialist clinics. One of the interviewed owners of the clinic highlighted:

I repeat, on a regular basis, to all my employees including mostly none-medical ones, that our mission is “we treat the patient”. Once, it is acknowledge by the whole organization, the satisfaction, growth while the profits just follow.

The second group of interviewees referred to financial results, like the growth of revenues or profits. The final group of interviewees considered sustainability of PHSP as its primary goal. One of the clinic owners stated:

Overall what is important to me, are not profits, which are OK, but the ability of the clinic to be operating in a long run, as it provides primary funds to me and my family. This requires a lot of compromises to medical doctors and nurses, without whom we wouldn't exist.

The strategy of PHSP is mostly un-formal, unstructured and not written. None of the interviewees named any indicator aimed to measure the steps towards PHSP goals achievement, nor the efficiency of the strategy.

4.3. Interviewees experience with performance management systems

In due course of interviews, the following findings were obtained:

- None of the interviewees works with formal performance management system.
- All of the interviewees measure basic financial quantities, like sales, net profitability or indebtedness, sales of auxiliary services, the value assets.
- The interviewees indicated to measure the following non-financial performance indicators for PHSP: number of general practitioners (GP), number of nurses, number of patients per GP, GP working hours, number of patients complaints, number of new patients per month, number of lost patients per month.
- The interviewees pay very limited attention to quality measurement. Despite 4 of the interviewees confirmed to be working with ISO quality standards, they do not analyse on a weekly or monthly basis, quality ratios, only paying some attention to them during ISO audits. Patients waiting time for a visit, although considered as critical, was not formally measured. However, despite that, the interviewees had a general understanding, that majority of patients are admitted to GP within 24 hours, with some patients in some periods waiting even up to 3 days, especially in case of paediatric patients.
- The measurement of long term goals achievement is ignored, although the interviewees have some awareness of actions aimed at a long term.

4.4. Critical factors for PHSP performance

In due course of interweaves the following critical areas for performance of PHSP were identified:

- Relationships with patients – the patients receive free of charge services from PHSP financed by NFZ, who pays to PHSP a fixed fee per patient per month. The fee is not linked to the quality, nor to the number of visits. If the patients are not satisfied with PHSP they can turn to another PHSP, hence their satisfaction is of utmost importance. During the study, waiting time and availability of services emerged as a critical driver of patients satisfaction. The interviewees postulated, waiting time in primary healthcare is superior to medical quality of services. This is primarily because majority of patients require basic but immediate treatments for acute diseases like colds, they need sickness leaves to their jobs, or receipts for medicines. This is just the opposite to specialized medical services, where patients are overall interested in the best possible treatment to their more complicated diseases, ignoring waiting time of several days and accepting waiting time up to even several weeks. One of the interviewees stated: *In my clinic the patients prefer to receive the service immediately, even though provided by not yet specialized doctors, than to wait 2 or 3 days for a professor of medicine. Waiting times is what my patients are primarily interested in.*

Next, the interviewees noted that patients are usually not able to evaluate medical skills of doctors, but very easily they can evaluate their courtesy, culture, punctuality, empathy and abilities to listen and to understand the patient. One of the interviewees raised an example, that in his clinic young medical doctors, due to more enthusiasm and courtesy, however yet without specialties attract more patients, than older doctors with considerably greater experience and approved specialties, but with lower enthusiasm. Satisfied patients, on the one hand stay loyal to PHSP and on the another are eager to buy additional services, vaccinations and so on.

- Relationships with medical doctors and nurses. Given, a great shortage of medical doctors and nurses on the market, these groups of employees can very quickly turn to competitors, if they are not satisfied with PHSP or receive better working conditions from them. One of the clinic owners stated: *the biggest barrier in my business development is the constant lack of experienced medical doctors. Since there are no problems with hiring graduates of medicine, I try to keep the balance between young and mature doctors, asking the latter ones to support their young colleagues.* Additionally, medical doctors and nurses work in the front line of PHSP, hence, their courtesy, politeness and professionalism contribute directly to better patient satisfaction, while their recommendations can support sales of additional services. As a result, it is critical to, on the one hand keep them satisfied and on the another to expect their full contribution.
- Risk management and compliance, mostly with National Health Fund (NFZ) laws. The agreements between PHSP and NFZ requires many details, to be met, which are unfavourable to PSHP. The interviewees provided, inter alia, the following noncompliance examples, from which PHSP can benefit in a short term: (1) provision of services by medical doctors without specialty, although reporting to NFZ the services are being provided by the doctors with specialty; (2) not keeping the location open in certain unfavourable hours, against the agreement, when only few patients arrive; (3) limitation of extra examinations, although medically required, which costs cannot be additionally reimbursed on NFZ (all in fixed fee rule); (4) nurses without required by laws certificates (courses) providing vaccinations to patients; Although stated examples of noncompliance would significantly reduce operating costs, they are not allowed under the contract with NFZ. The loss of a contract or penalties for not proper agreement execution might result in loss of going concern of PHSP. One of the clinic owners stated: *it is very easy to improve quickly the profitability of the clinic ignoring contractual liabilities to NFZ. However, than it is only a matter of time, when NFZ notice, which might led to breaking of the contract.* PSHP might be also tempted by other risky or unlawful actions like: (5) mixing medical with office garbage as to reduce costs; (6) risky savings on hygienic and antiseptic materials and others, which again, would improve profits in short term, but in a long one result in too much risk on PHSP.

- Operations management. PHSP receive the most significant part of its remuneration per patient per month. This remuneration is not linked to number of services, quality of medical doctors, value of outsourced examinations, which must be financed by PHSP. Lack of direct connection between costs and salaries triggers the need to manage the processes properly. Operations can be managed and improved in every level of PHSP operations, including the followings: (1) matching doctors working hours with the needs of patients, (2) deciding on the right mix of specialists (paediatricians, family doctors, internal medicine doctors, with or without specialty), (3) arranging logistics of medical examinations, (4) outsourcing or keeping inside the house head office services (bookkeeping, helpdesk, payroll), (5) management of patients admissions (6) and home visits if necessary; (7) deciding on medical approach towards treatment of patients (frequency of examinations, recommendation of vaccinations) Ensuring efficiency and effectiveness, although highly important is not a straight forward task for PHSP.
- Sales of additional services – despite PHSP are fully financed by NFZ, all of the interviewees provide additional not free of charge services to their patients. These services comprise: vaccinations, consultation with specialists, extra examinations and others. One of the interviewees combines successfully PHS with stomatology. Such additional services, provide extra surplus and improve the overall profitability of the clinic.
- Finally, the interviewees stated long-term initiatives, although receive very little attention should not be ignored. Among the options discussed were: (1) development of telemedicine; (2) investment in IT systems; (3) acquisition of medical graduates; (4) training of medical doctors and nurses; (5) looking for and entering into alliances with either other PSHP or specialist clinics.

5. The concept of performance management system for primary healthcare service providers. Discussion

As identified at the beginning of the study the experience of industry representatives with performance measurement and management systems is very limited. This is primarily because, PHSP are mostly small clinics, run frequently by medical doctors, who are focused on medicine and lack solid management background. This particular finding, confirms the result of this study might be interesting to decision makers and so have practical implications.

In the beginning of the study, it was assumed, that identified critical areas for performance measurement and management should be only several, so that the proposed concept is practical and straight forward to implement by the primary healthcare clinics. In due course of undertaken research the following areas have been identified as critical for successful

performance management of PHSP: (1) stakeholders relationship management; (2) operations management; (3) risk and compliance and (4) development. The interactions between these 4 areas can be well fitted with the concept rooted in stakeholders theory, and focused on 3 stated primary healthcare services areas, as disclosed in Figure 1.

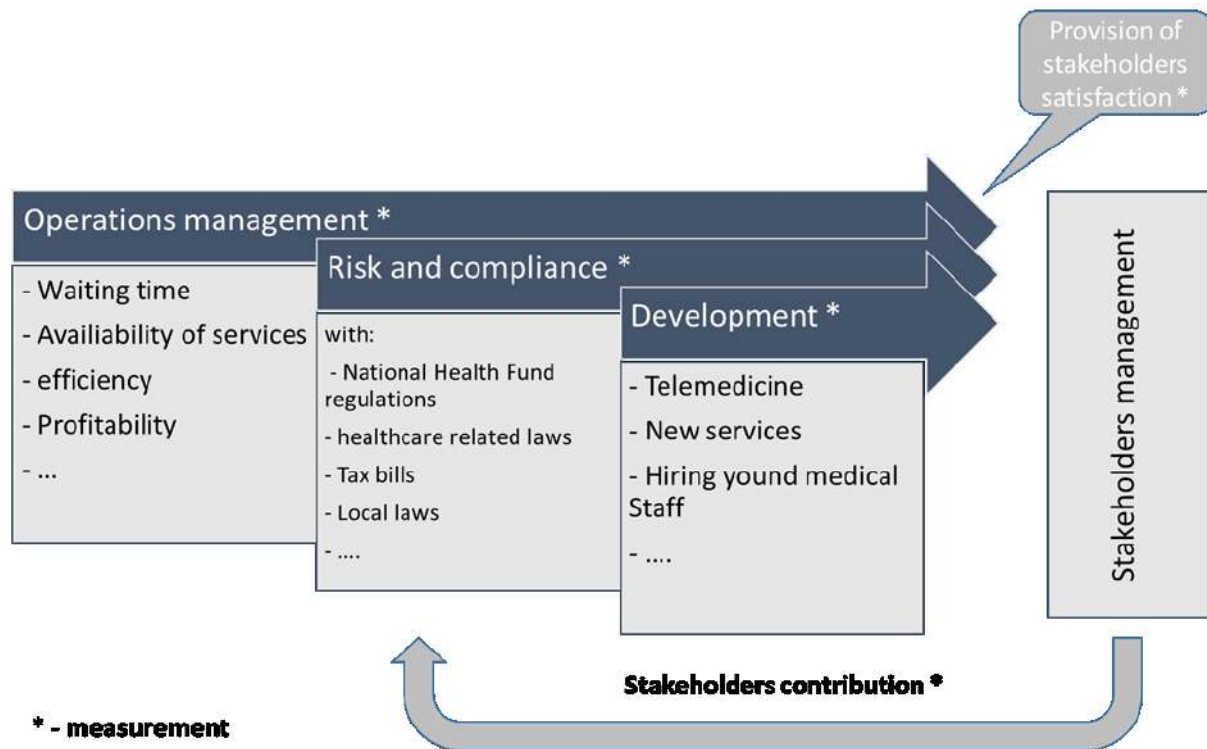


Figure 1. Performance management system for primary healthcare services providers.

As presented in Figure 1, PHSP receive contribution from stakeholders, in exchange for satisfaction, which they are obligated to deliver them in exchange. The aforementioned model proposes to provide satisfaction to stakeholders through (1) adequate operations management, (2) compliance with binding laws and regulations and (3) taking care of development activities. This concept echoes performance prism, proposed by Neely et al. (2001), with adjustments aimed to reflect the specific primary healthcare industry.

5.1. Stakeholders relationship management

The results obtained in this study indicate the adequate relationship management with stakeholders is an important determinant for successful performance management of PHSP. During the interviews 4 significant stakeholders have been identified: (1) medical doctors, (2) auxiliary medical personnel, comprising nurses and midwives (3) patients and (4) the stockholders (the owners of clinics) whose satisfaction and contribution should be measured and next managed. Additionally, the fifth very significant stakeholder – the National Health Fund (NFZ) has been identified, whose satisfaction should be measured. However, since NFZ is a remote stakeholder, whose contribution cannot be managed, we propose to analyze it in the next (risk and compliance) section of our concept. The results obtained in interviews regarding shortages of medical doctors and auxiliary personnel are aligned to findings presented by other

researchers: Haczyński J., Buraczyńska M. and Borkowska I. Given the key role of these stakeholders at primary healthcare, the measurement of their satisfaction is critical for sustainability of PHSP. The satisfaction of these stakeholders can be measured, for instance, with personnel rotation ratios, satisfaction surveys, ratios comparing their salaries as compared to the market or to prior years, development possibilities, including trainings received, or possibilities of discussion with specialists and other benefits. Their contribution can be measured with technical quality ratios resulting from medical knowledge (number of doctors with specialties, scientific degrees, courses and others), functional quality quantities, obtained from surveys: courtesy, politeness, punctuality, empathy and others; availability ratios; flexibility; readiness to provide auxiliary services or to work in overtime.

The following group of significant stakeholders, whose satisfaction and contribution should be measured are the patients. The results of this study indicate patients are overall interested in waiting time and availability of services. Next, the patients are interested in the quality understood more in a functional than in a technical way. The measurement of quality for patients is the same as described above, once the contribution of doctors was discussed. The findings of this study endorse therefore what has already been postulated by Chmiel M. (2019). Contribution of the patients can be measured with various patients rotation ratios, including new patients, lost patients, rotation of patients, additional services bought by patients and others.

Stockholders are always significant to the company. In PHSP the stockholders are frequently key medical doctors in the clinic, combining both functions. Their satisfaction should be measured with financial ratios, which reflect the growth of the value of the clinic. The contribution of stockholders can be measure with dividends withdrawn, the time spent in clinic or others.

5.2. Risk and compliance

Compliance area steams primarily from contracts with NFZ, which finances the vast majority of PHSP activities. NFZ pays PHSP a fixed monthly fee per patient, which is around 8 EUR, no matter how often a patient requires primary healthcare treatment. Stated fee, should also cover several basic treatments, like blood tests, USG or roentgen. As already indicated, NFZ is another significant stakeholder, however, conversely to others, we propose only to measure its satisfaction and not to measure its contribution. This is because the contribution of NFZ cannot be managed. As indicated in interviews, PHSP have many occasions and incentives not to comply with stated agreement, which is very detailed, and comprise many unfavorable points for PSHP. The none compliance comprise for instance not keeping the location open in agreed timeliness, or though providing services via medical doctors without specialties, although stated in the contract the opposite, and so on. NFZ is a government body which finance nearly all primary healthcare services in Poland. Although failure to comply with NFZ liabilities

might improve the profitability of a clinic in a short term, it puts a very high risk on the clinic. The none compliance with NFZ liabilities might result in a loss of a contract or significant penalties. Such loss practically means a loss of a going concern to PHSP, as practically, there are no other ways to obtain the funds for further operations.

The compliance should not be limited only to NFZ contracts. Provision of healthcare services is highly related to other considerable risks, which also should be decreased and managed. These risk might result from wrong medical treatment of patients, which might lose their health or lives, not paying enough attention to protection of PHSP employees (savings on antiseptics) and so on. Additionally to above, local laws, including tax ones should also be addressed properly.

5.3. Operations management

The importance of managing performance in the area of operations, results primarily from the fact that PHSP are paid per patient and not per quality or a number of services provided. Additionally, under the agreement with NFZ, PHSP must provide services in constant hours, while the patients prefer to visit doctors in certain hours than the others. The managers, or the owners of PHSP must therefore manage the operations carefully, especially as their cost are high. Finding the proper balance between providing satisfactory services to patients and keeping costs under control, through employment of the right mix of specialists not only during the day but also through the whole year, as this business is subject to high seasonality, is a challenge.

5.4. Development

Finally, PHSP should pay some attention to the performance management of future operations, undertaking initiatives aimed to benefit the companies in a long term. Although, for the moment PHSP are profitable organizations, with high sales margins, their future is not so obvious. Good profitability of PHSP results from niches they currently operate in. The most important factor for patients when they chose PHSP are: their proximity, availability of services and waiting times. Once the telemedicine develops, PHSP might lose the patients to larger competitors, who would provide primary healthcare services on-line, which are more quickly accessible than site visits. Although the answer to that challenge is not straightforward, PHSP should try approach this issue before is literally too late, and therefore should not ignore their development aimed to adjust them to changing environment.

6. Conclusions

The vast majority of primary healthcare services providers in Poland are small and medium sized clinics with limited performance management experience. We consider reduction of numerous challenges surrounding primary healthcare services providers to a 3 variables model, based on deep understanding of significant stakeholders, could become, due to its simplicity, a useful tool for decision makers. Stated 3 recommended areas for performance measurement and management namely are: (1) operations management, (2) risk and compliance and (3) development. Proposed concept is firmly rooted in a stakeholder theory and assumes 3 aforementioned areas should deliver satisfaction to the significant stakeholders, identified in empirical part of the study. These stakeholders are: patients, medical doctors, nurses and midwives, stockholders and the National Healthcare Fund. The concept assumes also measurement of significant stakeholders contribution. Given considerable shortages of medical doctors and auxiliary medical personnel, including nurses and midwives and their roles at the clinics, failure to address these stakeholders properly would result in considerable underperformance of the clinic. Their satisfaction can be measured with satisfaction surveys, salaries as compared to the market, development possibilities and rotations. Their contribution can be measured with quality ratios, both technical resulting from medical knowledge and functional comprising: courtesy, politeness and others; personnel availability ratios; flexibility; readiness to provide auxiliary services and others. Satisfaction of patients, is a prerequisite for their loyalty and sales of auxiliary services.

The first of identified critical areas for performance of primary healthcare services providers are operations, which if not managed properly can lead to many inefficiencies, not satisfaction of stakeholders and loss of profits. Operations are expensive (time of medical staff) and are not linked directly to sales revenues, which depend on the number of patients, not the number of services the patients receive. Such inconsistency puts a considerable risk on the clinics.

The second area that requires performance management is the risk management and compliance. This is due to the fact that primary healthcare is highly regulated by laws and agreements with National Healthcare Fund. Noncompliance with the latter can improve the profitability of primary healthcare services providers in a short term, triggers greater risk levels. This may eventually led to a loss of a contract or considerable penalties. Give National Healthcare Fund is the principal founder of primary healthcare services, loss of such a contract could result in a loss of going concern of the clinic. Risk management is also very important, which is due to the considerable threats resulting from the medical process itself and the environments in which the clinics operate.

Finally, primary healthcare services providers should also focus on development area. Despite, the clinics consider themselves to be operating in niche markets, resulting from their proximity to patients and availability of services, a proper attention should be paid to the future.

Quickly developing IT solution and telemedicine, can in a few years change the habits of patients and so change the structure of primary health care services market.

This paper has several limitations. Firstly, only primary healthcare service providers from Polish market has been studied. Secondly, the sample for this study has been reduced only to small outpatient clinics. This however, has been done deliberately. According to the author selected to the study companies require more attention from the researches, as are more numerous and poses less resources than larger companies. Also, because of the specific, for each country national laws relating to financing of primary health care, the scope of the study has been narrowed only to the Polish market. Because of these limitations, the results obtained in this study might not be suitable for wider generalizations.

Aforementioned limitations are a good direction for a further research. Additionally, in this study a great uncertainty about the future of Polish primary health care service providers has been identified. Stated uncertainty stems from IT changes in the environment, which combined with larger multinational companies healthcare companies development, which are already present in Poland, might reshape studied market in near future. Further study of potential market development could be very interesting from both scientific and decision makers point of view.

References

1. Amaratunga, D., Baldry, D., and Sarshar, M. (2001). Process improvement through performance measurement: the balanced scorecard methodology. *Work Study*, Vol. 50, No. 5, pp. 179-188.
2. Andersen, B., Henriksen, B., and Aarseth, W. (2006). Holistic performance management: an integrated framework. *International Journal of Productivity and Performance Management*, Vol. 55, No. 1, pp. 61-78.
3. Atkinson, A.A., Banker, R.D., Kaplan, R.S., and Young, S.M. (1997). *Management Accounting*, NJ: Prentice Hall.
4. Borkowska, I. (2018). Evaluation of Public Health Care Condition in Poland. *Studia i Prace Kolegium Zarządzania i Finansów*, Vol. 165, No. 1.
5. Bowen, G. (2008). Naturalistic inquiry and the saturation concept: A research note. *Qualitative Research*, Vol. 8, pp. 137-152.
6. Bresick, G., Christians, F., Makwero, M. et al. (2019). Primary health care performance: a scoping review of the current state of measurement in Africa. *BMJ Global Health*; 4:e001496. <http://dx.doi.org/10.1136/bmjgh-2019-001496>.
7. Chau, V.S. (2008). The relationship of strategic performance management to team strategy, company performance and organizational effectiveness. *Team Performance Management*, Vol. 14, No. 3/4, pp. 113-117.

8. Chmiel, M. (2019). Quality Attributes of Primary Health Care Services. *Scientific Papers of Silesian University of Technology. Organization and Management, Vol. 134*, pp. 7-16. <http://dx.doi.org/10.29119/1641-3466.2019.134.1>.
9. Cocca, P., Alberti, M. (2010). A framework to assess performance measurement in SMEs. *International Journal of Productivity and Performance Management, Vol. 59, No. 2*, pp. 186-200.
10. Cross, K.F., and Lynch, R.L. (1988). The SMART way to define and sustain success. *National Productivity Review, Vol. 8, No 1*.
11. Curtright, J.W., Stolp-Smith, S.C., Edell, E.S. (2000). Strategic performance management: Development of a performance measurement system at the Mayo Clinic. *Journal of Healthcare Management, Vol. 45, No. 1*, pp. 58-68
12. Fontana, A., and Frey, J.H. (1998). Interviewing, the art of science. In: N.K. Denzin, and Y.S. Lincoln (Eds.), *Collecting and Interpreting Qualitative Materials*. Thousand Oaks, CA: Sage.
13. Garvin, D.A. (1991). How the Baldrige Award Really Works. *Harvard Business Review, November/December*.
14. Haczyński, J., and Buraczyńska, M. (2018). Emigration of Polish Nurses – Reality and Consequences. *Management Issues, Vol. 16, No. 5*, pp. 77-89.
15. Haczyński, J., Ryć, K., Skrzypczak, Z., and Suchecka, J. (2017). Physician Resources in the Health System – Comparison of Poland and Selected European Countries. *Management Issues, Vol. 69, No. 3/1*.
16. Haj-Ali, W., and Hutchison, B. (2017). Establishing a Primary Care Performance Measurement Framework for Ontario. *Healthcare Policy, Vol. 12, No. 3*, pp. 66-79.
17. Hennink, M.M., Kaiser, B.N., Marconi, V.C. (2017). Code Saturation Versus Meaning Saturation: How Many Interviews Are Enough? *Qualitative Health Research, Vol. 27, No. 4*, pp. 591-608.
18. Kanji, G., and Moura, P. (2002). Kanji's Business Scorecard. *Total Quality Management, Vol. 13, No. 1*, pp. 13-27.
19. Kaplan, R.S., and Norton, D.P. (1992). The balanced scorecard – measures that drive performance. *Harvard Business Review, January/February*.
20. Kates, N., Hutchison, B., O'Brien, P., Fraser, B., Wheeler, S. and Chapman, C. (2012). Framework for Advancing Improvement in Primary Care. *Healthcare Papers, Vol. 12, No. 2*, pp. 8-21.
21. Korczak, K., and Karlińska, M. (2018). The Use of Telemedicine among Polish Healthcare Providers. *Roczniki Kolegium Analiz Ekonomicznych, Vol. 52*, pp. 59-70.
22. Korneta, P. (2018). The Concept of Performance Measurement and Management System for Small and Medium Size Polish Healthcare Services Providers. *Przedsiębiorczość i Zarządzanie, Vol. 19, No. 12/1*, pp. 211-222.

23. Korneta, P. (2019). Challenges of Performance Management Systems Implementations. Case Study. *Przegląd Organizacji*, Vol. 10, pp. 24-31.
24. Kwiatkowska, E.M., and Skórzewska-Amberg, M. (2019). Digitalisation of Healthcare and the Problem of Digital Exclusion. *Journal of Management and Business Administration. Central Europe*, Vol. 27, No. 2, pp. 48-63.
25. Leandri, S.J. (2001). Measures that matter: how to fine-tune your performance measures. *Journal for Quality and Participation*, Spring, pp. 39-41.
26. Lilford, R, Pronovost, P. (2010). Using hospital mortality rates to judge hospital performance: A bad idea that just won't go away. *British Medical Journal*, Vol. 340.
27. Lincoln, Y.S., and Guba, E.G. (1985). *Naturalistic inquiry*. Sage.
28. Marshal, C., and Rossman, G.B. (2011). *Designing qualitative research (5th ed.)*. Sage.
29. McNair, C.J., Lynch, R.L., and Cross, K.F. (1990). Do financial and nonfinancial performance measures have to agree? *Management Accounting Review*, Vol. 75, No. 5.
30. Neely, A., Adams, C., and Crowe, P. (2001). The performance prism in practice. *Measuring Business Excellence*, Vol. 5, No. 2.
31. Nita, B. (2016). Krytyka zrównoważonej karty wyników. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, Vol. 442.
32. Rampersad, H.K. (2004). *Kompleksowa karta wyników. Jak przekształcać zarządzanie, aby postępując uczciwie osiągać doskonałe wyniki*. Warszawa: Placet.
33. Robson, I. (2005). Implementing a performance measurement system capable of creating a culture of high performance. *International Journal of Productivity and Performance Management*, Vol. 54, No. 2.
34. Rogan, L., Boaden, R. (2017). Developing a new clinical governance framework for chronic diseases in primary care: an umbrella review. *International Journal of Health Care Quality Assurance*, Vol. 30, No. 1, pp. 4-15.
35. Sandy, Q. Qu, John Dumay, (2011). The qualitative research interview. *Qualitative Research in Accounting and Management*, Vol. 8, No. 3, pp. 238-264.
36. Shiva, R.A., and Vishnu, P.S. (2019). Measuring hospitals performance: Applying the management approach in Nepal. *International Journal of Healthcare Management*, Vol. 12, No. 4, pp. 292-301.
37. Silva, P., Ferreira, A. (2010). Performance management in primary healthcare services: evidence from a field study. *Qualitative Research in Accounting & Management*, Vol. 7, No. 4, pp. 424-449.
38. Starfield, B., SHI, L., Macinko, J. (2005). Contribution of Primary Care to Health Systems and Health. *Milbank Quarterly*, Vol. 83, No. 3, pp. 457-502.
39. Sushil (2010). Flexible Strategy Game-card. *Global Journal of Flexible Systems Management*, Vol. 11, No. 1/2.
40. Tangen, S. (2004). Performance measurement: from philosophy to practice. *International Journal of Productivity and Performance Management*, Vol. 53, No. 8, pp. 726-737.

41. Taticchi, P., Tonelli, F., Cagnazzo, L. (2010). Performance measurement and management: a literature review and a research agenda. *Measuring Business Excellence*, Vol. 14, No. 1.
42. Tyagi, A., and Singh, P. (2019). Hospital performance management: A multi-criteria decision-making approach. *International Journal of Healthcare Management*, Vol. 12, No. 4, pp. 286-291.
43. Weiner, B.J., Alexander, J.A., Shortell, S.M. et al. (2006). Quality improvement implementation and hospital performance on quality indicators. *Medical Care Research and Review*, Vol. 63, No. 1, pp. 29-57. <https://doi.org/10.1177/1077558705283122>.
44. Wouters, M. Sportel, M. (2005). The role of existing measures in developing and implementing performance measurement systems. *International Journal of Operations and Production Management*, Vol. 25, No. 11, pp. 1062-82.

SLEEP DEFICIT AND MANAGERS' FUNCTIONING IN STRESSFUL SITUATIONS

Magdalena KRACZLA

Akademia Wyższej Szkoły Biznesu, Dąbrowa Górnicza; magda.kraczla@wp.pl, ORCID: 0000-0002-9382-4249

Purpose: The aim of the article is to present the relationship between the daily sleep index of managers and their behaviour in stressful situations.

Design/methodology/approach: The article presents an overview of the determinants that influence how people in managerial positions choose to deal with stressful situations, a subject well described in psychological literature. This choice is determined by requirements and organizational context and is developed based on one's personal experience. This personal propensity should also be considered in the context of sleep deficit, which is not uncommon in today's organisational cultures as lack of sleep for the sake of increased managerial engagement and activity is not only quite commonplace, but is often glorified as a strategy.

Findings: The considerations presented in the article indicate that sleep, as an individual resource of every manager, creates the space that is needed for the implementation of appropriate strategies for coping with stress in the workplace.

Research limitations/implications: It is worth performing more research on larger sample groups, who would be differentiated according to organizational level and the decision-making independence of the managers being surveyed.

Practical implications: As identified by the research presented here, understanding the relationship between sleep deficit and the behaviour of managers in situations of emotional stress could help to create future working conditions that are beneficial for people's mental well-being and eliminating the consequences of sleep deficit, which can be dangerous for both individuals and their organisations.

Social implications: If organisations factored sleep, understood as the 'right to get enough sleep', into the well-being criteria for the benefit of their workforce, including their managers, this could help them in their focus on health as a responsibility they are accountable for in business.

Originality/value: The article determined the psycho-physical consequences of sleep deprivation as experienced by contemporary managers and the impact of sleep deficit on their behaviour in stressful circumstances. It has been shown that sleep, as a pivotal element contributing to 'health and energy', is a key competence resource of every manager.

Keywords: stress, strategies of coping with stress, sleep, sleep deficit, manager.

Category of the paper: review, article.

1. Introduction

It is very common for managers in contemporary organizations to find themselves in many stressful situations. Every time they face stressful factors, managers have to choose an appropriate strategy to maintain their own and their subordinates' effectiveness (Kraczla, 2016). When looked at from this perspective, managers' behaviour may be the subject of extensive analyses that take many factors and mechanisms into account. One component that contributes to managers' efficiency is their average daily sleep time. This perspective emphasizes the importance of sleep for the choices and decisions made by managers, who experience a lot of pressure in relation to their managerial roles.

The aim of this article is to reveal the importance of daily sleep deficiency and the impact of chronic sleep deprivation on the choices managers make while coping with stress. The cultures adopted by numerous contemporary organizations approve of sleep deprivation as a way towards faster and greater success. As a result, managers struggling with drowsiness have to do their best to maintain the highest possible level of efficiency while fulfilling their managerial duties. Thus, it is fascinating to study the working style of managers who operate under emotional pressure and are affected by lack of sleep.

2. Strategies of coping with stress

Research into stress is subject of numerous investigations in both popular and pure science. As regards the latter, stress studies are undertaken in different scientific disciplines, including psychology, sociology, anthropology, or widely understood medical science. These diverse and multi-dimensional scientific considerations produce a multitude of definitions of stress and a number of varied guidelines on how to cope with its effects.

According to an encyclopaedia definition, the term stress means "the state of overload of one's psychological regulation system that arises in stressful situations and can hinder or make it impossible to achieve goals, fulfil tasks, or uphold the values that are important for an individual" (PWN Encyclopaedia, 1997). Most reputable researchers describe the phenomenon of stress as something that occurs when the challenges posed by external circumstances exceed one's ability to cope with them (Wheeler, 2011).

Stress appears in various areas of human life and functioning; it comes from various sources and takes on various dimensions and degrees of intensity. Thus, people have to struggle constantly with the necessity to adapt to different pressures and employ the whole range of their personal abilities to cope with stressful factors (Kabat-Zinn, 2012).

Having reviewed the research into the phenomenon of stress, it can be concluded that it is an integral part of human life and affects every area of human functioning. Every time stress occurs, it requires a given individual to trigger an adaptive response so they can "find themselves" in a stressful situation (Strycharczyk, and Clough, 2018).

Since this article is focused predominantly on stress in managers' work, its considerations will remain centred solely around occupational stress.

It is easy to notice that professional work evokes a wide range of positive and negative emotions. Work enables people to satisfy many important needs, such as a sense of security, a sense of belonging to a group, or material and living needs (Ogińska-Bulik, 2006). Work can also enable one to develop personally and it contributes to one's health and sense of satisfaction (Bańka, 2001). At the highest level of one's self-fulfilment, work can also "make life meaningful and coherent" (Kabat-Zinn, 2012).

At the same time, however, professional work may create space for pathogenetic factors that exacerbate human concerns, emotional tension, psychosomatic diseases, and disorders in social and family life (Bańka, 2001).

At every level of an organization and regardless of the job position, one can experience a sense of threat, frustration or failure at work (Kabat-Zinn, 2012). The fact is, however, that one of the most emotionally burdensome professions is the position of a manager as this is associated with so-called "bipartite agency". Many authors indicate that **what generates significant stress in managerial roles is a manager's responsibility for their subordinates** (cf. Hallowell, 2011; Poczowski, 2003; Schultz, D., and Schultz, S., 2006). According to Biela (2001), the concept of the bipartite agency of work suggests that a manager feels the need for agency and seeks to satisfy it while at the same time remaining responsible for creating conditions to satisfy their employees' sense of agency. Therefore, holding a managerial position involves shaping the conditions for one's own agency whilst also providing agency for one's subordinates. This is what creates "bipartite agency" for managerial roles. When understood in this way, agency makes it possible to treat subordinates in a humane and empathetic manner, and the sense of agency is highly correlated with the work effectiveness of employee teams (Biela, 2001). Therefore, it is important that managers are aware of their employees' expectations, individual needs, as well as their concerns and anxieties. "Not only must they be able to control their own stress, but they also need to help their co-workers overcome their stress, which might not always be fully justified ..." (Penc, 2000).

The multiplicity of stressful stimuli experienced by managers with regard to the various limitations and requirements posed by demanding work environments results in the more frequent perception of stress as a difficult and negative phenomenon, although it does sometimes have positive effects (Hellriegel, Slocum, and Woodman, 1995).

When faced with stressful factors which are a source of internal tension and strong emotions, managers look for effective methods to maintain their managerial efficiency and the effectiveness of their own and their subordinate team's functioning (Kraczla, 2016).

Research into organizational stress was initiated by R.L. Kahn and his research team; this was also the beginning of the tradition of investigating occupational stress (Khan et al., 1964). Many of these interesting research findings and identified dependencies have been reflected in the pragmatics of business, for instance as rules and guidelines for dealing with stress at work. One of the most interesting of these observations was that *stress related to challenges* in the work environment (i.e., a large number of tasks and projects to be implemented) affects an employee in a different way than *stress related to obstacles* (i.e. bureaucracy, unclear division of duties or responsibilities, intrigue in their organization). It has been shown that **stress related to obstacles is much more burdensome than stress related to challenges** (Robbins, and Judge, 2012). It is worth noting that the contemporary pace of life has been increasing for many years, therefore the pressures on managers and their subordinates mean it is important to identify factors and methods that would stabilize workplaces and balance positive and negative feelings related to occupational functions and work environments.

Worryingly, the findings of studies carried out in this area lead to justified anxiety as **occupational stress is not only a very common phenomenon but its levels are also constantly growing and becoming alarmingly intense**. It has been shown that in the last few decades the level of occupational stress has increased, especially in highly industrialized countries. This has resulted in a sharp increase in sickness absenteeism rates and the more frequently identified inability to work as a result of stress. The World Health Organization reports that nearly half of professionally active people feel unhappy in their workplace (cf. Białek, 2012; Bartkowiak, 2009; Le Blanc, de Longe, and Schaufeli, 2002; Kabat-Zinn, 2012; Ogińska-Bulik, 2006).

It is worth noting that stress in many professions seems to be inevitable and is often part of the culture or environment in which a given organization operates. In such circumstances, it is necessary to identify stress factors and then develop and implement strategies and mechanisms for coping with these stressful conditions in organizations. As a result, members of the organization will be able to carry out their tasks, achieve their goals, and minimize the damage that results from being in stressful situations (Strycharczyk, and Clough, 2018).

Therefore, it is now a challenge to develop strategies for dealing with stress which would be adequate and applicable in contemporary organizations, where stress is common due to the unstable and volatile conditions in which managers work.

From the psychological point of view, it is necessary to analyse **the activities undertaken by an individual** in stressful situations which might often exceed their adaptability. Stressful situations stimulate people to take action (based on their internal resources and external circumstances) in order to restore their balance and improve their emotional state (Bartkowiak, 2009). These types of activities are referred to in science as *ways of coping with stress* (Strelau, 2007).

The concept of **coping with stress** was coined by science in the 1960s; it may be understood as the basic adaptive mechanism associated with making a conscious effort to restore balance in oneself. Therefore, this mechanism plays the role of a regulator between one's aims and one's abilities (Ogińska-Bulik, 2006).

Stress coping strategies are aimed at dealing with the threat that arises from a stressful situation (Bartkowiak, 2009). These are the actions which an individual takes at the level of their cognitive, emotional and behavioural functioning; they are a response to existing internal or external needs (Terelak, 2004). At the same time, the choice of a particular method of coping with stress is always determined by the characteristics of the situation itself, the individual characteristics of the given person, and the state of their personal resources (Ogińska-Bulik, and Juczyński, 2008).

The literature on this subject describes many models of coping with stress. Prominent researchers of this phenomenon, R.S. Lazarus and S. Folkman, distinguished two basic functions of coping with stress: **instrumental** and **regulatory**. Having combined these functions with how people act under stress, they distinguished two main strategies of coping with stress (Lazrus, and Folkman, 1984):

1. Problem-focused strategy – instrumental function.
2. Emotion-focused strategy – regulatory function.

As part of their problem-solving strategy, an individual strives to remove the existing stressor by undertaking their own activities, such as developing an action plan, looking for alternative solutions, or limiting competitive activities. As regards the emotion regulation strategy, people take steps that aim to deal with the experienced emotional burden. These could be, for instance, a rationalization mechanism, attempts to adapt to the problem, distancing oneself, acceptance of the situation, flight reactions, a denial mechanism, a repression mechanism, taking responsibility, or self-blame. Both types of strategies are often used simultaneously and the extent of their use depends on the individual characteristics of a given person. Flexibility in using the aforementioned strategies and their skilful application determine one's ability to overcome existing difficulties and the pace of one's return to a state of equilibrium (cf. Kraczla, 2013b).

The analyses performed by R.S. Lazarus and S. Folkman are continued in the concept developed by N.S. Endler and D.A. Parker, who describe three **styles of coping with stress** (1990). Two of the styles they indicate correspond to the functions described by R.S. Lazarus and S. Folkman: the **task-orientated** style and the **emotion-oriented** style. N.S. Endler and D.A. Parker define the third style as **avoidance-oriented**. In this way, the authors emphasize the variety of actions taken by people acting under stress (Endler, and Parker, 1990).

When analysing stress in the context of professional work, it can be concluded that managing stress in an organization requires many coordinated actions at both the individual and organizational level (Terelak, 2004). Individuals are expected to increase the degree of their resistance to stress, find a balance between their private and professional life and choose

appropriate action strategies in stressful situations (Pocztowski, 2003). The goal of stress coping strategies is to increase awareness of the phenomenon of stress itself as well as its symptoms, effects, and possible forms of counteracting it (Le Blanc, de Longe, and Schaufeli, 2002). However, the variety of stressful situations and their varied dynamics make it necessary to assume that the exact type of coping strategy adopted by a given person in stressful circumstances will be based on multidimensional conditions, and the process of coping with stress itself can be treated as "a series of strategies that change over time and are connected with changes in the situation and the psychophysical state of the given individual" (Wrześniewski, 2000). Therefore, it seems that the effects of coping with a stressful situation depend on the individual characteristics of a person, the type and dynamics of the stressful situation, and the support available from the organization (Kraczla, 2016).

3. Sleep deficit and its consequences

In the second half of the twentieth century, the average total amount of sleep people got per day decreased by over two hours. The common daily sleep norm of many contemporary people is only 5-6 hours, and a constant feeling of permanent fatigue and lack of sleep accompanies millions of people around the world. Sleep deprivation is such a severe condition that it has been used as an effective torture method throughout history. One of the antidotes to sleep deprivation that is proposed by modern Western medicine is various kinds of sleeping pills (Winters, and Kelley, 2018). Many people regularly turn to them even though their constant use for two and a half years can cause a fivefold increase in the risk of cancer and death (Kripke, Langer, and Kline, 2012).

Based on the findings of numerous studies, it may be concluded that adults need at least eight hours of sleep a day, whereas children need twelve hours. It is during sleep that many important processes take place in the human body, including growth, tissue reconstruction, hormonal reactions, regeneration of hormonal connections and strengthening of the immune system. Sleep is also of great importance to the body's response to insulin. Sleep deficiency causes a deficit of many hormones important for the body, e.g. satiety hormone (leptin), or increased levels of other hormones, e.g. the hunger hormone (ghrelin). Lack of sleep stimulates appetite, thus leading to weight gain and widespread obesity in modern societies. Additionally, ghrelin (a hormone) is also responsible for the development of neoplastic conditions and the invasiveness and migration of neoplastic cells (Chopin et al., 2011).

Health and the psychophysical condition of contemporary people are closely dependent on sufficient or insufficient amounts of sleep. Many modern diseases, referred to as civilization diseases, such as allergies, asthma, hormonal disorders, digestive problems, rheumatoid arthritis or chronic pain, are undoubtedly associated with insomnia and sleep deficits (Kripke, Langer,

and Kline, 2012). What is more, psychiatrists have long emphasized the coexistence of sleep disorders and mental diseases. However, it was believed that it was mental illnesses that caused sleep disorders, and this conviction assumed a one-way causality of this relationship. Meanwhile, many studies have shown the opposite: sleep-deprived people demonstrate neurological patterns of brain activity similar to those seen in numerous mental illnesses (Walker, 2019). Other studies have also shown that by improving the quantity and quality of sleep, one can reduce the risk of developing certain mental health conditions or at least delay their development. This kind of dependency has been identified in relation to Alzheimer's disease or bipolar disorder (cf. Ancoli-Israel et al., 2008; Moraes et al., 2006).

One brain function that can be easily affected by even the slightest disruption of the amount of sleep per night is attention span. As a consequence of insufficient sleep, it is difficult for the human brain to focus attention on activities during the day. Lapses of attention may also occur during so-called microsleep, which occurs when the brain stops perceiving the outside world for a short while. Such a temporary drop in attention span happens for only a few seconds, but it often affects people who chronically feel drowsy. The most tragic manifestation of impaired attention might be unexpected and uncontrolled falling asleep while driving a car or operating specialist devices or machinery (Walker, 2019).

D. Dinges and his team from the University of Pennsylvania (Dinges, 1995; Banks, and Dinges, 2007) compared the stimuli response time of well-rested people and people who were deprived of sufficient sleep. First, all the participants were given the opportunity to get eight hours of sleep per night, which made it possible to assess their reaction times when fully rested. Then, they were divided into four groups and each of them was "administered" a different amount of sleep. The first group was kept awake for 72 hours, i.e. for three consecutive nights. The second group slept four hours per day for three consecutive nights. The third group slept six hours each night, and the fourth group were allowed eight hours of sleep. During this experiment, the researchers observed that people deprived of sleep demonstrated slower stimuli reaction times and slowness, which is typical of sleepiness. The most important thing they noticed, however, was gaps in consciousness called microsleeps, when the sleep-deprived participants' attention would lapse for several seconds. People who were deprived of sleep for 72 hours experienced the most drastic impairment of concentration. Equally disturbing were the conclusions from the observation of the second and third groups, i.e. people partially deprived of sleep. With each subsequent night, people sleeping for only six or four hours showed a several hundred percent increase in the number of microsleeps during the day. Additionally, an important discovery made by this team was that people who were sleep deprived had great difficulty determining the degree of their own concentration loss; they were also somewhat unaware of their cognitive impairment and were unable to describe it in an objective way.

The emotional aspect of brain functioning can display equally worrying effects of sleep deprivation. It is a well-known fact that lack of sleep causes significant confusion in human emotions, and the parts of the brain that are responsible for the activation of emotions become highly hypersensitive when people are short of sleep (Walker, 2019). Many studies have shown an increase in anxiety levels as a result of insufficient sleep per day. Researchers have repeatedly observed the reactions of the amygdala of people who were deprived of sleep for a day up to a few days. When they applied functional magnetic resonance imaging, they discovered that the amygdala, which is the centre of emotions in the brain, was a few dozen percent more reactive to negative images. This meant that such a person experienced much more anxiety and other emotional reactions like anger or irritability (Yoo et al., 2007). Other studies also found that lesser amygdala stimulation could be associated with more REM sleep (van de Helm et al., 2011). This means that getting enough good sleep (which allows people to cycle through different sleep phases in a certain order throughout the night) can soothe one's amygdala. As a consequence, it is then possible to mitigate many physical symptoms that may be displayed by the human body as a result of the anxiety activated in the amygdala. As is known from the biology of this part of the brain, the amygdala operates automatically based on a kind of pre-programmed pattern, but it is also extremely sensitive to (and responds to) the states experienced by a given individual in particular situations. Importantly, the amygdala reacts more strongly and negatively to sleep deprivation than any other part of the brain (Pittman, and Karle, 2018). Fortunately, it is reassuring to know that insufficient sleep does not force the brain into a permanent negative and depressed mood. A sleepy brain tends towards two emotional extremes: positive and negative (Walker, 2019).

It can therefore be concluded that poor sleep quality has a significantly detrimental effect on the human brain, its cognitive functions, and emotional reactions. People who experience regular sleep deficiencies have difficulties with concentration, memory efficiency, recalling remembered content, and their general health deteriorates. Such people demonstrate excessive and violent emotional reactions caused by their "restless" amygdala, which is overactivated by lack of sleep (Pittman, and Karle, 2018). All major human body systems and organs suffer damage due to constant sleep deprivation. Insufficient sleep severely affects many of the basic biological systems of the human body, including the cardiovascular, metabolic, reproductive and immune systems. Also, many common diseases of contemporary people, such as heart disease, diabetes, obesity, cancer and premature dementia, are all at least partially caused by sleep deprivation (Walker, 2019).

4. Strategies for counteracting managers' stress and sleep deficit

Contemporary organizations tend to glorify a working style that features a busy schedule, numerous business trips, working under time pressure, multitasking, and a fast pace of working (Czeisler, 2006, 2016). The professional life of a modern employee, especially a manager, requires speed and accuracy, full availability, and professionalism (Berndt, 2015). In many corporate cultures, ambitious managers work for 80-100 hours a week; they sleep for only five to six hours at night and keep awake during the day by means of a few cups of strong coffee. What is worse, corporate managers often "live in a suitcase" – frequently moving between different time zones (Czeisler, 2006, 2016).

According to D. Dinges (1995), many people in managerial positions are convinced that they only need a 20-minute nap during the day to let them function effectively and compensate for lack of sleep at night. Therefore, there is a growing belief among managers that they do not need to get enough sleep at night as naps and caffeine can help keep their brains active. However, when people do not get sufficient sleep, power naps can only temporarily increase their levels of basic concentration. Many studies have shown that neither naps nor caffeine can sufficiently aid processes such as concentration, learning, memory, emotional balance, or decision-making.

Ch.A. Czeisler (2006, 2016) believes that managers who behave in the described way pose a serious threat to themselves, their teams, their organizations, and other people around them. He is also convinced that the cult created by organizations of a 100% worker who does not need sleep is highly dangerous and is the opposite of what could be called wise management. As shown by the research conducted at the Harvard Medical School's Division of Sleep Medicine, this style of functioning is counterproductive in terms of high work efficiency as sleep deprivation is much more important than one might think. Contemporary work and social cultures which glorify employees' lack of sleep cause a significant deterioration in both their biological and psychological condition. A person who does not allow themselves enough sleep has highly limited cognitive performance, which, according to researchers, is similar to the decline in one's abilities (concentration, memory, cause-and-effect thinking, etc.) that is demonstrated in a state of alcohol intoxication with 100 milligrams of alcohol in 100 millilitres of blood. Such a condition significantly affects one's work efficiency and leads to a phenomenon known as "ineffective attendance at work", causing many organizational, social and economic losses (Hemp, 2005). Sleep deprivation is responsible for a whole host of risks to organizations. Exhausted employees operate dangerous machines and devices, while intelligent and well-educated managers make bad decisions with serious consequences for the organization that they would never allow to happen if they were well rested (Czeisler, 2006, 2016).

It is also worth considering the consequences of sleep deprivation of managers working for contemporary organizations in the context of the growing stressfulness of managerial roles.

According to psychology literature, it is assumed that the results of effective actions taken in stressful situations depend on the individual features of a given individual and the type and dynamics of the stressful situations created within their organization.

When considering the human struggle with stress, the concept of *resources* appears. Usually, *resources* are understood as "psychological, social and biological factors treated as moderators in the course of experiencing and coping with stress" (Ogińska-Bulik, 2006). In this view, resources include everything that an individual brings to the process of coping with stress. Sęk (2005) understands *resources* more broadly and describes them as "specific functional properties of features that potentially exist in people's environment, themselves, and in their relations with this environment". This author introduces the concept of dividing resources into internal and external ones: internal resources are understood as mental resources, such as emotional competences, cognitive and intellectual functions, temper; biological resources are determined by genetic conditions, immune resistance or the physiological resistance of one's organism. External resources include biological and physical environment resources as well as socio-cultural resources.

The stress researchers mentioned earlier in this article, R.S. Lazarus and S. Folkman (1984), distinguished several categories of resources (after Ogińska-Bulik, 2006):

- health and energy,
- positive beliefs,
- ability to solve problems,
- social skills.

R.S. Lazarus (1999) introduced the term **coping resources**. In his opinion, when considering all the personal resources that have been identified, the most important role is actually played by a person's health, energy, and positive convictions about themselves and the world.

What R.S. Lazarus and S. Folkman (1984) also emphasize is the great importance of the sense of threat that is experienced by an individual in various life circumstances. According to these authors, a strong sense of threat may significantly limit an individual's ability to use their personal resources. The strength of the perceived threat determines how an individual can use their personal resources. On the other hand, one's awareness of these resources and their availability may be determined by one's beliefs or values, which shape one's behaviour in specific life circumstances. The approach presented by these authors has attracted acclaim from other researchers of the phenomenon of stress and has become the basis of many empirical studies. A list of the determinants that influence one's stress coping strategy is presented in Figure 1.

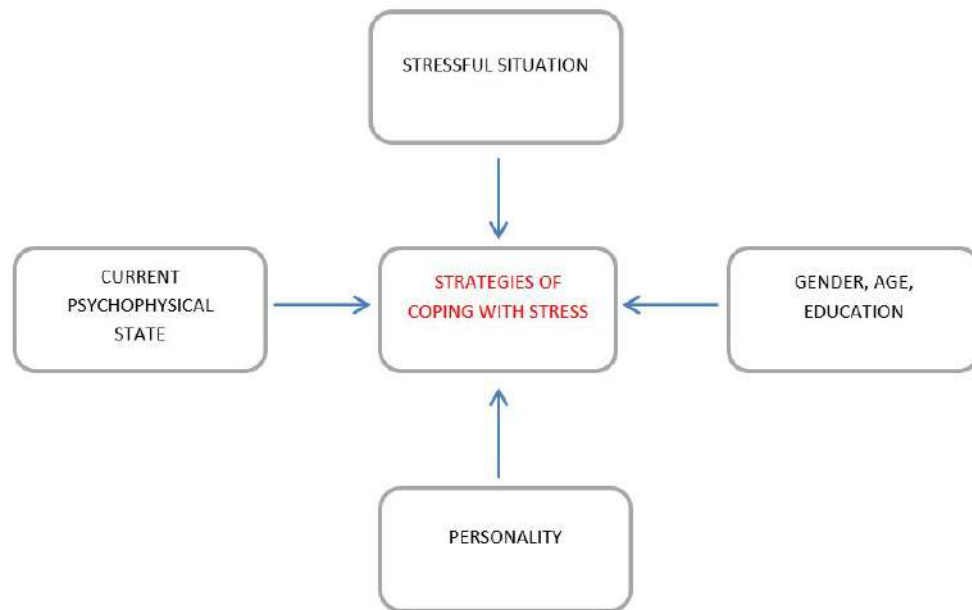


Figure 1. Strategies of coping with stress. Adapted from: "Style a strategie radzenia sobie ze stresem. Problemy pomiaru" by K. Wrześniewski. Copyright 2000 by Publisher.

It can be noticed that one's success in the actions one undertakes while experiencing stress depends on many of one's individual properties and the conditions created in one's environment (Łosiak, 2008).

"Consistent treatment of coping as a form of deliberate human behaviour requires recognition of the role of both individual and situational classes of factors as well as the interactions between them during this behaviour" (Heszen-Niejodek, 2000).

Based on many empirical studies, it may be concluded that people are able to adjust their stress coping strategies to the specific conditions determined by a given stressful situation. Each time, however, this decision will be the result of the interaction between individual and situational factors, thus creating a kind of space for flexibility in terms of how people cope with stress (Heszen-Niejodek, 2000).

Assuming that sleep deficits affect one's emotional and cognitive efficiency, one's decision regarding the choice of the best strategy for dealing with stress may be heavily burdened with the consequences of one's poor mental condition. When treating sleep as both a health and energy resource, one should expect a significant impact of sleep deficiency on managers' cognitive processes. The affected areas may include attention, memory processes, cause-and-effect thinking, or the decision-making process itself. If it recurs frequently, sleep deficit may overly activate the emotional structures of one's brain, thus significantly increasing one's levels of anxiety and fears. Deregulation of such emotional mechanisms will result in the disturbance of managers' emotional stability. Therefore, it can be assumed that the increased emotional anxiety and weakened cognitive functions caused by insufficient daily sleep will have a significant impact on managers' choice of behaviour when acting in stressful conditions.

5. Summary

Psychophysical well-being is an important factor in effectively coping with stressful situations. This resource, in turn, is also dependent on an appropriate amount of sleep, which allows an individual to reach the desired level of cognitive and emotional performance. However, the complex and constantly increasing organizational requirements faced by contemporary managers force them to limit their daily sleep, which leads to sleep deficit, which may actually be dangerous for both the given individual and the environment in which they operate. The tendency of modern managers to reduce sleep results from the fact that their organizations expect them to continuously increase and accelerate their managerial activities. As a result, work environments that are not employee-friendly and approve a lack of sleep put their members at the risk of functioning under the influence of heavy emotional burdens. However, sleep (and one's right to sleep), when treated as an individual resource of each manager, is crucial for health and energy; it also creates the space needed for the implementation of appropriate stress coping strategies in stressful situations and allows sufficient flexibility when applying these strategies.

References

1. Ancoli-Israel, S., Palmer, B.W., Cooke, J.R., Orey-Bloom, J., Fiorentino, L., Natarajan L., Liu, L., Ayalon, L., He, F., and Lored, J.S. (2008). Cognitive Effects of Treating Obstructive Sleep Apnea in Alzheimer's Disease: A Randomized Controlled Study. *Journal of the American Geriatric Society*, 56(11), 2076-2081.
2. Bańka, A. (2001). *Psychopatologia pracy*. Poznań: Wydawnictwo Gemini.
3. Banks, S., and Dinges, D.F. (2007). Behavioral and Physiological Consequences of Sleep Restriction. *Journal of Clinical Sleep Medicine*, 3(5), 519-528.
4. Bartkowiak, G. (2009). *Człowiek w pracy. Od stresu do sukcesu w organizacji*. Warszawa: PWE.
5. Berndt, Ch. (2015). *Tajemnica odporności psychicznej. Jak uodpornić się na stres, depresję i wypalenie zawodowe*. Kraków: Wydawnictwo Uniwersytetu Jagiellońskiego.
6. Białek, E.D. (2012). *Psychosomatyczne, emocjonalne i duchowe aspekty chorób ze stresu*. Warszawa: Instytut Psychosyntezy.
7. Biela, A. (2001). *Wymiary decyzji menedżerskich*. Lublin: Towarzystwo Naukowe KUL.
8. Chopin, L., Walpole, C., Seim, I., Cunningham, P., Murray, R., Whiteside, E., Josh, P., and Herington, A. (2011). Ghrelin and Cancer. *Molecular and Cellular Endocrinology*, 1(2011), 65-69.

9. Czeisler, Ch.A. (2006). Sleep Deficit: The Performance Killer. A Conversation with Harvard Medical School Professor Charles A. Czeisler. *Harvard Business Review*, 84(10), 53-59.
10. Czeisler, Ch.A. (2016). SLEEP. Measuring the Passage of Brain Time. *Science*, 12(8), 353(6300), 648-649.
11. Dinges, D.F. (1995). An Overview of Sleepiness and Accidents. *Journal of Sleep Research*, 4(2), 4-14.
12. *Encyklopedia PWN* (1997). Warszawa: PWN.
13. Endler, N.S., and Parker, D.A. (1990). Multidimensional Assessment of Coping: A Critical Evaluation. *Journal of Personality and Social Psychology*, 58(5), 844-854.
14. Hallowell, E.M. (2011). *SHINE: Using Brain Science to Get the Best from Your People*. Boston: Harvard Business Review Press.
15. Hellriegel, D., Slocum, J.W., and Woodman, R.W. (1995). *Organizational Behavior*. St. Paul: West Publishing Company.
16. Hemp, P. (2005). Niedysponowani pracownicy: obecni ciałem, nieobecni duchem. *Harvard Business Review Polska*, 32, 128-137.
17. Kabat-Zinn, J. (2012). *Życie, piękna katastrofa*. Warszawa: Wydawnictwo Czarna Owca.
18. Kahna, R.L., Wolfe, D.M., Quinn, R.P., Snoek, J.D., and Rosenthal, R.A. (1964). *Organizational Stress: Studies in Role Conflict and Ambiguity*. New York: Wiley.
19. Kraczla, M. (2013). Wypalenie zawodowe jako efekt długotrwałego stresu. *Zeszyty Naukowe Wyższej Szkoły HUMANITAS. Zarządzanie*, 2, 69-81.
20. Kraczla, M. (2016). *Stres w pracy menedżera*. Warszawa: Wydawnictwo CeDeWu.
21. Kripke, D.F., Langer, R.D., and Kline, L.E. (2012). Hypnotics' Association with Mortality or Cancer. A Matched Cohort Study. *BMJ Open*, 1, e00850.
22. Lazarus, R.S., and Folkman, S. (1984). *Stress Appraisal and Coping*. New York: Springer.
23. Le Blanc, P., de Jonge, J., and Schaufeli, W. (2002). Stres zawodowy a zdrowie pracowników. In: N. Chmiel (Ed.), *Psychologia pracy i organizacji* (pp. 169-203). Gdańsk: GWP.
24. Moraes, W.S., Poyares, D., Guilleminault, C., Ramos, L., Bertolucci, P., and Tufik S. (2006). The Effect of Donepezil on Sleep and REM Sleep EEG in Patients with Alzheimer's Disease: A Double-Blind Placebo-Controlled Study. *Sleep*, 29, 199-205.
25. Ogińska-Bulik, N. (2006). *Stres zawodowy w zawodach usług społecznych. Źródła – konsekwencje – zapobieganie*. Warszawa: Difin Sp. z o.o.
26. Ogińska-Bulik, N., and Juczyński, Z. (2008). *Osobowość, stres a zdrowie*. Warszawa: Difin Sp. z o.o.
27. Penc, J. (2000). *Menedżer w uczącej się organizacji*. Łódź: Wydawca Menadżer.
28. Pittman, C.M., and Karle, E.M. (2018). *Zalękniony mózg*. Kraków: Wydawnictwo Uniwersytetu Jagiellońskiego.

29. Pocztowski, A. (2003). *Zarządzanie zasobami ludzkimi. Strategie – procesy – metody*. Warszawa: PWE.
30. Robbins, S.P., and Judge, T.A. (2012). *Zachowania w organizacji*. Warszawa: PWE.
31. Schultz, D.P., and Schultz, S.E. (2006). *Psychologia a wyzwania dzisiejszej pracy*. Warszawa: PWN.
32. Strelau, J. (2007). *Psychologia. Podręcznik akademicki, vol. 2 and vol. 3*. Gdańsk: GWP.
33. Strycharczyk, D., and Clough, P. (2018). *Odporność psychiczna. Strategie i narzędzia rozwoju*. Gdańsk: Gdańskie Wydawnictwo Psychologiczne.
34. Terelak, J. (2004). *Stres organizacyjny*. Warszawa: Wydawnictwo WSM-SIG.
35. Van der Helm, E., Yao, J., Dutt, S., Rao, V., Salentin, J.M., and Walker, M.P. (2011). REN Sleep Depotentiates Amygdala Activity to Previous Emotional Experiences. *Current Biology*, 21, 2029-2032.
36. Walker, M. (2019). *Dlaczego śpimy. Odkrywanie potęgi snu i marzeń sennych*. Warszawa: Wydawnictwo Marginesy.
37. Wheeler, C. (2011). *10 prostych sposobów radzenia sobie ze stresem*. Gdańsk: Gdańskie Wydawnictwo Psychologiczne.
38. Winters, N., and Kelley, J.H. (2018). *Zagłodzić raka. Metaboliczne podejście do walki z chorobą nowotworową*. Łódź: Galaktyka Sp. z o.o.
39. Wrześniewski, K. (2000). Style i strategie radzenia sobie ze stresem. Problemy pomiaru. In: I. Heszen-Niejodek, and Z. Ratajczak (Eds.), *Człowiek w sytuacji stresu* (pp. 44-64). Katowice: Wydawnictwo Uniwersytetu Śląskiego.
40. Yoo, S., Gujar, N., Hu, P., Jolesz, F.A., and Walker, M.P. (2007). The Human Emotional Brain Without Sleep: A Prefrontal Amygdala Disconnect. *Current Biology*, 17(20), 877-878.

STATISTICAL ANALYSIS OF THE PREPARATION OF A FUTURE STUDENT DURING THE SARS-COV-2 PANDEMIC (ECONOMIC APPROACH)

Monika KREZYMON^{1*}, Krystian STRÓŻEWSKI²

¹ Uniwersytet Szczeciński, Szczecin; mkrezymon1603@gmail.com, ORCID: 0000-0002-2787-3667

² Uniwersytet Szczeciński, Szczecin; kstrozewski@gmail.com, ORCID: 0000-0001-5384-8142

* Correspondence author

Purpose: The aim of the article is to statistically analyze the preparation of the future student during the SARS-CoV-2 pandemic. The article is based on the answers of this year's high school graduates to the questions asked in the questionnaire regarding the assessment of their knowledge and the work of teachers during online classes. Moreover, prospective students expressed their opinion on the choice of a university and access to information about the fields of study. The article also deals with the financial situation of families during the pandemic and the impact of this situation on the possibility of further education of this year's high school graduates.

Design/methodology/approach: Critical analysis of the literature on the subject allowing to define the term e-education. Analysis of the questionnaire and drawing conclusions based on the statistics.

Findings: When analyzing the questionnaire, it was found that this year's high school graduates are not prepared to start their studies in the coming academic year and the teachers' work according to the survey was not effective. The financial situation of the families of this year's high school graduates does not affect their further education.

Research limitations/implications: The article was based on a statistical survey using the questionnaire method. The analysis of the respondents' answers provided results on the substantive preparation of high school graduates, teachers' work and the financial situation of families. The conclusions from the analysis indicate that this year's high school graduates may become poor students in the future due to the educational deficiencies they indicated. The analysis of the survey results led to the main question that may become the direction for future research, such as considerations on improving the educational process conducted remotely.

Originality/value: The article presents the original statistical study (survey questionnaire). The survey is addressed to secondary school teachers, university teachers and high school students who are planning academic education.

Keywords: statistics, education, sociology, economics, SARS-CoV-2.

Category of the paper: Research paper.

Introduction

Education is one of the most important elements of social life, because from the earliest stage of human development it shapes his personality, worldview and improves skills on many levels (Malewski, 2010, p. 46). The aim of education is, above all, the progress of knowledge, so that in the future, young people will be an added value for society (Muszyński, 2014, pp. 77-87). Correctly, education should take place in science centers designed for this, because young people should have close contact with peers and teachers and the possibility of active participation in school life (Okoń, 2008, p. 383).

The spread of SARS-CoV-2 virus has severely affected education. Many countries, including Poland, have closed schools and decided to transfer education to remote mode, and this form of education may have a number of effects that will be felt for many years (MNiSW, 2020).

The aim of the article is to present the preparation of this year's high school graduates for the further education process and the effects of e-education.

Education during a pandemic SARS-Cov-2

The term e-learning can be defined as a teaching process that takes place outside the school premises, based on the concept of distance learning/distance education (Clarke, 2007, pp. 11-12). E-education is also defined as training or teaching with the use of information technology, which means supporting the didactic process through devices with Internet access (Matusiak, 2011, pp. 59-60). E-education allows you to complete courses, training, and studies, excluding physical presence in the classes and complements the traditional teaching process (Dertln, 2005, pp. 12-15). E-education is a very wide application of electronic technology in the teaching process and has been used since the mid-1980s. E-education is a form of flexible learning combining traditional forms of education with access to automated teaching tools and materials, and the main burden of learning lies with the learner, not the teacher (Hojnacki, 2006, p. 26). The aim of creating e-education was to give the teaching process a new quality, which would improve education, with the use of multimedia ICT tools (Kuźmicz, 2012, p. 130). Solutions for the implementation of e-education are stationary and portable multimedia computers, devices such as palmtop, mobile phones, and learning using the above-mentioned tools can take two basic forms.

The first is CBL (Computer Based Learning), which is based on the use of computers with access to educational content available using data carriers such as CDs, DVD ROMs, pendrives, hard drives, flash memory. In the course of teaching according to the CBL model, there is no

direct exchange of information or dialogue between the student and the teacher. The student's task is to choose a convenient date for him, in which he independently performs tests and exercises on the above-mentioned data carriers, using a personal device to analyze them (Techopedia).

Another form of e-education is WBL (Web Based Learning). It is a form of teaching based on the use of personal computers, telephones, or other devices with access to the Internet or intranet. These materials are sent via the Internet to, for example, an e-mail address indicated by the student, to educational platforms created for students. The WBL model assumes apart from the asynchronous teaching mode the possibility of communication between the teacher and the student. Teaching then takes place in real mode and is conducted by the teacher. WBL is also known as on-line learning. During such a lesson, students communicate with the teacher and with each other using online communication tools such as instant messaging, chats, discussion forums, audio conferences and videoconferences (McKimm, Jollie, & Cantillon, 2003).

The development of information and communication technologies has made it possible for society to have access to educational materials and contact the teacher regardless of the time and place of stay of both parties, and many opportunities for acquiring knowledge and education. However, can transferring learning from schools to the network contribute to the weakening of education as a whole system? Can this year's high school graduates, who spent only a few weeks in schools, be prepared for the matriculation examination as effectively thanks to e-education and stationary education? Will they be an added value for universities, and will they go to university at all? Has the economic situation of households deteriorated enough to become an obstacle to the further development of young people?

A statistical study of the effects of e - education during a pandemic

In order to obtain answers to the above questions, a survey was conducted among high school graduates taking the secondary school-leaving examination in 2021. The research sample was 100 people, and the analysis of the questionnaire was carried out on the basis of the answers provided, the most important questions were taken into account, which will allow to formulate conclusions.

Figure 1 shows the breakdown of the respondents by gender.

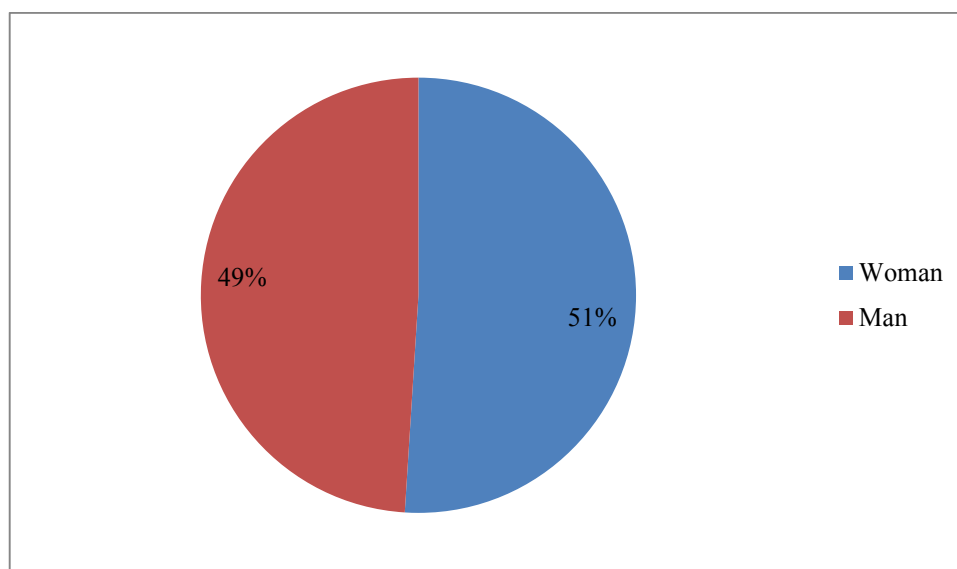


Figure 1. Division of respondents by gender. Source: own study based on a questionnaire survey (n = 100).

Figure 1 shows the division of respondents by gender. 51% of the respondents are women and 49% are men. On the basis of the sample, it can be concluded that a similar number of women and men study in secondary schools.

Figure 2 contains information about the type of school that this year's high school graduates will complete.

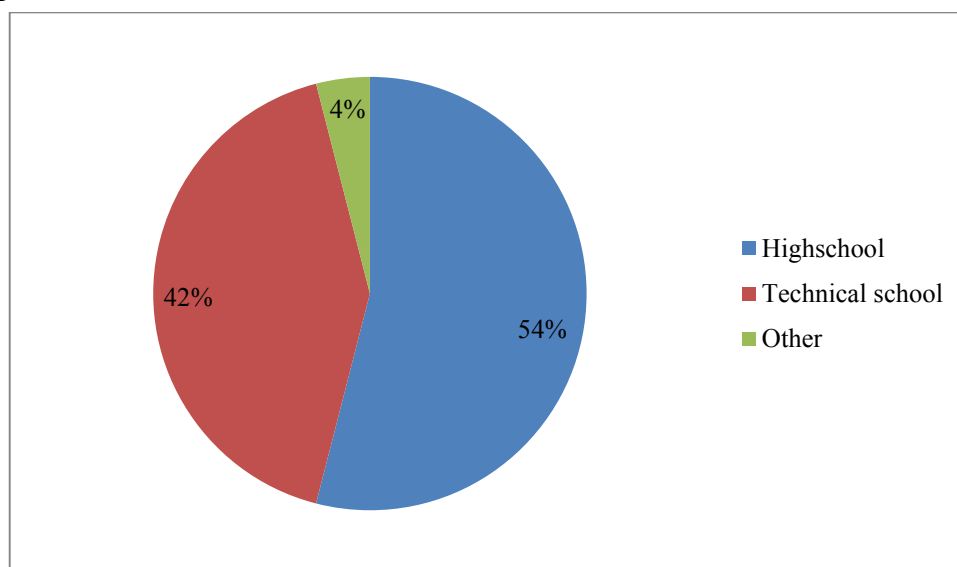


Figure 2. Type of school graduated. Source: own study based on a questionnaire survey (n = 100).

According to the survey, 54% of the respondents declared that they would graduate from a general secondary school this year, 42% indicated a vocational technical school, and 4% were students of other schools than those mentioned. Analyzing Figure 2, it can be concluded that over half of the respondents graduating from general secondary school remain without a learned profession, which is a premise for the choice of further education, including at a university.

Figure 3 is an assessment of the knowledge acquired in school since the start of the pandemic and the transition to online learning.

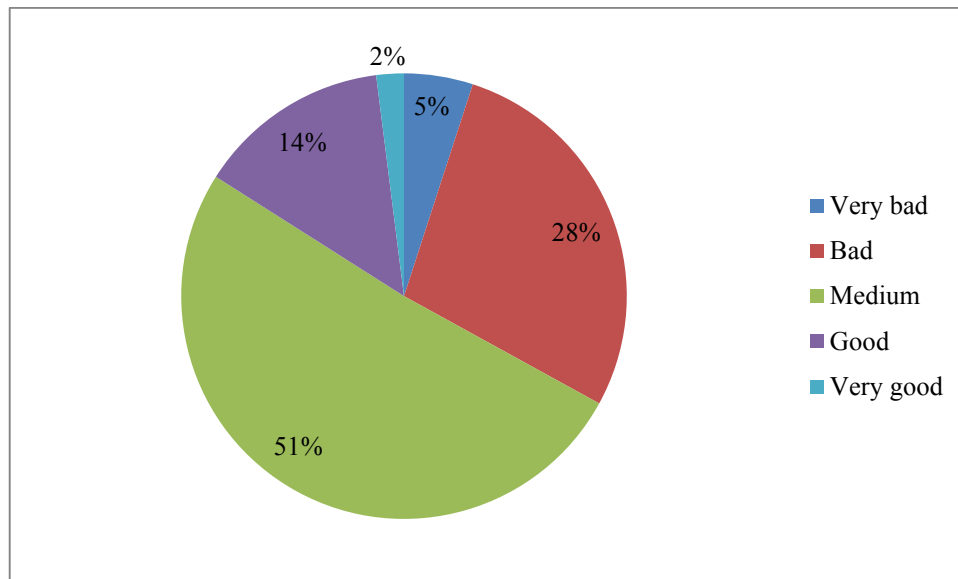


Figure 3. Assessment of the acquired knowledge. Source: own study based on a questionnaire survey (n = 100).

When interpreting Figure 3, it can be concluded that the level of knowledge of secondary school students is generally assessed as unsatisfactory, 51% of respondents assess the knowledge acquired during e-lessons as average, 28% of young people indicate that their knowledge is poor, 14% of respondents estimate their level of knowledge. good knowledge, 5% assess their knowledge very badly from the moment of starting the e-lesson, and only 2% assess their abilities as very good.

Figure 4 presents the answers of high school graduates regarding the place of preparation for the matriculation examination. The respondents were asked if they would feel better prepared for the Matura exam if the lessons were held at school.

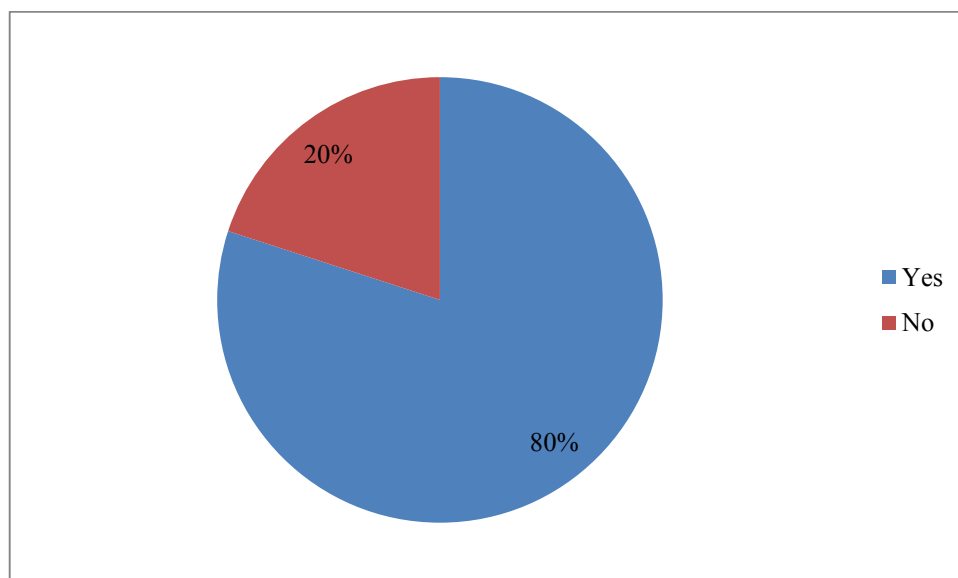


Figure 4. Preparation for the Matura exam, and lessons at school or on-line. Source: own study based on a questionnaire survey (n = 100).

According to high school graduates, preparation for the matura exam should take place at school, as many as 80% of them declared this answer, while 20% believe that regardless of the form of education, they feel equally prepared for this exam.

Figure 5 concerns the evaluation of teachers' performance during a pandemic. The teacher is the person responsible for organizing the lessons as effectively as possible. It is up to the teacher to provide the material in a comprehensible way and to encourage young people to cooperate with the teacher and the rest of the group.

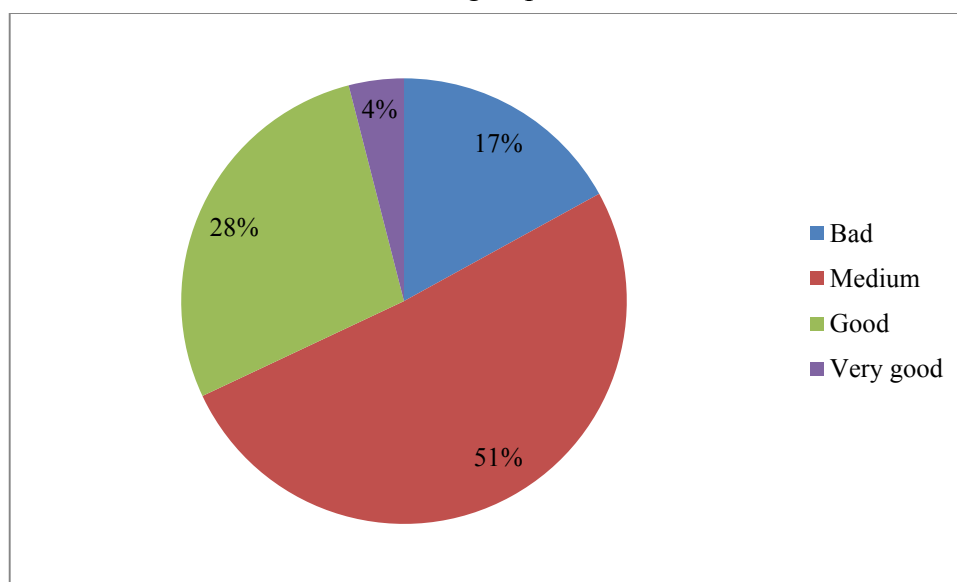


Figure 5. Assessment of the teacher's work during on-line lessons. Source: own study based on a questionnaire survey (n = 100).

In Figure 5, students rated teachers' performance during the pandemic on a four-point scale. 51% of the respondents assessed the teachers' didactic efforts as average, 28% of the students considered that teachers do their job well, 17% of the respondents considered the teachers' work as unsatisfactory, and only 4% assessed the teachers' teaching efforts as very good.

Figure 6 shows the level of students' understanding of the material discussed in online lessons.

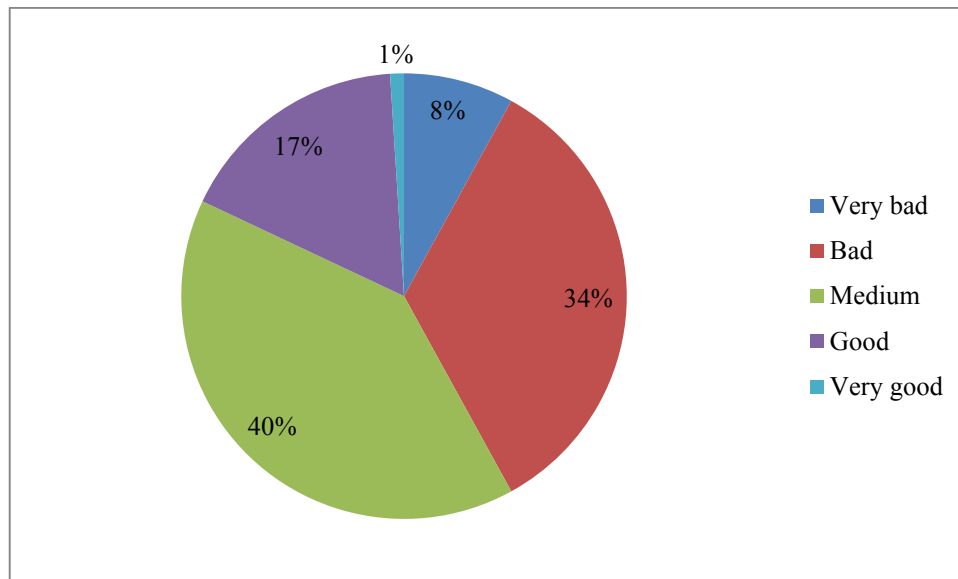


Figure 6. Understanding the material in online lessons. Source: own study based on a questionnaire survey (n = 100).

Figure 6 presents the students' answers to the question concerning the acquisition of material from online lessons aimed at preparing them for passing the matriculation examination. 40% of the respondents assess the understanding of the scope of knowledge with the on-line method on average, 34% of the respondents stated that they do not understand the material from the lessons poorly, 17% evaluate their education at a good level, 8% acquire knowledge from online lessons very well, and 1% the respondents practically did not learn from these lessons.

Figure 7 is an assessment of the substantive preparation by the high school graduate to start studies.

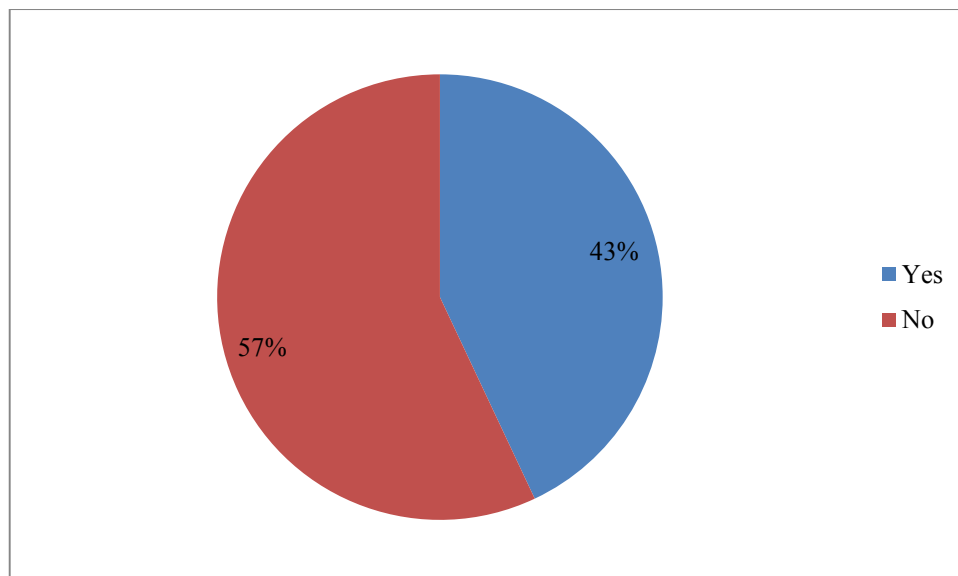


Figure 7. Assessment of substantive preparation before starting studies. Source: own study based on a questionnaire survey (n = 100).

According to the respondents, 57% of people do not feel ready to start studies, the remaining 43% declared that they are ready to undertake further education.

For the purposes of the study, if in the question in Figure 7, the respondent answered "No", then the secondary school graduates were asked to provide the reason why they provided such an answer, as shown in Figure 8.

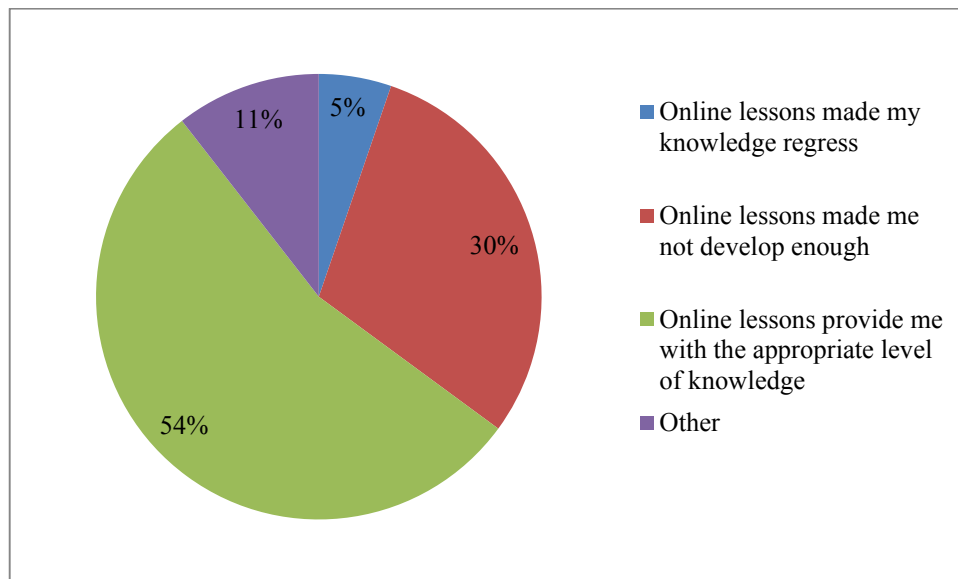


Figure 8. The reasons for the lack of substantive preparation for studies. Source: own study based on a questionnaire survey (n = 100).

When asked about the lack of preparation for starting studies (Figure 8), the respondents indicated the following answers, 54% believe that online lessons do not provide them with sufficient knowledge to feel prepared for the exam, 30% of people say that by introducing online education is not developing enough, 11% of people indicated that they have other reasons not to feel prepared for the baccalaureate, and 5% believe that their knowledge has regressed since the beginning of the pandemic and the change of the education system.

Another question asked of high school graduates was the choice of a university, the answers to which are shown in Figure 9.

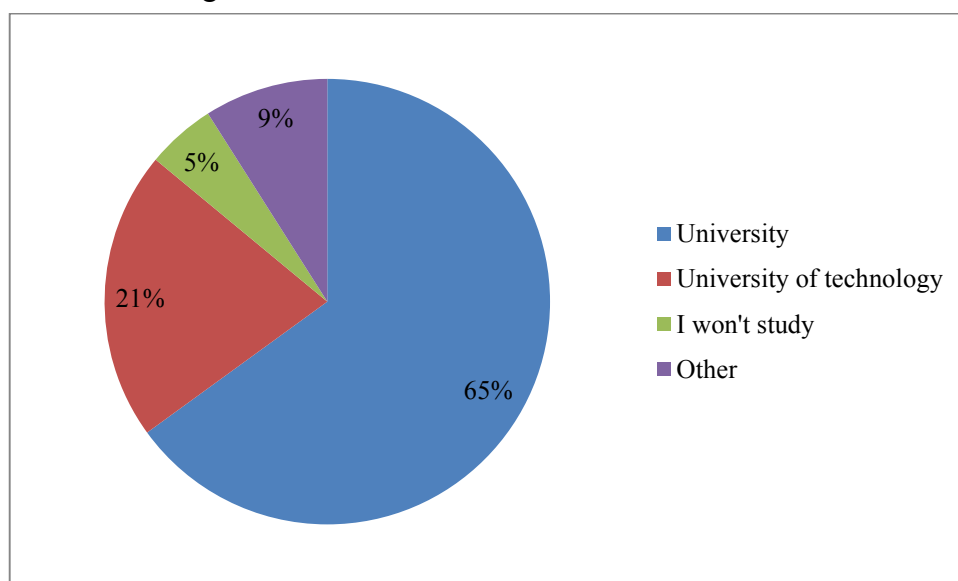


Figure 9. Preferences of high school graduates regarding the choice of higher education institutions. Source: own study based on a questionnaire survey (n = 100).

This year's high school graduates, in response to the question about the choice of university, declared as follows (Figure 9), 65% want to study at the University, 21% intend to choose a polytechnic, 9% of people declare a different form of further education, and 5% of respondents do not plan to go to university.

Information is a valuable resource. It is a source of knowledge and helps in making decisions. When asked if they felt sufficiently well informed about the available fields of study, the respondents replied as follows (Figure 10).

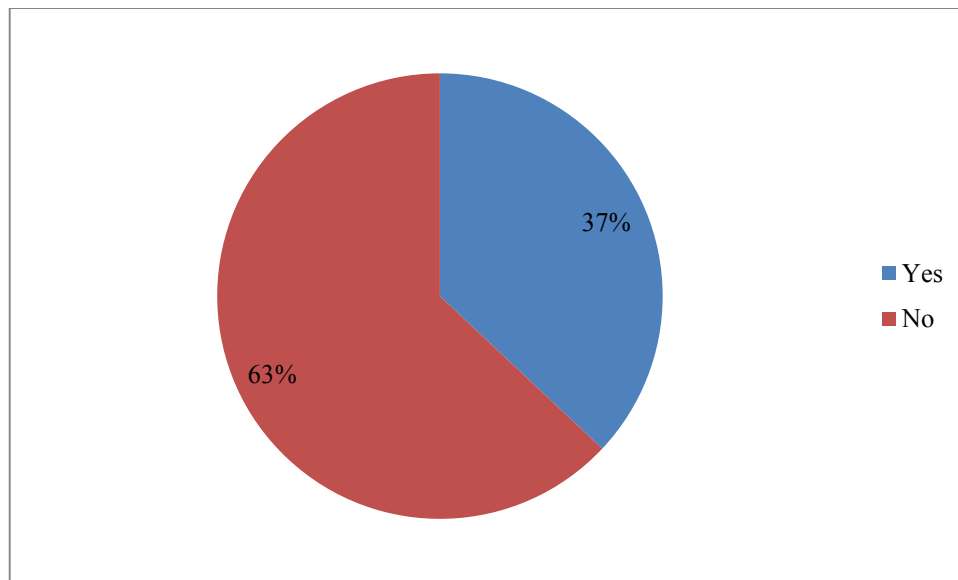


Figure 10. Availability of courses at universities. Source: own study based on a questionnaire survey (n = 100).

Figure 10 shows that only 37% of people feel sufficiently informed about the available fields of study, while as many as 63% of respondents do not have sufficient information about the available fields of study to be able to make a choice.

If the respondents answered the previous question (Figure 10) "No", then in the survey they were asked to indicate the reason for such an answer. The most common answers are shown in Figure 11.

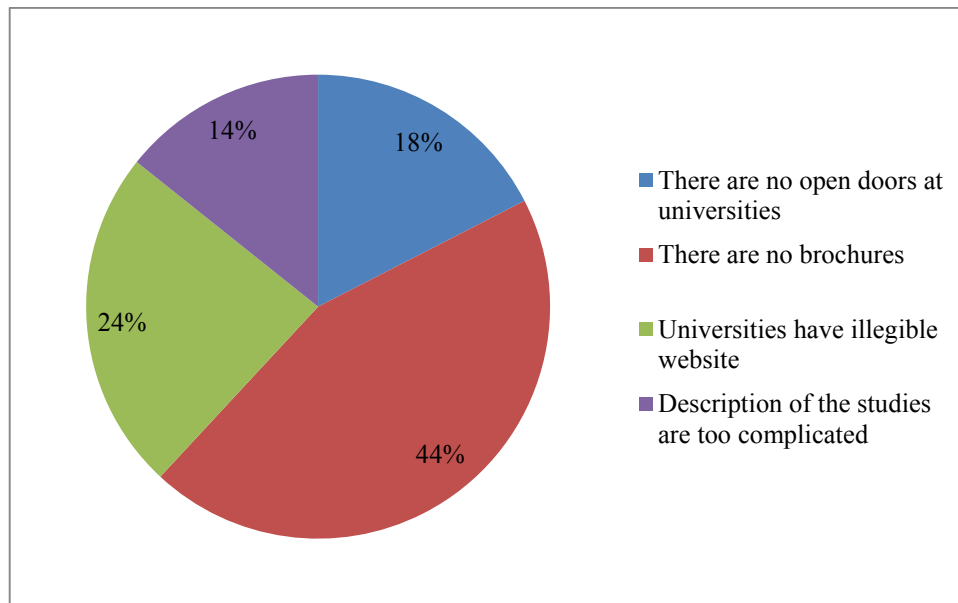


Figure 11. The reasons for the lack of information about the fields of study indicated by high school graduates. Source: own study based on a questionnaire survey (n = 100).

Figure 11 illustrates the answers to the question "Why do you not feel informed/informed about the available fields of study" to which high school graduates answered as follows, the most 44% of people say that there is a lack of information brochures provided by universities to secondary schools, 24% of respondents indicate problems with mobility on the university's website, 18% of students would like to participate in the open days of universities, and 14% of respondents believe that the course descriptions are too complicated, which makes it hard to understand.

It is important to emphasize whether the impact of the pandemic on the financial situation of households is related to the lack of opportunities for further education. Restrictions and restrictions introduced to contain the further spread of the virus may have depleted many households' wallets. The reasons for this could be, inter alia, dismissal or shortening of working hours or the inability to continue business activity.

Figure 12 shows the answer to the question about the correlation of financial conditions with resignation from studies.

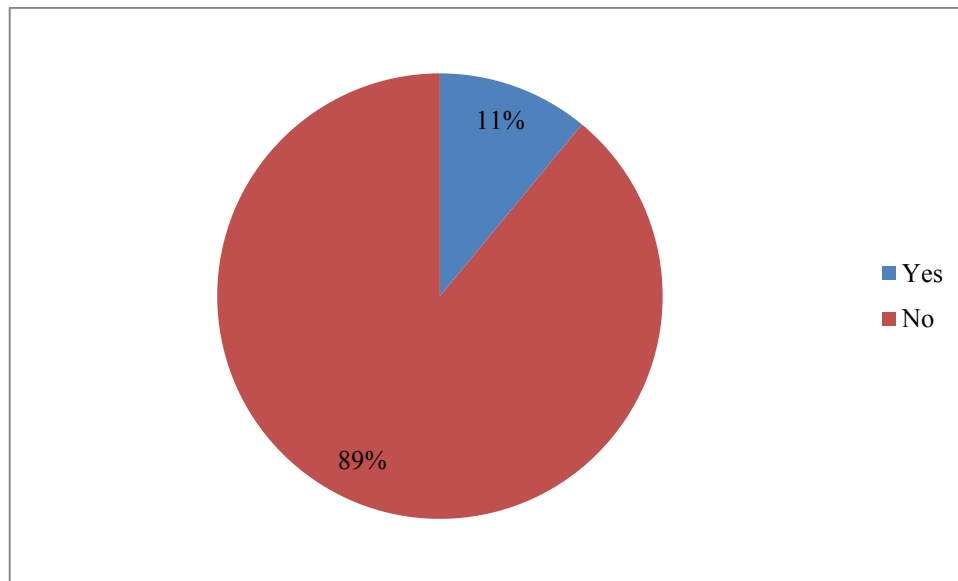


Figure 12. Linking the pandemic to the financial situation of households. Source: own study based on a questionnaire survey (n = 100).

As shown in Figure 12, 89% of respondents will not have to withdraw from studying due to financial conditions, 11% responded that the pandemic had an impact on household finances, and therefore they are forced to withdraw from studies for some time.

Another question addressed to the respondents was to raise the topic of a trip to another city or country. Many young people do not want to study in their hometown and choose to study further away from home. Figure 13 provides the answer to the question whether the pandemic prevented the respondents from going abroad to study outside their home.

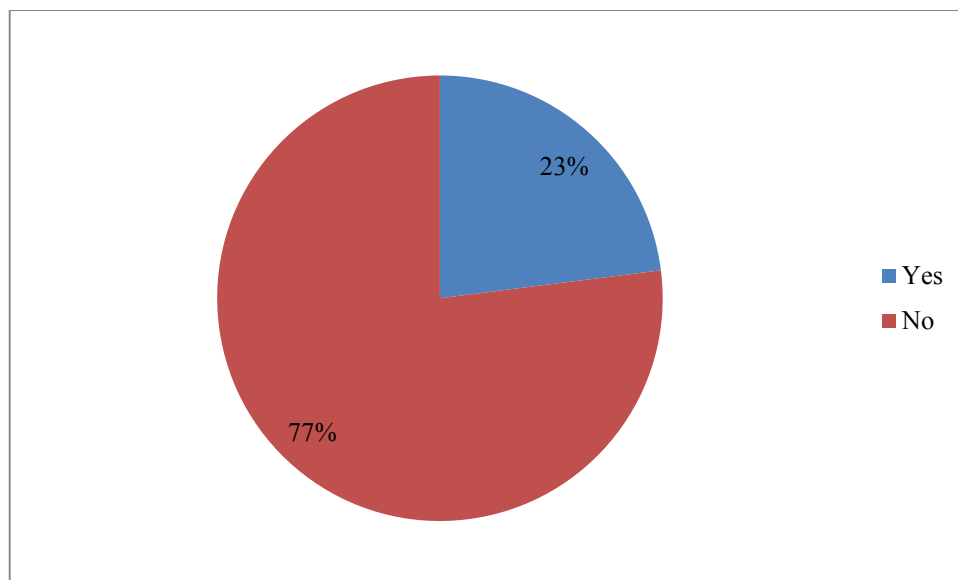


Figure 13. Impact of the pandemic on the possibility of going to study in another city or country. Source: own study based on a questionnaire survey (n = 100).

According to this year's high school graduates, as many as 73% of them will have the opportunity to go to study in another city or country (Figure 13), while 23% of those surveyed by the pandemic will not be able to do so.

The last question analysed is whether the funds that were to be allocated to further education will be spent in a different way. Figure 14 presents the responses of the respondents.

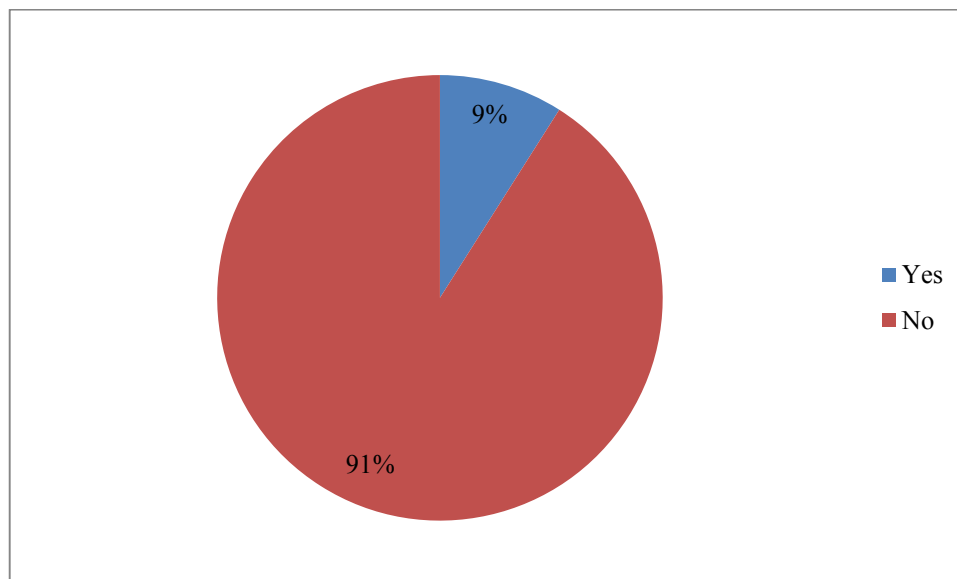


Figure 14. Allocation of funds for purposes other than studies. Source: own study based on a questionnaire survey (n = 100).

As shown in Figure 14, 91% of respondents believed that the pandemic did not affect the spending of funds earmarked for studies for other purposes, 9% of people said that the pandemic funds allocated to further education had to be used for other expenditure.

Summary

Summing up, the analysis shows that more than half (54%) of the respondents are high school graduates who will graduate from general secondary school this year. This is a prerequisite for considering their studies as this type of secondary school does not provide them with a specific profession.

For many high school students graduating from high school, enrolment is a huge step towards adulthood. It is important that this year's high school graduates are open to development and self-improvement while simultaneously learning the material they have learned in high school. This year, only 5% of the respondents from a sample of 100 people assessed their level of knowledge as very good, as many as 28% of the respondents stated that their knowledge was low, and 51% of high school graduates assessed themselves as average students. The aforementioned assessment of the state of knowledge may become a milestone for the decision to start studies. Another problem that may affect the decision regarding further education is the fact that as many as 80% of this year's high school graduates declared that they would feel better prepared for the matriculation examination if they were studying at school.

Moreover, the work of teachers conducting on-line lessons was assessed by the respondents as average (51%). The difference between a very good (4%) and a bad (17%) grade is also disturbing, as it amounts to as much as 13 percentage points, the survey result may indicate at this point that teachers are not prepared to conduct effective classes remotely, which may result in perhaps the same disturbing results of the material assimilated by the students. As far as online lessons are concerned, as many as 34% of this year's high school graduates do not understand the presented scope of issues applicable in this exam, and only 1% of them considered that they had fully absorbed the material.

The considerations presented so far show that as a result of the pandemic, due to which the stationary education system, later transformed into a remote part of high school graduates, may withdraw from studying, as many as 57% of respondents considered that they did not feel sufficiently prepared for it, indicating that on-line did not provide them with a sufficient level of knowledge (54%).

The vast majority of high school graduates are planning to go to the University (65%), the polytechnic was indicated by much less respondents (21%). The survey analysis shows that 63% of future students do not feel sufficiently informed about the available fields of study, indicating the lack of information in the form of brochures sent to secondary schools (44%) as the main reason for the lack of knowledge about a given university.

Referring to the financial situation of Polish families and the impact of the pandemic on the household budget, as many as 89% of this year's high school graduates admitted that for reasons related to the pandemic, they will not have to give up their studies, while the remaining 11% will be forced to withdraw from further education for some time. High school graduates who planned to go to study in another city or country declared that due to financial reasons related to the pandemic, 23% of them would not be able to achieve this goal, and 9% of respondents said that the funds that were to be allocated to their further education will be spent on meeting the basic needs of their families.

The results of the study indicate that this year's high school graduates may become poor students in the future who, due to educational deficiencies originating from high school, may not be able to cope with the academic mode of education. As a result, many of them may resign from studies during the academic year. The question that arises is whether secondary school teachers are able to improve the educational process remotely enough to make it more effective in the future if online education is required again. At this point, a question can also be asked whether the choice of a university over a polytechnic is dictated by a poorly efficient remote education system.

References

1. Clarke, A. (2007). *e-learning nauka na odległość*. Warszawa: WKŁ.
2. Derntl, M. (2005). *Patterns for Person – Centered e-Learning*. Vienna: University of Vienna.
3. Hojnacki, L. (2006). Pokolenie e-learningu – nowe wyzwanie dla szkoły. *e-mentor*, 1(13), p. 26.
4. Ifenthaler, D. *Computer-Based Learning*. https://link.springer.com/referenceworkentry/10.1007%2F978-1-4419-1428-6_499, 18.04.2021.
5. Kuźmich, K. (2012). E-edukacja jest wszędzie – rozważania dotyczące istoty i zastosowania technologii mobilnych w kształceniu zdalnym. *Zeszyty Naukowe Dolnośląskiej Szkoły Wyższej*, pp. 129-140.
6. Malewski, M. (2010). *Od nauczania do uczenia się. O paradygmatycznej zmianie w andragogice*. Wrocław: Wydawnictwo Naukowe Dolnośląskiej Szkoły Wyższej.
7. Matusiak, K.B. (2011). *Innowacje i transfer technologii. Słownik pojęć*. Warszawa: Polska Agencja Rozwoju Przedsiębiorczości.
8. McKimm, J., Jollie, C., Cantillon, P. *Web based learning*. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1125774/>, 18.04.2021.
9. MNiSW. <https://www.gov.pl/web/edukacja-i-nauka/rekomendacja-ministra-nauki-i-szkolnictwa-wyzszego-w-zwiazku-z-rozprzestrzenianiem-sie-koronawirusa-sars-cov-2>, 18.04.2021.
10. Muszyński, M. (2014). Edukacja i uczenie się – wokół pojęć. *Rocznik Andragogiczny*, 21, pp. 77-88.
11. Okoń, W. (2008). *Nowy słownik pedagogiczny*. Warszawa: Wydawnictwo Akademickie „Żak”.
12. Techopedia. <https://www.techopedia.com/definition/11167/computer-based-learning-cbl>, 18.04.2021.

THE ROLE OF CHANGE IN ENTERPRISES DURING THE CRISIS

Anna KWIECIEN

University of Economics in Katowice; anna.kwiecien@ue.katowice.pl, ORCID: 0000-0003-4928-5396

Purpose: Drawing attention to some positive aspects caused by the pandemic in the area of business management and presenting skilful change management, the application of new technologies and the use of flexibility as a way to survive and emerge from the crisis.

Design/methodology/approach: The study was developed on the basis of a critical analysis of the literature, and due to the topicality of the subject matter, on the basis of numerous press publications and internet sources.

Findings: The considerations presented in this paper have shown that adaptive change, the implementation of new technologies and flexibility are the factors that will allow the enterprise to survive the crisis.

Practical implications: Although the presented considerations are theoretical in nature, they are supported by the results of research that was conducted on the Polish market. They can be useful in practice for managers of various enterprises. They show what behaviours can help enterprises to survive in a crisis situation.

Social implications: Presenting the ways of dealing with the crisis can have multi-faceted beneficial socio-economic consequences. The survival of enterprises in the conditions of the crisis is important both for the state and for the society.

Originality/value: The study shows that despite the entire scale of problems and negative effects caused by the pandemic, there are also some situations that can be assessed positively. Flexibility and effective implementation of changes that were not planned before in some enterprises and the use of new technologies that helped companies to survive this difficult time are an example here.

Keywords: crisis, change, flexibility, new technologies.

Category of the paper: Viewpoint, General review.

1. Introduction

The declaration of the coronavirus pandemic and the introduction of sanitary restrictions by most developed countries caused the global economy to stand still. Uncertainty occurred. Governments' decisions related to the pandemic have triggered an avalanche of economic consequences. Many industries were closed or had to significantly reduce their activities.

Investors suspended the planned transactions and withdrew from the ongoing negotiations. Maintaining liquidity and, in some cases, the struggle to maintain business has become the priority (Gałązka, 2020).

In this situation, in many cases, the thought about enterprise development gave way to thoughts about survival and search for an answer to the question of how to do it?

The crisis caused the rise of many doubts and uncertainties for entire economies and individual companies in all areas of their activity.

However, despite the crisis and many negative effects of the pandemic, there are also some positive phenomena in terms of functioning and management of enterprises, caused by the pandemic. Companies undertook many changes that had been postponed or not planned at all. There was an exceptional mobilization of managers and employees (JK, Zarządzanie, 2021).

The aim of the paper is to draw attention to some positive aspects caused by the pandemic in the area of enterprise management and to present the skilful management of change and the use of flexibility as a way to survive and emerge from the crisis.

The study was developed on the basis of a critical analysis of the literature, and due to the topicality of the presented subject matter, on the basis of numerous press publications and internet sources.

2. Negative effects of the pandemic in Poland

The coronavirus has caused an economic crisis around the world. A slowdown or even collapse of the economy can be observed practically everywhere.

Theoretically, management sciences are familiar with the concept of crisis and we have tools to deal with it. There is anti-crisis management. It is a process in which the danger of a crisis is predicted, its symptoms and activities limiting the negative consequences of the crisis are analysed, and its factors are used to continue the development process (Krzakiewicz, 2008). Therefore, we can state that the anti-crisis management system should enable the prevention and effective overcoming of the crisis (Strzemecki, 2015). Unfortunately, not this time. Until recently, the crisis caused by the epidemic was an almost forgotten category, because pandemics did not happen frequently, and the concept of crisis was perceived differently. Many companies and entire economies were not preparing themselves in this regard, because they were not aware of the possible scale of the pandemic and the scale of the economic effects it might cause. That is why the coronavirus pandemic had a noticeable impact on the Polish economy, which can be clearly observed and demonstrated on the basis of several basic indicators.

GDP dynamics is one of the basic measures of the country's economy. The loss in Polish GDP in 2020 related to the coronavirus pandemic reached PLN 130.8 billion, according to the estimates of the economists of Credit Agricole Bank (Business Insider, 2021). The level of investment has decreased as much as 10.9%. In the second quarter of 2020, our economy's GDP fell by 8.2%, which is the worst result in history. In the fourth quarter, it was only by 2.8%. However, the decline in GDP in Poland is still much lower than that of the world's decreases. In the same period, the average decline in GDP among EU member states was 11.9%, and in the United Kingdom alone, as much as 20.4% (Koper, 2020).

The level of unemployment is another important measure that can be referred to here. From the end of February until the end of July 2020, there were 110,000 the new registered unemployed in Poland. There were 1 million 30 thousand people officially unemployed, and this gave an unemployment rate of 6.1%. The registered unemployment rate in March 2021 was – 6.4%. On the other hand, according to the Eurostat methodology, in February 2021 the unemployment rate in Poland was 3.1%, which was the same as in January. This was the lowest level of unemployment among EU countries. (JK, Unemployment, 2021). However, there is a concern that this result does not fully reflect the existing situation, as many people do not register with offices and try to look for a job on their own.

The deficit in the state treasury is also an indicator of the impact of crisis situations. The state budget had to endure negative effects from two sides. On the one hand, there was a huge increase in unplanned expenses related to the coronavirus that amounted to PLN 72.7 billion, and on the other hand, there was a decrease in revenues, from Polish businesses that were under numerous restrictions, which was estimated at around PLN 36.7 billion (Koper, 2020). The budget deficit in 2020 was supposed to reach PLN 109.3 billion, but the Prime Minister reports that it is about PLN 25 billion lower (Morawiecki, 2021).

The current economic situation is difficult, but it is assumed that the decreasing restrictions related to the pandemic, the return to normality of many industries in the economy, government aid programs, as well as a slow recovery in the main trading partners will allow Poland to return to the path of a moderate growth in 2021.

According to World Bank economists, in 2021 gross domestic product (GDP) growth may reach 3.5%. Due to the dynamism of the pandemic situation and the multitude of uncertainties, one cannot be sure of the future. Therefore, the current forecasts bear a considerable risk of error, differ from analyst to analysts, and may prove to be too optimistic.

The scale of negative changes is significant, but many companies have managed to survive it, therefore, attention should be paid to the positive phenomena thanks to which they achieved it.

3. Implementation of changes as an effective management tool in times of crisis

"Change or die" said Jack Welch (Włodarczyk, 2020). "You don't have to change, survival is not obligatory" – these are W.E. Deming's words (Popieluch, 2020). These words have now become prophetic. If an organization's environment changes faster than its inside, the company may not survive it.

Companies that fail to adapt in time will not only lower their competitive advantage, but they will simply collapse. The ability to develop and create new quality should always be a part of the processes and standards of the organization (Popieluch, 2020).

2020 could be called "the year of change management" because it is difficult to look for ready-made models of any crises from the past that could prepare us for what happened together with the pandemic, i.e. not only the health and economic crisis, but also rapid changes in consumer behaviour.

During the pandemic, many companies had to modify more or less drastically their way of functioning, i.e., introduce changes. It is worth emphasizing that the change in the face of the crisis is a change of the largest format, because it forces multifaceted changes, and the dynamics of negative changes in the environment is extremely severe.

Organizational change includes all transformations that occur in various sectors of an organization. These transformations occur under the influence of both internal and external factors. Changes are introduced in order to increase the effectiveness of the functioning of a given organization (Auster, Wylie, Valente, 2005).

Therefore, the ability to manage change is one of the fundamental business competences that more and more often determines an enterprise survival.

This study does not describe change and change management in detail, because these concepts are already described in many literature references (Auster, Wylie, & Valente, 2005; Osbert-Pociecha, 2011; Czop, 2016). Here, the main focus is on identifying the usefulness and role of change management for the effective functioning of enterprises during a pandemic.

Improving change management skills (leading change) has now become a very important competence of a professional manager (Green Cameron, 2004). Introducing changes in such a way that the organization maintains organizational efficiency in the short term and development opportunities in the long term is the challenge for the organization. According to G. Osbert-Pociecha (2011), it is one of the management paradoxes that an organization, in order to achieve its natural goal of duration, must undertake changes which, in a way, become a price that the company pays for the possibility of continuing its operations and difficult to predict environment.

All contemporary organizations operate in conditions of dynamic and unpredictable changes, but the crisis caused by the pandemic has made this situation even worse. If a company wants to function efficiently and effectively, it must adapt to the requirements of the environment and implement appropriate changes. As a result, uncertainty is becoming a hallmark of modern economies. Companies endeavour to implement changes. Unfortunately, as the 2021 Report on the National Research on Change Management (OBZZ) shows, only less than 30% of changes are implemented effectively (Rubin, Naumiuk, Grabowski, 2021) and this is a typical situation all over the world, not only in Poland (importantly, the pandemic did not cause the decrease in this value). The relatively low effectiveness rate of changes introduced by organizations means that the problem of implementing changes, factors influencing their course, and determinants of changes is still valid and important for theoreticians and practitioners, so it is worth talking about it. The low effectiveness of implemented projects suggests that there is no framework for implementing and managing change, and the traditional balance-based approach may be one of the reasons (Beer, Nohira 2000; Pellettiere 2006). This is because Lewin's three-stage process of change assumes that organizations exist in some form of equilibrium before disruption or change occurs. The organization then goes through a period of rapid changes and then reaches a period of stability if the implementation of the change is successful. This approach shows that change is a rare situation in the life of an organization. The change is associated with a violation of the status quo, the need to develop new habits and reorientate the image of the world; it requires effort and causes protests. That is why the company's ability to effectively implement changes in the period marked by the pandemic proved to be one of the key competences that offer the ability to survive, but also the ability to use the opportunities. Organizational change should therefore be perceived as an integral function of the system, which is a consequence of transformations in the environment, the aim of which is to improve the efficiency and effectiveness of organization management. It is a very complex concept that requires comprehensive consideration from various points of view (Walczak, 2009).

Each change aims to improve the situation in the more or less distant future. Therefore, implementing them with a view of long-term goals is often contrary to the requirements determined by the current functioning of the organization. The process of reorganization is usually associated with the occurrence of many disruptions and difficulties in everyday activities, which results in the fact that the tendency to delay the introduction of the desired change is quite common in practice (Kaczmarek, Sikorski, 1999). Therefore, the rapidly introduced, favourable changes caused by the negative crisis can be treated as a positive aspect of the current situation. Companies have undertaken many changes that were postponed or not planned at all. There was an exceptional mobilization of managers and employees.

The transition to remote work, organizational changes and cost reduction were the priorities of changes during the pandemic (40% of projects), (Rubin, Naumiuk, Grabowski, OBZZ Report, 2021). Most of the changes were spontaneous and action-oriented (in 27% of cases

there was no schedule, budget or knowledge about them), which unfortunately proves the low level of business and organizational maturity of our organizations. Although this situation is typical for the Polish market, its justification can be found in the current situation caused by the pandemic. 60% of the respondents positively assessed the results of the introduced changes.

As the OBZZ 2021 research from this year shows, this skill was "framed" with the ability to change at the appropriate pace and supported by the adequate mobilization of both managerial staff and employees (Rubin, Naumiuk, Grabowski, OBZZ Report, 2021).

Since the beginning of the research on change management, i.e., from 2016, the number of changes successfully completed has not exceeded 30% and still does not show a growing trend.

Banking and financial services are the best at implementing changes (full success in 38% of the described changes). Trade and service-providing companies poorly deal with the changes. The full success of the completed changes was indicated by 10% of respondents from the Trade sector and 21% from the Services sector. This result is not surprising. Banks and other financial institutions have been providing many services remotely for a long time, and this was the condition for success in the pandemic era. The truth is that the service and hotel industries have been seriously affected by lockdown restrictions, and unfortunately, in their case, remote service delivery is in many cases impossible.

As the overall level of successful implementation of changes is constantly low, practices that were associated with success are worth highlighting. Iterative planning and piloted implementation were the two most effective techniques supporting the implementation of changes that worked during the pandemic. Iterative planning consists in setting the goal of change, and then planning for shorter periods, and collecting information about the effects of activities. Following the analysis of the results of activities and collected feedback, it is possible to correct the plan and prepare a set of activities for the next stage. On the other hand, the pilot study shows that when the situation is uncertain, you should not stake everything on one card. It is worth trying whether the adopted solution could work in a selected part of the organization. Preceding the change with a pilot study is an experiment that shows whether a given solution brings the expected results. At the same time, the pilot program increases the security of the organization (Rubin, Naumiuk, Grabowski, Report OBZZ, 2021).

This result is a suggestion on how to act in the world of VUCA (volatility, uncertainty, complexity, ambiguity), and how to act when a crisis occurs.

When the situation is fluid and changing rapidly, when serious problems arise and the picture of the future is uncertain, a long-term, detailed change plan is no longer useful. Rapid adaptability and flexibility are gaining importance.

Many Polish companies have come to this conclusion. Companies from the SME sector abandoned long-term planning during the pandemic - only 5% of them plan activities for the next year. The group of entrepreneurs who do not plan anything and instead prefer to make decisions overnight has doubled. However, failing to think about development can be

dangerous. It is an activity on the border of existence that does not fully reflect the idea of flexibility (Ratajczak, 2020).

Before the pandemic almost 1/4 of entrepreneurs (24.8%) were preparing a schedule of activities for the next month. Over 31% of companies were planning their activities quarterly in advance. Every fifth (19.8%) was planning for the next six months, and only 17% were boldly planning the entire next year. 7% of the respondents were making ad hoc decisions.

During the pandemic, there was a clear increase in the number of companies that make decisions overnight (+ 8%) and one month in advance (+ 7.2%). On the other hand, there was a significant decrease in the rate of entrepreneurs planning activities for the coming year (-11.2%) and those planning for the next six months (-6.6%).

The implementation of changes in the sphere of new technologies in Polish enterprises is a specific example of positive changes caused by the coronavirus pandemic. Modern technologies undoubtedly support enterprises in various areas of activity. The benefits of using them were even more visible in the difficult period of their functioning, during the time of the COVID-19 pandemic. Restrictions and limitations introduced to combat the pandemic have prevented many businesses from operating normally. The companies began to compensate for the lack of direct interpersonal contacts with methods using modern technologies. Remote work was used, electronic circulation of documents and IT systems for enterprise management were introduced to a greater extent. Research in this area was conducted by the Polish Economic Institute (Dębkowska, et al., 2020). The most important conclusions from the study show that the range of new technologies introduced to companies during the pandemic is relatively wide, but technologies for contacting customers and building relationships with business partners and providing employees of the company with remote work opportunities are predominant. The participants in the study emphasized that the crisis accelerated the implementation of new technologies, the possession of which proved to be crucial for the functioning of the company in the new reality.

Desk research analysis of documents identified during the monitoring of the functioning of the Polish economy in the period of fight against the pandemic showed the multidimensional development of e-commerce, as well as wider use of tools for electronic identity verification or changes in communication with customers and contractors.

The results of quantitative research indicated that most companies use at least one, and more than a half at least three new technologies. The situation of constraints resulting from the need to counteract the pandemic increased the use of these technologies. Assessing the perspective after the pandemic, companies declare that they will continue to use modern technologies. The summary of the results is presented in Table 1.

Table 1.
Indicators of the use of modern technologies

Values as %	Enterprises before the pandemic: (November 2019)
47	highly rated its state of use of modern technologies in production or services
54	highly rated the use of modern technologies in communicating with their clients
48	highly rated the use of multi-channel sales of its products or services
73	did not invest in modern technologies
	Enterprises during the pandemic: (April 2020)
91	use at least one new technology
70	use modern forms of communicating with clients
10	large companies have implemented remote work management systems during a pandemic (not using them earlier)
	Enterprises after the pandemic: plans
69	intend to use modern forms of communicating with the client
45	intend to use online sales channels and customer service
27	intend to use systems for managing and monitoring remote work

Adapted from: Dębkowska K., Kłosiewicz-Górecka U., Leśniewicz F., Szymańska A., Święcicki I., Ważniewski P., Zybertowicz K. (2020). Raport: Nowoczesne technologie w przedsiębiorstwach przed, w trakcie i po pandemii COVID - 19, Warszawa: Polski Instytut Ekonomiczny. Retrieved from https://pie.net.pl/wp-content/uploads/2020/06/PIE-Raport_Nowoczesne_tehnologie.pdf

The introduced changes will permanently transform the functioning of enterprises. Almost all respondents, regardless of the size of the represented enterprise and sector, indicated that they would permanently introduce the use of modern remote communication systems in their companies. During the crisis, thanks to online communication and the possibility of providing various types of e-services, companies can function relatively efficiently. As the respondents indicated – these solutions will also be beneficial in the future, although at this stage it is still difficult to specify plans and visions. Representatives of micro and small enterprises were mainly those who declared that they would be more focused on Internet activities in the future. It mostly concerned reaching customers, the way of working and handling matters (remote work and electronic document flow), as well as providing services and online sales.

Prof. Nassim Nicholas Taleb stated that we were very lucky that the pandemic broke out in the age of the Internet, because technologies saved us from many negative economic effects of this crisis (Mońka, 2020). They made it possible to introduce many changes and thus enabled many entities to survive.

The change of working style was a sign of the resourcefulness and flexibility of these companies. It is this feature of enterprises that can be perceived as one of the most important determinants of effective change implementation.

4. Flexibility as a condition for effective implementation of changes

It was said that a strategy, management method, systems, processes and people are necessary for the development of a company. Once, when a crisis came, the strategy was changed. Today, the quantity, frequency and scale of changes mean that quick decisions based on an increasingly smaller amount of data have to be made. Changing strategy is not enough anymore, and there is even no time for it. The solution may be flexibility, which should be included in the strategy and ought to facilitate the implementation of changes that adapt the company to the new crisis situation.

A flexible approach can be applied to every aspect and area of the organization's functioning. Flexibility is in structures, processes, systems and people, as well as in how they think, why they think so, and what experiences they have. It is one of the approaches to strategy, which is very useful nowadays (Niewińska, 2021).

It represents the ability to change quickly, i.e., the ability of the system to adapt and react to the external impulses that disturb its current stability.

Flexible and inflexible enterprises are different in such a way that a change, i.e., a reaction to the influence of external or internal factors, can take place during the performance of operational activities, without the need to suspend them (Czerska, Szpitter, 2010), i.e., it does not disturb efficiency. And this is what many companies that make changes during a pandemic want.

Flexibility means a broadly understood ability to adapt an organization to changing environmental conditions. The high popularity of this issue is currently brought by the huge scale of changes caused by the pandemic. However, it should be emphasized that the dynamics of environmental changes has been increasing for a long time, which forces adaptive changes in the organization.

Flexibility can be perceived as a determinant of the company's operation in an extremely turbulent environment (Osbert-Pociecha, 2008). The concept of flexibility was most fully developed by A.C.J. De Leeuw and H.W. Volberd (1996). They assumed that flexible organizations, being open systems, do not have to be "puppets" in the hands of their environment, they can maintain a certain scope of independence (resistance) from their environment and, as part of fulfilling their control function, strive to control their environment (dual nature of flexibility) (Czerska, Szpitter, eds., 2010).

As with the change, this paper only provides a synthetic approach to the perception and definition of flexibility. This is because the concept is widely interpreted in numerous studies (e.g., Krupski, 2005, 2008; Czerska, and Szpitter, 2010; Bridges, 2008; Kwiecień, 2018). The author's intention was only to draw attention to the role of flexibility in the context of introducing changes necessary for the organization to survive in conditions of crisis.

In the past, it was thought that the success of an organization was determined by the level of its resistance to the external influences. However, with the evolution of views, it has been recognised that the organization is an open system, which should not be separated from the influences of the environment. In the event of a general market crisis, it is almost impossible to isolate the company from these influences. The faster and more accurately an enterprise reacts to changes occurring in the environment, the higher its efficiency is, as it means making activities more flexible.

That is why flexibility is one of the most important features a company needs in times of crisis. The ability to quickly adapt to changing conditions in the economic environment may even be a necessary condition for the survival of an organization (Blichiewicz, 2020).

Entrepreneurs agree that in order to survive the period of restrictions related to the next wave of the pandemic, it will be necessary to react very quickly, and accurately recognise the current needs of consumers, i.e., to act with flexibility. The expert emphasizes that many companies do not have very specific solutions for the coming months, because the most important thing is to respond quickly to the changing needs, new restrictions and unstable situation caused by the pandemic (Flexibility, 2020).

Flexibility should always be a part of a company management. This is because it is an attribute of an organization that reflects the position of a given entity on the stability-chaos continuum. However, nowadays, in the conditions of progressing globalization, deregulation of markets, the growing intensity of competitive struggle (according to the pattern of hyper-competition) and the crisis caused by the pandemic, the importance of flexibility as such is increasing.

To emphasize the role of flexibility in the current situation, it can be asked whether the strategies of enterprises are crisis-proof? There is no single correct answer to this. It largely depends on the correctness of the strategy preparation, including its flexibility in specific situations. Crisis situations and a comprehensive, flexible way of dealing with such situations should be planned in the strategies, because although the pandemic is a new and specific phenomenon for us and some situations related to it, such as lockdown, have not appeared before, the very crisis it caused has not occurred before.

This should encourage enterprises to constantly search for new ways and tools of improving their strategies, as it will allow for preparing companies for the crisis. Flexibility can be such a key to success.

A high level of flexibility is a prerequisite for achieving the assumed organizational susceptibility to adaptive changes. Change is not caused by the simple need for change, but in order to achieve a level of effectiveness in action that will ensure a high level of adaptation of the company to the circumstances and enable it to survive or even develop.

A modern, flexible enterprise, operating on the market, has a chance to (Wieniarz, 2018):

- adapt more easily to changes, and thus ensure fast information flow, easier communication within the enterprise and lifting information barriers,
- respond quickly to stimuli from inside and outside the company, to use opportunities and own potential, and overcome weaknesses,
- stimulate the creativity of all employees, integrate them and decentralize decisions.

All these effects should enable the organization to survive and develop in a crisis situation.

In addition to the role of flexibility for modern enterprises described in this study, the literatures shows that flexibility in its various aspects can complement, and often even replace, financial capital as the basic source of value creation (Urbanek, 2011). This is reflected in the higher market valuation of companies whose operation is based on intangible resources as compared to those which exploit mainly tangible assets. It is also an extremely important issue in the time of crisis when many entities are struggling with financial problems.

5. Summary

Summarizing the considerations about changes during the crisis and the related situation of enterprises, an attempt can be made to answer the question of What should enterprises do when they find themselves in a crisis situation and are trying to survive?

The analysis of the presented materials shows that they should change, use new technologies and flexibly adapt to the new situation.

As Peter F. Drucker used to say, "The best method of predicting the future is to create it" (Cytatyinfo, 2012). Therefore, there is nothing for companies to do but to undertake such an attempt and introduce effective changes (Popieluch, 2020).

The past year (2020) was a year of great changes, forced by functioning in pandemic conditions. It verified the approach of entrepreneurs to change. The year showed us very clearly how important it is to be aware of the need for adaptive changes. It also proved that those who are open to them have real resistance to external changes.

Entrepreneurs should analyse the assumptions and goals they defined earlier, before the pandemic, and look for solutions that are adequate to the new situation and provide flexibility of operation. Introducing changes and skilful management of them has now become an extremely important competence. The crisis has become a driving force for transformation that – if it were not for it – probably would not have happened. Companies undertook many changes that had been postponed or not planned at all.

As research shows, many companies have succeeded and successfully implemented changes. They have also applied new technologies that allowed them to survive. Many companies are still fighting for it, so it should be indicated to them that iterative planning

and pilot projects support effective implementation of changes. New technologies will often enable to maintain business continuity, whereas flexibility will make it easier to adapt to a new, demanding situation.

Due to the pandemic, Polish business had to reorganize and introduce changes to continue its functioning. Fortunately, the flexibility of our entrepreneurs, natural competitive advantages and implemented changes have saved many companies from collapsing (Fedoruk, 2020).

However, it is worth following the effectiveness of the changes implemented in the pandemic after its completion. To control whether what allowed to survive will now allow it to develop and continue to function effectively. Further research should include companies that declared that they had implemented effective changes during the pandemic. The analysis of the effectiveness of operations in the long run should show the real effectiveness of the implemented changes

References

1. Auster, E.R., Wylie, K.K., Valente, M.S. (2005). *Strategic Organizational Change: Building Change Capabilities in Your Organization*. New York: Palgrave Macmillan.
2. Beer, M., Nohria, N. (2000). Cracking the Code of Change. *Harvard Business Review*, Vol. 78 (May-June). Retrieved from <https://hbr.org/2000/05/cracking-the-code-of-change>, 21.04.2021.
3. Blichiewicz, Ł. (2020). *Elastycznym organizacjom łatwiej przetrwać kryzys*. Retrieved from <https://www.sluzby-ur.pl/artukul/elastycznym-organizacjom-latwiej-przetrwac-kryzys>, 01.05.2021.
4. Bridges, W. (2008). *Zarządzanie zmianami. Jak maksymalnie skorzystać na procesach przejściowych*. Kraków: Wydawnictwo Uniwersytetu Jagiellońskiego.
5. Businessinsider. Available online <http://businessinsider.com.pl/finanse/makroekonomia/spadek-pkb-i-inwestycji-zwiazany-z-pandemia/qr1mq60>, 21.04.2021.
6. Cytatyinfo (2012). Available online <https://www.cytaty.info/peter-drucker.htm>, 21.04.2021.
7. Czerska, M., Szpitter, A. (Eds.) (2010). *Koncepcje zarządzania*. Warszawa: C.H. Beck.
8. Czop, K. (2016). Zdolność organizacji do zmian i jej wpływ na proces zarządzania zmianą. *Zeszyty Naukowe Politechniki Częstochowskiej, Zarządzanie*, Nr 24, t. 2. Częstochowa, pp. 69-81.
9. De Leeuw, A.C.J. Volberda, H.W. (1996). On the Concept of Flexibility: A Dual Control Perspective. *OMEGA – International Journal of Management Science*. Vol. 24, No. 2, pp. 121-139.

10. Dębowska, K., Kłosiewicz-Górecka, U., Leśniewicz, F., Szymańska, A., Święcicki, I., Ważniewski, P., Zybortowicz, K. (2020). *Raport: Nowoczesne technologie w przedsiębiorstwach przed, w trakcie i po pandemii COVID-19*. Warszawa: Polski Instytut Ekonomiczny. Retrieved from https://pie.net.pl/wp-content/uploads/2020/06/PIE-Raport_Nowoczesne_tehnologie.pdf, 21.04.2021.
11. *Elastyczność kluczem do przetrwania drugiej fali pandemii* (2020). Available online <https://www.wiadomoscihandlowe.pl/artukul/elastycznosc-kluczem-do-przetrwania-drugiej-fali-pandemii>, 30.04.2021.
12. *Encyklopedia zarządzania. Zmiana organizacyjna*. Available online https://mfiles.pl/pl/index.php/Zmiana_organizacyjna, 21.04.2021.
13. Fedoruk, A. (2021). Firmy rodzinne. Specjaliści od pokonywania kryzysów. *Forbes*, 2. Retrieved from <https://www.forbes.pl/kongres-firm-rodzinnych-forbes/2020/czy-w-polsce-oplaca-sie-byc-firma-rodzinna-jak-radzily-sobie-w-czasie-pandemii/djm5995>, 21.04.2021.
14. Gałązka, A. (2020). *Wpływ pandemii na due diligence finansowe oraz wycenę przedsiębiorstwa. Cz. I Analiza EBITDA i wyniki operacyjne*. Retrieved from <https://grantthornton.pl/publikacja/wplyw-pandemii-na-due-diligence-finansowe-oraz-wycene-przedsiębiorstwa-cz-i-analiza-ebitda-i-wyniki-operacyjne/>, 21.04.2021.
15. Green, M., Cameron, E. (2004). *Making sense of change management*. London: Kogan Page.
16. JK (2021). *Bezrobocie w Polsce. Pandemia koronawirusa COVID-19 zmieniła rynek pracy*. Retrieved from <https://www.pulshr.pl/rekrutacja/bezrobocie-w-polsce-pandemia-koronawirusa-covid-19-zmienila-rynek-pracy,80749.html>, 21.04.2021.
17. JK (2021). *Zarządzanie zmianą w czasie pandemii. Jak poradziły sobie firmy?* Retrieved from <https://www.pulshr.pl/zarzadzanie/zarzadzanie-zmiana-w-czasie-pandemii-jak-poradzily-sobie-firmy,78949.html>, 21.04.2021.
18. Kaczmarek, B., Sikorski, Cz. (1999). *Podstawy zarządzania. Zachowania organizacyjne*. Łódź: Wydawnictwo Absolwent.
19. Kaprowska, J., Trojanowski, M. (2017). *Zarządzanie zmianą – jak przekonać podwładnych, że zmiany mają sens?* Retrieved from <https://www.ican.pl/b/zarzadzanie-zmiana---jak-przekonac-podwladnych-ze-zmiany-maja-sens/P1Gm7hfW9>, 21.04.2021.
20. Koper, G. (2020). *Wpływ koronawirusa na gospodarkę Polski*. Retrieved from <https://www.ifirma.pl/aktualnosci/wplyw-koronawirusa-na-gospodarke.html>, 30.04.2021.
21. Krupski, R. (Eds.) (2005). *Zarządzanie przedsiębiorstwem w turbulentnym otoczeniu. Ku superelastycznej organizacji*. Warszawa: PWE.
22. Krupski, R. (Eds.) (2008). *Elastyczność organizacji*. Wrocław: Wydawnictwo UE we Wrocławiu.
23. Krzakiewicz, K. (2008). *Zarządzanie antykryzysowe w organizacji*. Poznań: Wydawnictwo Akademii Ekonomicznej w Poznaniu.

24. Kwiecień, A. (2018). Elastyczność funkcjonowania podmiotów gospodarczych a sukces i kreacja wartości przedsiębiorstw. *Studia Ekonomiczne. Zeszyty Naukowe Uniwersytetu Ekonomicznego w Katowicach*, Nr 377, pp. 52-65.
25. Mońka, B. (2020). *Żadne technologie nie zastąpią kontaktu z ludźmi. Wielki wstrząs, czyli jak pandemia zmienia nas wszystkich*. Retrieved from <https://businessinsider.com.pl/firmy/strategie/pandemia-a-zarządzanie-firma-jak-zmieniaja-sie-liderzy-felieton-beatymonki/8bmm2tg>, 21.04.2021.
26. Morawiecki, M. (2021). *Deficyt budżetu 2020 – o ok. 25 mld zł poniżej znowelizowanego planu*. Retrieved from <https://www.parkiet.com/Gospodarka---Kraj/302039909-Morawiecki-Deficyt-budzetu-2020---o-ok-25-mld-zl-ponizej-znowelizowanego-planu.html>, 21.04.2021.
27. Niewińska M. *Kryzys może być katalizatorem pozytywnej zmiany*. Retrieved from <https://idealab.cbre.pl/organizacja/kryzys-moze-byc-katalizatorem-pozytywnej-zmiany/>, 21.04.2021.
28. Osbert-Pociecha, G. (2011). *Zdolność do zmian jako siła sprawcza elastyczności organizacji*. Wrocław: Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu.
29. Osbert-Pociecha, G., Moroz, M., Lichtarski, J.M. (2008). Elastyczność przedsiębiorstwa jako konfiguracja elastyczności częściowych. *Gospodarka Narodowa*, nr 4, pp. 59-84.
30. Pellettiere, V. (2006). Organization Self-Assessment to Determine the Readiness and Risk for a Planned Change. *Organization Development Journal*, Vol. 24(4), pp. 38-43.
31. Popieluch, K. (2020). *Zarządzanie zmianą 3D, a zarządzanie kryzysowe*. Retrieved from <https://www.kaizenhr.pl/publikacje/zarządzanie-zmiana-w-kryzysie.html>, 21.04.2021.
32. Ratajczak, J. (2020). *Koronawirus uderza w małe firmy. Problemy finansowe MŚP*. Retrieved from <https://www.wroclaw.pl/przedsiębiorczy-wroclaw/badanie-imas-international-plynnosc-finansowa-msp-w-pandemii>, 21.04.2021.
33. Rubin, J., Naumiuk, M., Grabowski, W. (2021). *Raport OBZZ – VI Ogólnopolskie badanie zarządzania zmianą*. Szkoła Zarządzania Zmianą. Retrieved from https://www.izbacoachingu.com/wp-content/uploads/2021/01/Raport_OBZZ2021.pdf, 21.04.2021.
34. Strzemecki, P. (2015). Strategie organizacji w sytuacji kryzysowej. *Zeszyty Naukowe PWSZ w Płocku Nauki Ekonomiczne*, t. XXII, pp. 27-34.
35. Urbanek, G. (2011). *Kompetencje a wartość przedsiębiorstwa: Zasoby niematerialne w nowej gospodarce*. Warszawa: Oficyna a Wolters Kluwer business.
36. Walas-Trębacz, J. (2009). Zmiany organizacyjne przeprowadzane w przedsiębiorstwie. *Zeszyty Naukowe Małopolskiej Wyższej Szkoły Ekonomicznej w Tarnowie*, nr 2(13), pp. 31-41.
37. Walczak, W. (2009). Metodyka zarządzania zmianami organizacyjnymi. *Kwartalnik Nauk o Przedsiębiorstwie*, nr 4, pp. 71-77.

38. Wieniarz, M. (2018). *Zarządzanie procesami i jego rola w dynamicznych koncepcjach zarządzania*. Retrieved from <https://docer.pl/doc/xnevccv>, 21.04.2021.
39. Włodarczyk, J. (2020). *Jak efektywnie zarządzać firmą w nowej rzeczywistości biznesowej?* Retrieved from <https://www.crowe.com/pl/insights/jak-efektywnie-zarzadzac-firma-w-nowej-rzeczywistosci-biznesowej>, 21.04.2021.

THE IDENTIFICATION OF PROBLEMATIC SOFTWARE TESTERS MANAGEMENT AREAS

Alina LANGA^{1*}, Ireneusz J. JÓŹWIAK², Kacper STAROŚCIAK³, Jan SWITANA⁴,
Alicja M. JÓŹWIAK⁵, Wojciech M. NOWAK⁶

¹ Wrocław University of Science and Technology, Faculty of Computer Science and Management, Wrocław;
alina.langa2@gmail.com

² Wrocław University of Science and Technology, Faculty of Computer Science and Management, Wrocław;
ireneusz.jozwiak@pwr.edu.pl, ORCID: 0000-0002-2160-7077

³ Wrocław University of Science and Technology, Faculty of Electronics, Wrocław;
kacper.starosciak@gmail.com

⁴ Wrocław University of Science and Technology, Faculty of Microsystem Electronics and Photonics, Wrocław;
switana.jv@mail.com, ORCID: 0000-0001-7188-8199

⁵ Wrocław University of Science and Technology, Faculty of Architecture, Wrocław; ajozwiak07@gmail.com,
ORCID: 0000-0002-8796-2549

⁶ Wrocław University of Science and Technology, Faculty of Architecture, Wrocław;
wojciech98nowak@gmail.com, ORCID: 0000-0003-4861-8566

* Correspondence author

Purpose: The purpose of this paper is to explore the condition of managing manual software testers.

Design/methodology/approach: The analysis is based on a survey targeting three groups (managers, testers, development team members) that will touch on areas consistent with the management functions.

Findings: The condition of testers' management can be described as good, but there is a probability of improvement for the areas that have been studied.

Research limitations/implications: It's worth carrying out similar research on larger samples to make sure about the obtained averages values and statistical differences between them. It's also worth proposing methods to improve the possible problematic areas that have been found in this research paper.

Practical implications: This paper may draw the attention of managers whose subordinates are software testers that there are areas where they can improve their management.

Originality/value This research shows how testers' management is perceived by managers, how it is perceived by testers and how it is perceived by other members of development teams.

Keywords: software tester management, management function, manual testing.

Category of the paper: Research paper.

1. Introduction

Software testing is often treated dismissively. It's not only a separate opinion of the authors of this article but it's also pointed out in the literature on the subject. For example, it's noted (Roman, 2015) that while it can be said that software testing exists as long as its development, many organizations only pay attention to employing high-class programmers, at the side of which, unfortunately, testers with both low experience and commitment still happens to work, because their competences and qualifications are not so comprehensively verified. Even testers working in such a huge and significant organization as Google weren't treated equally, until they have learned the techniques of tests automation (Whittaker et al., 2012). Managers often forget that this approach leads to high risk of releasing applications with critical defects, which consequently gives rise to significant additional costs.

The key core of software testing management is software testers management. This is caused by the specificity of their work, because software testing is hard to observe. He's not a producing worker – he's a worker who controls what others have produced. Tester shouldn't therefore be assessed directly for the effects that are visible from the outside, but for his general attitude to the position as well as approach to the duties entrusted to him. It's related to the differences between human psychology and testing (Certyfikowany tester, ISTQB, 2018) because informing about errors detected by the tester may be perceived by other people involved in the product as a reprimand, although it should be a natural part of working on software. The measurability of the effects is often in conflict with diplomacy in communication. Tester should not show satisfaction with the errors he found, to avoid offending the programmers. On the other hand, for managers, sometimes it's the only determinant of whether the tester has done his job. If there are no bugs in the application, the tester's work may go unnoticed.

The research carried out at the initial stage of this work didn't reveal the existence of any research concerning the diagnosis of the condition of software testing management. It was decided to identify areas of testers management that make problems.

2. Management functions in the context of testers management

Management functions are logical groups of activities related to each other. Continuous performance of them is one of the basic duties of every manager (Koźmiński, Piotrowski, 2007). These functions are planning, organizing, leading and controlling (Griffin, 2004). Different authors distinguish management functions differently, for example by adding human resources (Koontz, O'Donnell, 1972) to them or identification (Stabryła, 2018). Others omit leading,

limiting them to planning, organizing and controlling Steinmann, Schreyogg, 2001). Some authors expand this classification even further, listing as many as nine functions: planning, organizing, information and knowledge management, organization financial management, operations management, personnel policy, marketing and public relations, negotiations, controlling (Jemielniak, Koźmiński, 2011). The first of the typologies, that is planning, organizing, leading and controlling, was considered by the authors of this work to be the most universal and adequate to the problem discussed in it, therefore it will be subject to further considerations.

Planning can be defined as setting goals and ways to achieve them (Griffin, 2004). It allows gathering tips on how to act. It's a kind of starting point for all activities undertaken. It doesn't only mean setting goals, but also the ways in which they will be monitored and controlled. The main difference between monitoring planning and controlling planning is that monitoring planning determines how progress will be checked, and controlling planning determines how the effect of this work will be checked. With regard to the management of testers, it seems interesting to figure out what action should be taken by the tester and what should be achieved by these actions, because his work is often highly creative. The set goals should be measurable, specific and unambiguous by definition, so there is a supposition that such formulation of goals may be difficult when managing testers. It may also be problematic to figure out ways to monitor and control work, also because of their frequent non-normative character.

Organizing is a logical grouping of activities and resources (Griffin, 2004). It consists in coordinating and sharing work – so as not to create conflicts and properly allocate human resources. It should allow the manager to be relieved of the duties that have been entrusted to him, as long as his employees have the appropriate competences to be able to fulfill them. It is also extremely important to create an appropriate communication network between employees so that they are as well informed as possible about what co-workers are doing, which prevents duplication of work and gives a picture of the current situation of activities. The quality of the testers work organization can be recognized by comparing the planned time for the tests with the actual duration time. It can also be recognized that the division of labor between the testers is right – if no one is overloaded, if no one is obliged to do many small tasks and simultaneously focus their attention on different disjoint areas of action.

Leading, that is the most important and most ambitious managerial activities. They are used to encourage employees to cooperate so that it benefits their organization (Griffin, 2004). The manager should, through his interpersonal skills, ensure good communication with his subordinates. He should also motivate in such a way as to have a positive impact on employees for both sides. In the case of testers management it is particularly important to give consent to going beyond schemes – while guarding that these schemes were also filled. It is worth paying attention to the existence of an interesting form of leadership, which is situational leadership (Blanchard et al., 2019). It consists in the appropriate adaptation of the management style depending on the competences of the employee and the commitment he puts in the work.

There is a suspicion that the situational leadership is rarely used to manage the testers, which can be invaluable loss for many organizations.

Controlling is watching the progress of the objectives (Griffin, 2004). Here there is a direct reference to the planning, the implementation of the established monitoring and control there. With regard to tester management, it can be considered whether the work of testers is actually measurable, because only by meeting this condition can we talk about the proper implementation of this function.

In summary, each of these management functions can be easily applied in theory to the management of testers. It may be more difficult, however, to perform them in reality. It should be remembered that in order for the use of management functions to bring measurable results, it's necessary to use them all at the same time, skillfully intertwining them.

3. Research goal and design of the survey

The research goal is to identify problematic areas of testers management. These areas will be divided according to the management functions, as well as more detail, narrowing them to specific managerial challenges. To achieve this will be used one-time survey.

The research material will be three groups of thirty people professionally related to software testing. The first group included in the research will be managers whose subordinates are testers. The next group will be just software testers. The last group consists of people cooperating with testers, so they will be other members of project teams.

Summing up, 90 people will be surveyed. The estimated return of surveys sent via LinkedIn, a social networking site that specializes in professional and business contacts, is about 5% (Stokes et al., 2019). This means that to get 90 completed questionnaires, should contact about 1,800 people. Despite such a low level of feedback, it was decided to distribute the survey by LinkedIn because it is considered a reliable source of information about the professional experience of users (Paliszkiewicz, 2018), which will allow the survey to be directed to the appropriate target group. Attempts will be made to increase the feedback rate by designing a questionnaire with a short completion time, that would be about 5 minutes, and by personalizing invitations to complete the survey sent in private messages. The survey will be anonymous with an optional possibility to sign.

The questionnaire will contain a list of closed questions. The answer scale used for all questions will be a five-point Likert scale (Kaczmarek, Tarka, 2013): 1) definitely not, 2) probably not, 3) I don't know, 4) probably yes, 5) definitely yes.

The list of questions, divided into categories, is as follows:

1. Planning

P1 – Is in your team defined what actions the tester should take?

P2 – Is in your team defined what the tester should achieve with his actions?

P3 – Is in your team defined how the tester's activities will be monitored – how will the progress of work be checked?

P4 – Is in your team defined a way in which the tester's activities will be controlled – how will the results of the work be checked?

2. Organizing

P5 – Is there equality in your team between estimation of the time needed for tests and how much time actually needs to be spent on them?

P6 – Is the division of labor between the testers in your team appropriate?

P7 – Does it happen in your team that testers interfere with each other, for example if they are working on the same test environment?

P8 – Does the tester in your team has the appropriate competences, some managerial responsibilities and decision-making powers delegated to him by the manager?

P9 – Is communication between testers in your team good?

P10 – Is communication between testers and other team members in your team good?

3. Leading

P11 – How good is communication between testers and the manager in your team?

P12 – Is in your team openness to ideas and creativity of testers?

P13 – Is there a different treatment due to competences and commitment of testers in your team?

P14 – Is there a proper motivation for testers to do their work?

4. Controlling

P15 – Is tester's work measurable in your team?

P16 – Are tester's activities monitored in your team (is the progress of tester's work always checked)?

P17 – Are in your team tester's activities controlled (is the result of tester's work always checked)?

4. Analysis of the results

Collecting responses to the survey was launched on 6 October 2020. A higher than expected feedback, around 20%, allowed to complete the collection of responses on 27 October 2020.

The survey was attended by 30 managers, 30 manual testers and 30 other team members. In the last mentioned group were programmers, business analysts, UX and UI designers, system architects and consultants. Managers and team members work directly with manual software testers.

Valuing answers for the P7 question was reversed for purposes of analysis because it has the opposite sense than all the other questions.

The overall average of all responses without the division into target groups and categories was 3,71, which means that the overall assessment of tester management quality is the closest to the answer "Probably yes". Therefore, it is assessed more positively than negatively. The variance was 1,45. We can define the variance as quite large, so the responses are varied. The obtained skewness is -0,83. This indicates a left-hand distribution, which can be interpreted so that most of the respondents placed the assessment above average.

Average, variance and skewness for the results of the research divided into categories are presented in the table 1. The highest average was achieved for the planning area and the lowest for controlling. At the same time, the highest variance was obtained for controlling and the lowest for leading. Also recorded the highest skewness for leading, and the lowest for organizing.

Table 1.

Average, variance and skewness of the results divided into categories

	Average	Variance	Skewness
Planning	3,80	1,50	-0,90
Organizing	3,76	1,44	-0,91
Leading	3,64	1,34	-0,65
Controlling	3,60	1,56	-0,81

Source: own work.

It would be interesting to know whether the variation in the results obtained in these categories varies significantly. To determine this, a one-way variance analysis ANOVA will be performed using the Excel Data Analysis tool at the significance level $\alpha = 0,05$. The test hypotheses are as follows:

H0: $\mu_{\text{Planning}} = \mu_{\text{Organizing}} = \mu_{\text{Leading}} = \mu_{\text{Controlling}}$

H1: it's not true that H0

The resulting table 2 provides a summary – the test statistics such as the number of elements, sums, averages, and variances. In the table 3 a variance analysis is presented, including the sum of squares SS, degrees of freedom df, square averages, F value, p-value and a critical F value for a given df. The value that we are primarily interested in is p-value. It's higher than the significance level, that is, we don't have the basis to reject the zero hypothesis. On the basis of the sample, we can therefore conclude that, at the accepted significance level, the differences between the averages in the populations of the categories under consideration are not statistically significant.

Table 2.*One-way ANOVA for categories – summary*

Groups	Counter	Sum	Average	Variance
Planning	360	1368	3,8	1,497493
Organizing	540	2028	3,755556	1,435498
Leading	360	1312	3,644444	1,34398
Controlling	270	973	3,603704	1,563555

Source: own work.

Table 3.*One-way ANOVA for categories – variance analysis*

Sources of variance	SS	df	MS	F	p-value	F test
Between groups	8,620044	3	2,873348	1,980081	0,115033	2,610734
Within groups	2214,419	1526	1,451126			
Total	2223,039	1529				

Source: own work.

The table 4 presents averages, variances and skewness for the survey results divided into a target groups. The highest average and response skewness were achieved among managers and the lowest among testers. Conversely was the response variance – the lowest was among managers and the highest was among testers.

Let's check whether the differences between the averages in the population surveyed by target groups are statistically significant. We will also use a one-way ANOVA at the significance level $\alpha = 0,05$. The test hypotheses are as follows:

H0: $\mu_{\text{Managers}} = \mu_{\text{Testers}} = \mu_{\text{OtherTeamMembers}}$

H1: it's not true that H0

Table 4.*Average, variance and skewness of the results divided into target groups*

	Average	Variance	Skewness
Managers	4,09	1,15	-1,37
Testers	3,44	1,57	-0,52
Other team members	3,61	1,42	-0,74

Source: own work.

The resulting summary is shown in the table 5 and the variance analysis is shown in the table 6. The p-value was set to 0 by the tool¹, so is very small much less than the significance level. To make sure, it has also been calculated with another, more accurate tool and amounted to 1,1102e-16. We can therefore reject a zero hypothesis in favor of an alternative hypothesis and conclude that the differences between the averages in populations of the samples are statistically significant.

¹ One-way ANOVA post-hoc Tukey HSD Calculator, https://astatsa.com/OneWay_Anova_with_TukeyHSD/.

Table 5.*One-way ANOVA for target groups – summary*

Groups	Counter	Sum	Average	Variance
Managers	510	2086	4,090196	1,147055
Testers	510	1753	3,437255	1,574641
Other team members	510	1842	3,611765	1,416757

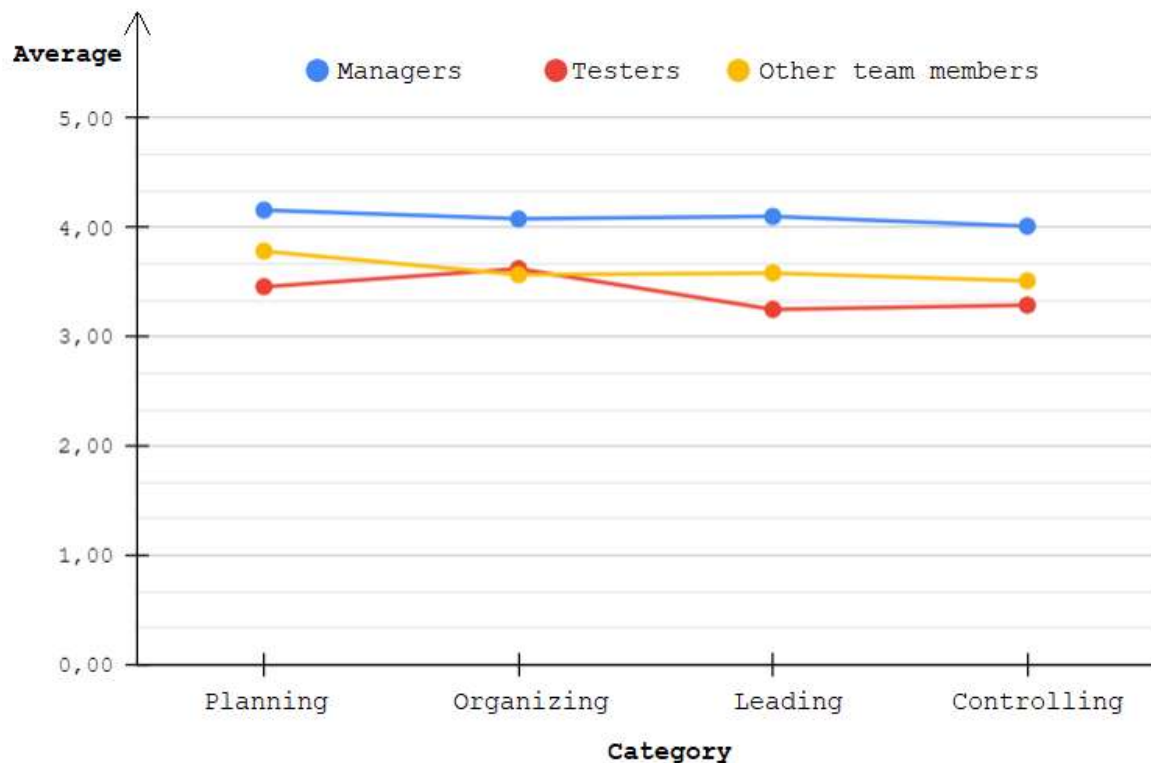
Source: own work.

Table 6.*One-way ANOVA for target groups – variance analysis*

Sources of variance	SS	df	MS	F	p-value	F test
Between groups	116,566	2	58,28301	42,24985	0	3,001617
Within groups	2106,473	1527	1,379484			
Total	2223,039	1529				

Source: own work.

The additional post-hoc Tukey HSD analysis, carried out using the same tool used to ensure the p-value, showed that there are statistically significant differences in the averages between each of the three pairs of groups, namely between managers and testers ($H_0: \mu_{\text{Managers}} = \mu_{\text{Testers}}$, H_1 : it's not true that H_0 , p-value = 0,0010053), between managers and other team members ($H_0: \mu_{\text{Managers}} = \mu_{\text{OtherTeamMembers}}$, H_1 : it's not true that H_0 , p-value = 0,0010053) and even between testers and other team members ($H_0: \mu_{\text{Testers}} = \mu_{\text{OtherTeamMembers}}$, H_1 : it's not true that H_0 , p-value = 0,0467403).

**Figure 1.** The chart of average results for categories by target groups. Source: own work.

As we start the analysis at a lower level and now have more detailed results to compare, so to make the differences more visible, a chart (fig. 1) of the average results for the categories by group is prepared based on the data in the table 7. The chart shows that managers gave the average highest responses in each category. The lowest average responses were provided by testers, except for organizing where the other members gave the lowest responses.

Table 7.

Average, variance and skewness of the results divided into target group and categories

	Managers			Testers			Other team members		
	Average	Variance	Skewness	Average	Variance	Skewness	Average	Variance	Skewness
Planning	4,16	1,34	-1,29	3,46	1,51	-0,54	3,78	1,41	-1,06
Organizing	4,08	1,13	-1,46	3,62	1,57	-0,71	3,57	1,46	-0,70
Leading	4,10	0,86	-1,21	3,25	1,63	-0,33	3,58	1,19	-0,34
Controlling	4,01	1,31	-1,42	3,29	1,51	-0,43	3,51	1,62	-0,81

Source: own work.

We already know that there are statistically significant differences between the average responses of managers, testers and members, so we will no longer analyze whether there are significant statistical differences between the averages for groups by category. We will look at whether there are differences between the categories for each of the groups separately, because we had no reason to reject the hypothesis that the averages for the categories (without a division into groups) are equal at the given significance level. For this purpose, we will perform a one-way ANOVA tree times at the significance level $\alpha = 0,05$. The first will be performed with the following test hypotheses for managers only:

H0: $\mu_{\text{PlanningM}} = \mu_{\text{OrganizingM}} = \mu_{\text{LeadingM}} = \mu_{\text{ControllingM}}$

H1: it's not true that H0

P-value is 0,799625. It's higher than the significance level, that is, we don't have the basis to reject the zero hypothesis. On the basis of the sample, we can therefore conclude that, at the accepted significance level, for managers the differences between the averages in the populations of the categories under consideration are not statistically significant. The second analysis will be performed with the following test hypotheses for testers only:

H0: $\mu_{\text{PlanningT}} = \mu_{\text{OrganizingT}} = \mu_{\text{LeadingT}} = \mu_{\text{ControllingT}}$

H1: it's not true that H0

P-value is 0,048174. It's lower than the significance level, that is, we can reject a zero hypothesis in favor of an alternative hypothesis and conclude that for testers the differences between the averages in populations of the samples are statistically significant. The third analysis will be performed with the following test hypotheses for other team members only:

H0: $\mu_{\text{PlanningO}} = \mu_{\text{OrganizingO}} = \mu_{\text{LeadingO}} = \mu_{\text{ControllingO}}$

H1: it's not true that H0

P-value is 0,326192. It's higher than the significance level, that is, we don't have the basis to reject the zero hypothesis. On the basis of the sample, we can therefore conclude that, at the accepted significance level, for other team members the differences between the averages in the populations of the categories under consideration are not statistically significant.

Different authors distinguish management functions differently, for example by adding human resources (Knootz, O'Donnell, 1972) to them or identification (Stabryła, 2018). Others omit leading, limiting them to planning, organizing and controlling (Steinmann, Schreyogg, 2001). Some authors expand this classification even further, listing as many as nine functions: planning.

The obtained p-value for testers was very close to the significance level. An additional Tukey HSD post-hoc analysis has been carried out which showed that there are no statistically significant differences between the averages for the categories – planning and organizing ($H_0: \mu_{\text{PlanningT}} = \mu_{\text{OrganizingT}}$, H_1 : it's not true that H_0 , p-value = 0,6604168), planning and leading ($H_0: \mu_{\text{PlanningT}} = \mu_{\text{LeadingT}}$, H_1 : it's not true that H_0 , p-value = 0,5602368), planning and controlling ($H_0: \mu_{\text{PlanningT}} = \mu_{\text{ControllingT}}$, H_1 : it's not true that H_0 , p-value = 0,7392183), organizing and leading ($H_0: \mu_{\text{OrganizingT}} = \mu_{\text{LeadingT}}$, H_1 : it's not true that H_0 , p-value = 0,0567492), organizing and controlling ($H_0: \mu_{\text{OrganizingT}} = \mu_{\text{ControllingT}}$, H_1 : it's not true that H_0 , p-value = 0,1653593), leading and controlling ($H_0: \mu_{\text{LeadingT}} = \mu_{\text{ControllingT}}$, H_1 : it's not true that H_0 , p-value = 0,8999947).

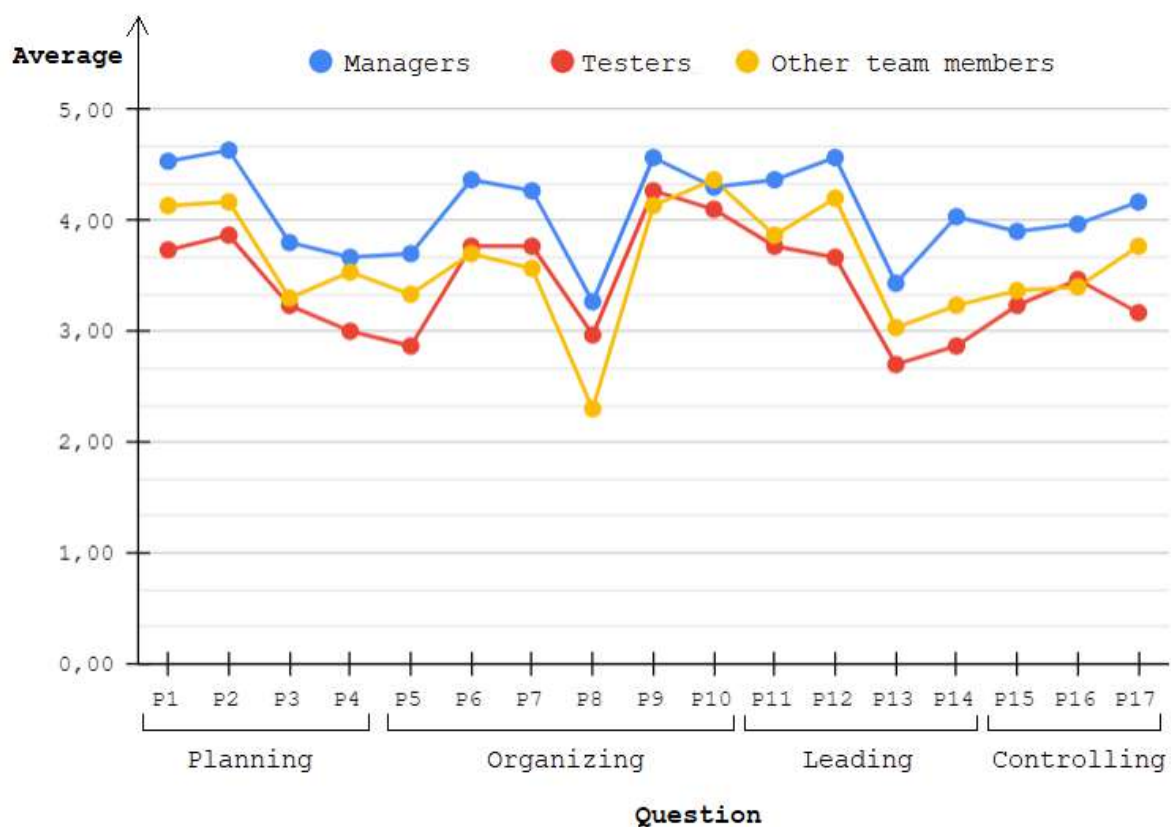


Figure 2. The chart of average results for questions by target groups. Source: own work.

We will carry out an analysis at an even deeper level, namely by target groups and by questions. The average, variance and skewness of the results are presented in a table 8 and it was a base for a chart, shown in the figure 2. Additionally, a table 10 has been prepared, in which the questions for each target group were sorted according to the average obtained in them.

The lowest rated questions were those with an average answer of less than 3, below the neutral answer. They are bolded in the table 10. There were no such questions among managers at all, there were four such questions among testers, and the other members included one. Both testers and the other members pointed to question P8, concerning the delegation of managers responsibilities and decision-making powers, if testers have the appropriate competence. Testers also rated the lowest P13 question about differentiated treatment based on their competencies and commitment, P5 question about inconsistencies between estimation of the time needed for tests and how much time actually needs to be spent on them and P14 question about motivation for testers to their work. Summing up, among the lowest rated questions were questions from the areas of organizing (P5, P8) and leading (P13, P14).

Managers rated the highest on P2 question related to defining what the tester should achieve with his actions. On the other hand, the testers rated the highest P9 question about communication between testers. The other team members rated the highest on P10 question regarding communication between testers and other team members. So it's worth to check how the communication between testers and managers was rated (P11 question) – it also doesn't look bad and in each of target groups it was in the second half of the total number of questions.

Table 8.

Average, variance and skewness of the results divided into target group and questions

		Managers			Testers			Other team members		
		Average	Variance	Skewness	Average	Variance	Skewness	Average	Variance	Skewness
Planning	P1	4,53	0,88	-2,66	3,73	1,31	-0,92	4,13	0,81	-1,80
	P2	4,63	0,65	-3,40	3,87	0,95	-0,92	4,17	0,63	-1,21
	P3	3,86	1,39	-0,73	3,23	2,05	-0,37	3,30	1,94	-0,42
	P4	3,67	1,82	-0,52	3,00	1,38	0,00	3,53	1,84	-0,74
Organizing	P5	3,70	1,32	-1,11	2,87	1,43	-0,37	3,33	1,06	-1,15
	P6	4,37	0,52	-1,29	3,77	1,15	-0,94	3,70	1,04	-0,79
	P7	4,27	0,62	-1,44	3,77	1,50	-0,73	3,57	1,29	-0,56
	P8	3,27	2,41	-0,24	2,97	1,96	-0,10	2,30	1,46	0,38
	P9	4,57	0,25	-0,28	4,27	1,03	-1,43	4,13	0,81	-0,58
	P10	4,30	0,63	-2,38	4,10	0,85	-1,05	4,37	0,65	-1,63
Planning	P11	4,37	0,45	-1,33	3,77	1,43	-0,95	3,87	0,81	-0,33
	P12	4,57	0,32	-0,88	3,67	1,26	-0,68	4,20	0,92	-1,68
	P13	3,43	1,56	-0,46	2,70	1,53	0,15	3,03	1,55	0,28
	P14	4,03	0,45	-0,04	2,87	1,57	-0,07	3,23	0,67	0,34
Controlling	P15	3,90	1,20	-1,48	3,23	1,29	-0,49	3,37	1,48	-0,90
	P16	3,97	1,41	-1,38	3,47	1,71	-0,47	3,40	1,70	-0,52
	P17	4,17	1,39	-1,70	3,17	1,59	-0,45	3,77	1,70	-1,23

Source: own work.

In the table 9 are shown questions that have statistically different averages for groups. This was calculated using the Tukey HSD test² at the significance level $\alpha = 0,05$ and only the results obtained are presented in the table. The notations used are: M – averages are significantly different for managers, T – averages are significantly different for testers, O averages are significantly different for other team members. Based on this in the table 10 have been marked with blocks questions for which we cannot exclude that their average for the whole population are equal to those previously considered to be the lowest (bold in the table 10). For example, for testers for question P13 this was done in the following way: If you selected P13 question earlier, you should also mark the P1, P2, P3, P4, P5, P7, P12, P14, P15, P16, P17 questions because there is a significant probability that differences in these averages are not coincidental. The same operation was performed for the other bold questions.

Table 9.

Statistically different averages for questions divided by target groups

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17
P1	-							MO					MO				
P2		-	T	M	M			MO					MO				
P3		T	-					O		O							
P4		M		-				O	T	T							
P5		M			-			O	T	TO							
P6						-		MO					MT				
P7							-	MO					T				
P8	MO	MO	O	O	O	MO	MO	-	MTO	MTO	MO	MO			O	O	O
P9				T	T			MTO	-				MTO	T			T
P10			O	T	TO			MTO		-			TO	TO	O		
P11								MO			-		MT				
P12								MO				-	MO				
P13	MO	MO				MT	T		MTO	TO	MT	MO	-				
P14									T	TO				-			
P15								O		O					-		
P16								O								-	
P17								O	T								-

Source: own work.

Among testers only P9, P10 and P11 questions stayed unchecked – all of them relate to communication, respectively, between testers, between testers and other team members, and between testers and managers. For other team members, only two additional questions were marked, namely P13 and P14 – both of these questions were previously bolded for testers. Finally, all the questions selected, both in bold and marked rectangles, should be considered the lowest.

² Due to the limitation of the number of columns in the previous tool, in this case the calculation was done with: One Way ANOVA Calculator, Analysis Of Variance, Tukey HSD test, <https://www.statskingdom.com/180Anova1way.html>.

Table 10.*Average results for questions sorted ascending*

Managers		Testers		Other team members	
Question	Average	Question	Average	Question	Average
P8	3,27	P13	2,70	P8	2,30
P13	3,43	P5	2,87	P13	3,03
P4	3,67	P14	2,87	P14	3,23
P5	3,70	P8	2,97	P3	3,30
P3	3,80	P4	3,00	P5	3,33
P15	3,90	P17	3,17	P15	3,37
P16	3,97	P3	3,23	P16	3,40
P14	4,03	P15	3,23	P4	3,53
P17	4,17	P16	3,47	P7	3,57
P7	4,27	P12	3,67	P6	3,70
P10	4,30	P1	3,73	P17	3,77
P6	4,37	P6	3,77	P11	3,87
P11	4,37	P7	3,77	P1	4,13
P1	4,53	P11	3,77	P9	4,13
P9	4,57	P2	3,87	P2	4,17
P12	4,57	P10	4,10	P12	4,20
P2	4,63	P9	4,27	P10	4,37

Source: own work.

5. Summary

Each of the management functions can be reflected in the management of testers. Designed and conducted survey showed that the overall condition of the testers management is not the worst. It's hard to distinguish specific management functions that would look better or worse in the study – the condition of each can be described as good but not very good, which creates place for improvement. It was clearly noted that managers were the best to judge the management of the testers, and they actually judged their own work. Worse results were reported in the assessments of the other team members, and the worst management was judged by the most involved in testing – testers. When the results were divided by the target groups and the differences in averages between the different management functions were analyzed separately for each of them, it was once again difficult to find significant differences among all the groups.

References

1. Blanchard, K., Zigarmi, P., Zigarmi, D. (2019). *Jednominutowy menedżer i przywództwo. Przywództwo sytuacyjne i lepsza komunikacja na linii przełożony-podwładny*. Warszawa: MT Biznes.
2. *Certyfikowany tester. Sylabus poziomu podstawowego ISTQB*. International Software Testing Qualifications Board, Stowarzyszenie Jakości Systemów Informatycznych, ver. 2018, V 3.1.
3. Griffin, R.W. (2004). *Podstawy zarządzania organizacjami*. Warszawa: PWN.
4. Jemielniak, D., Koźmiński, A.K. (2011). *Zarządzanie od podstaw*. Warszawa: Wolters Kluwer.
5. Kaczmarek, M., Tarka, P. (2013). *Metoda gromadzenia danych a ekwiwalencja wyników pomiaru systemu wartości w 5- i 7-stopniowych skalach ratingowych likerta*. Handel Wewnętrzny.
6. Koontz, H., O'Donnell, C. (1972). *Principles of Management: An Analysis of Managerial Functions*. New York: McGraw-Hill Companies.
7. Koźmiński, A.K., Piotrowski, W. (2007). *Zarządzanie. Teoria i praktyka*. Warszawa: PWN.
8. Paliszkiewicz, J. (2018). *Kreowanie w mediach społecznościowych wizerunku kandydata do pracy na przykładzie portalu linkedin*. Human Resource Management/Zarządzanie Zasobami Ludzkimi.
9. Roman, A. (2015). *Testowanie i jakość oprogramowania. Modele, techniki, narzędzia*. Warszawa: PWN.
10. Stabryła, A. (2018). *Podstawy organizacji i zarządzania. Podejścia i koncepcje badawcze*. Kraków: Wydawnictwo Uniwersytetu Ekonomicznego.
11. Steinmann, H., Schreyögg, G. (2001). *Zarządzanie. Podstawy kierowania przedsiębiorstwem. Koncepcje, funkcje, przykłady*. Wrocław: Oficyna Wydawnicza Politechniki Wrocławskiej.
12. Stokes, Y., Vandyk, A., Squires, J., Jacob, J.D., Gifford, W. (2019). *Using facebook and linkedin to recruit nurses for an online survey*, Western Journal of Nursing Research.
13. Whittaker, J.A., Arbon, J., Carollo, J. (2012). *Testuj oprogramowanie jak Google. Metody automatyzacji*. Gliwice: Helion.

A STRATEGY FOR RESEARCHING THE PERFORMANCE OF WEB APPLICATIONS CLIENTS

Hubert ŁOPUSIŃSKI^{1*}, Mateusz ŁOPUSIŃSKI², Ireneusz J. JÓŹWIAK³,
Kacper STAROŚCIAK⁴

¹ Wrocław University of Science and Technology, Faculty of Computer Science and Management;
hubert.lopusinski@gmail.com

² Wrocław University of Science and Technology, Faculty of Computer Science and Management;
mateusz.lopusinski2@gmail.com

³ Wrocław University of Science and Technology, Faculty of Computer Science and Management;
ireneusz.jozwiak@pwr.edu.pl, ORCID 0000-0002-2160-7077

⁴ Wrocław University of Science and Technology, Faculty of Electronics; kacper.starosciak@gmail.com
* Correspondence author

Purpose: The article presents a comparative analysis of the web application clients performance.

Design/methodology/approach: A strategy of comparing the performance of web application clients using the JavaScript programming language was proposed.

Findings: The metrics used to measure the performance of web application clients were presented.

Research limitations/implications: Techniques affecting the optimal work of web application clients, which can be used regardless of the technology applied were described.

Originality/value: Comparison of the performance of frameworks using the JavaScript programming language. The necessary steps during the process of testing the performance of web applications were proposed and measures relevant to the test were listed. The article is dedicated to the wide spectrum of computer system users.

Keywords: web application, performance, research strategy.

Category of the paper: Research paper.

1. Introduction

Poor software performance is a problem that developers have been struggling with from the very beginning of personal computers existence. Initially, the difficulty was in the implementation of programs that had to be run on equipment with much weaker parameters than those used today. The first IBM PCs had 4.77 MHz processors, while today it is about 3-5 GHz, which is a thousand times more. The most visible progress can be noticed in

RAM memory, because in the past PCs had an amount of RAM equal to 16 KB, and today the standard is from 8 to 16 GB, which means it is a million times more memory. The problem of software performance was then focused on the minimum consumption of hardware resources, which were so small, therefore so valuable. It is also an open secret, that people has not been requiring quick software response time because they were not used to new technologies and their capabilities yet.

It should be remembered that technology and its development are supposed to be human-friendly, facilitating and supporting their work, as well as providing entertainment, e.g. through various types of computer games. Modern society is accustomed to well-developed technology, which is why it has high requirements for software functionality and requires fast response time of mobile applications, web applications, desktop applications and websites. This is obvious, because every time we use a computer or smartphone, we always want them to perform our tasks as quickly and as efficiently as possible. In the 21st century, time is a highly valued resource. People try to save their time in every possible aspect of life, hence they would rather use from the quick meals, quick trainings, quick conversations etc. Many people get nervous very quickly when an application or computer system freezes, does not work properly, is not intuitive or it takes a long time to wait for a response from the system.

For the reasons mentioned above, the question of user feelings has become the subject of interest in the area of software development. A new profession is emerging, a designer of user experience employed in many companies. There are many similar applications on the market. Therefore, companies try to attract users and encourage them to use their product. A satisfied user is an additional profit for the application producer, e.g. by advertising or buying a license for the given software. On the other hand, a dissatisfied user will most likely not want to use the application and will be looking for applications with similar functionalities at the competing companies.

The user experience consists of many aspects, including the response time of the application, and thus the software performance. Manufacturers ensure that their software is the fastest and the best on the market, but these are usually mere lies. Software performance is verified by the empirical usage of the program by its clients, but there are many tools that can be used to audit system performance. Having measurements obtained using professional tools and using additional statistical methods and tests, comparison of the performance of various applications can be conducted.

In the article the performance analysis of web applications were presented. Necessary steps during the process of testing the performance of web applications were proposed. Important metrics to conduct performance test were listed. The performance of frameworks using the JavaScript programming language was compared.

2. Technologies used to create software

An important aspect for the manufacturer himself is the choice of technology used to create the software. First of all, it must be a new technology, because technological debt is very difficult and expensive debt for the company itself. Moreover, employees do not want to work using old technologies, they want to develop and use modern solutions. There are a lot of frameworks, libraries and tools on the market that support programmers during software development. Choosing the right tools for software development also affects the quality of the final product. Not every tool used in the software development process is perfect. There are better and worse tools that can be used to achieve the same set of system functionalities, but other features may vary, e.g. performance. The obvious fact is that the quality of the final product also includes experience and solutions used by programmers that are not dependent on technology.

3. Application performance

There are many scientific positions on the subject of researching application performance. Modern websites have much more complicated logic than before, and they must also be able to run using different internet networks at different speeds and on various types of mobile or computer devices. Because of that, testing the performance of web applications has gained in importance and is becoming a common topic of many researches. Jeremy Wagner claims that when considering application performance, we should take into the account: the number of users using the application, the profits of the company using the application and the users of the application itself (Wagner, 2020). As confirmation of his statement several examples were mentioned. The developer of the Pinterest app has been examining a time that it takes to display first page when turning on the app. By improving the user's waiting time for a response by 40%, an increase by 15% in application usage and registration of new users was achieved (Wagner, 2020). COOK increased profits by 7% and the number of pages visited during one visit by 10%, as a result of reducing the average loading time of the first page by 850 milliseconds (Wagner, 2020). Other studies say that 53% of website visits are dropped while waiting for a system response when the page load time is greater than 3 seconds (Wagner, 2020). The above research confirms the fact that the number of users using the application affects the performance of the application.

Regarding the company's profits, examples of two surveyed companies are given. Mobify company achieved an increase in annual revenues of over 380 thousand dollars, by reducing the time it took to load the first page (Wagner, 2020). AutoAnything achieved a 12-13%

increase in sales after halving the first page load time (Wagner, 2020). Based on these examples, it can be concluded that the time to load the first page of the application is greatly reflecting on the number of users using the application, and thus in the income of the application owner. In addition, Jeremy Wagner claims that when examining application performance, we should take into account the diversity of users using the application, i.e. different speeds of the Internet network that users use and the variety of devices owned by users (Wagner, 2020).

The consequences of low performance are also mentioned by Subraya (2006). He claims, that low software performance may result in temporary cessation in usage of the application, or the complete abandonment in use of the system. Moreover, it can also discourage others from accessing this manufacturer's products. As evidence, the results of a study done on 117 web pages, showing the consequences of a long page loading time were presented. This is shown in Table 1 (Subraya, 2006).

Table 1.

Percentage of pending users depending on how long the web page loads (Subraya, 2006)

Page loading time (s)	Percent of users waiting for the result (%)
10	84
15	51
20	26
30	5

4. Application performance tests and their measure

The authors of the article (Ninka, and Proko, 2013) on the subject of testing web application performance as basic tests state: scalability tests, load tests and stress tests. In turn, Sharmila S. and Ramadevi E. (2014) listed the following steps as necessary during the process of testing the performance of web applications:

1. Identifying the test environment.
2. Identifying the performance test.
3. Planning and designing the test.
4. Configuring the test environment.
6. Test implementation.
6. Test execution.
7. Analyze test results and retest if necessary.

In addition, the authors (Sharmila, and Ramadevi, 2014) of the above steps list measures important during the test, such as response time, bandwidth, CPU resource utilization, RAM, network input and output packets, and critical application errors. Another approach proposed by the authors (Sharmila, and Ramadevi, 2014) is to perform performance analysis based on historical data of the running application obtained from events in the application (logs).

In this approach, each event in the application should be saved to a log file on the hard disk or in the database. Particularly important are events appearing on the client-side applications and each user data, e.g. session data. As it comes to events, the authors (Sharmila, and Ramadevi, 2014) mean places where the user clicks on the page, which pages and for how long the user views them and how much time he stays on the page. Such data is sequentially aggregated using tools for analyzing logs, and based on that places where the application is inefficient may be discovered.

Another concept to carry out the performance tests is the method proposed by Kajol Mittal and Rizwan Khan (2018). These authors claim that testing application performance should be a permanent part of the software development process and such tests should be conducted on an ongoing basis during every build and every application deployment (Khan, and Mittal, 2018). In addition, performance testing according to what authors mentioned, can not be based on general measures, but on conditions strictly defined for a given application and specific functionality. For example, the loading time of the login page should not take longer than 5 seconds with 50 users using the application at the same time. They proposed a solution using CI/CD (Continuous Integration/Continuous Deployment), in which such rules would be written in the code. Such a system is designed to automate performance testing and performance analysis in the software lifecycle by integrating with the Jmeter performance testing tool and the Dynatrace performance analysis tool with the Continuous Integration Jenkins platform (Khan, and Mittal, 2018; Cassone et al., 2001).

5. Comparison of frameworks performance

In the research conducted by Mariano C.L. (2017), the author compares the performance of frameworks using the JavaScript programming language. Four frameworks with libraries were compared: BackboneJS, AngularJS, React-noJSX and React-JSX. To perform the tests, the application that runs tests using Node.js was implemented. The test for each framework was launched on three browsers: Chrome, Edge and Mozilla (Mariano, 2017). The application simulates user behavior by performing a sequence of actions (e.g. adding an item to the list, refreshing the list), while measuring the total duration of the test. The results of the tests conducted by the author are shown in Figures 1, 2 and 3, taking into account the type of web browser. The smaller the time, the better the test result. The time shown in Figures 1, 2 and 3 is the average of 25 tests runs (Mariano, 2017).

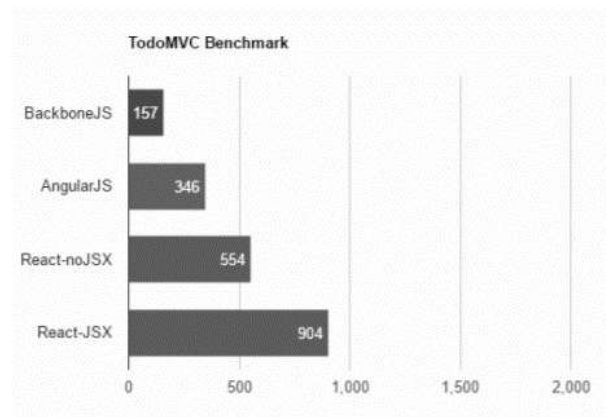


Figure 1. Average test duration for various JavaScript frameworks obtained by Mariano C.L. on a Chrome web browser (Mariano, 2017).

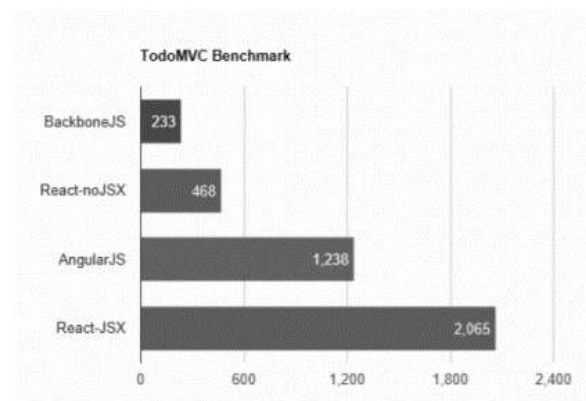


Figure 2. Average test duration for various JavaScript frameworks obtained by Mariano C.L. on a Microsoft Edge web browser (Mariano, 2017).

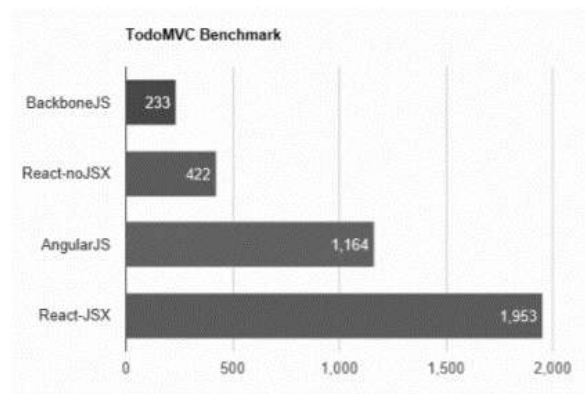


Figure 3. Average test duration for various JavaScript frameworks obtained by Mariano C.L. on a Mozilla Firefox web browser (Mariano, 2017).

Mariano C.L. in the conclusions of the tests indicated that the results slightly differ in different browsers (Mariano, 2017). However, in all tests BackboneJS turned out to be the most efficient JavaScript framework.

Similar performance testing of JavaScript frameworks was carried out by Meyghani (2020). He used the Stefan Krause tool (Krause, 2020) to test the performance of JavaScript frameworks and libraries. The tests were performed on a MacBook Pro (Retina, 15-inch, Mid 2015) with a 2.2 GHz Intel Core i7 processor, 16 GB RAM 1600 DDR3 memory and Intel Iris Pro

1536 MB graphics using Google Chrome version 69.0.3497.100. The author divided the frameworks he researched into pairs, where the framework with better results in pair was compared with a framework from another pair. Aspects such as: DOM element manipulation, start time, memory allocated by the application and actions simulation (understood as updating 1000 rows at the same time) were taken into account. The results of the author's research (Meyghani, 2020) are shown in Figure 4.

Based on Figure 4, it was noticed that in the Meyghani (2020) tests the Choo framework was the best. As a conclusion the author of above tests stated, that these tests are only examples and the research itself should be focused on application-specific requirements and take into account the real problem of users and business problems, instead of artificially generated behavior.

Name	elm-v0.19.0-bugfix2-keyed	choo-v6.13.0-keyed	mithril-v1.1.1-keyed	marionette-v4.0.0-beta.1-keyed	angular-optimized-v6.1.0-keyed	angularjs-v1.7.4-keyed	aurelia-v1.3.0-keyed
ready memory Memory usage after page load.	2.4 ± 0.3 (1.1) 2.636%	2.4 ± 0.3 (1.1) 3.436%	2.2 ± 0.2 (1.0) 0.014%	2.8 ± 0.3 (1.3) 100.000%	3.3 ± 0.2 (1.5) 0.037%	3.3 ± 0.3 (1.5) 0.128%	4.3 ± 0.3 (2.0) 0.000%
run memory Memory usage after adding 1000 rows.	6.0 ± 0.0 (1.8) 0.000%	3.4 ± 0.0 (1.0) 0.000%	6.1 ± 0.0 (1.8) 0.000%	4.8 ± 0.0 (1.4) 100.000%	6.0 ± 0.0 (1.7) 0.000%	10.9 ± 0.0 (3.2) 0.000%	8.5 ± 0.0 (2.5) 0.000%
update each 10th row for 1k rows (5 cycles) Memory usage after clicking update every 10th row 5 times	6.1 ± 0.0 (1.5) 0.000%	4.2 ± 0.0 (1.0) 0.000%	8.2 ± 0.0 (1.9) 0.000%	4.8 ± 0.0 (1.1) 100.000%	6.1 ± 0.0 (1.4) 0.000%	11.0 ± 0.0 (2.6) 0.000%	8.5 ± 0.0 (2.0) 0.000%
replace 1k rows (5 cycles) Memory usage after clicking create 1000 rows 5 times	6.1 ± 0.0 (1.7) 0.000%	3.6 ± 0.2 (1.0) 0.000%	6.2 ± 0.0 (1.7) 0.000%	5.3 ± 0.0 (1.5) 100.000%	6.4 ± 0.0 (1.8) 0.000%	11.5 ± 0.0 (3.2) 0.000%	8.8 ± 0.0 (2.4) 0.000%
creating/clearing 1k rows (5 cycles) Memory usage after creating and clearing 1000 rows 5 times	2.8 ± 0.0 (1.0) 0.000%	2.7 ± 0.0 (1.0) 0.000%	2.8 ± 0.0 (1.0) 0.000%	3.4 ± 0.0 (1.2) 100.000%	3.9 ± 0.0 (1.4) 0.000%	4.4 ± 0.4 (1.6) 0.003%	5.7 ± 0.0 (2.1) 0.000%

Figure 4. Test results obtained in tests by Meyghani (2020).

6. Summary

Based on the above documented research, pros and cons of different approaches can be noted. Both Mariano C.L. (2017) and Meyghani (2020) examined the metrics that were not relevant from the real point of application. Mentioned authors simulate user actions in their test

runs, where one of them has stated in the summary that such studies do not make sense, because they should focus on real problems specific to the application. In addition, Mariano C.L. did not provide specifications for the research environment that may be relevant when choosing a technology.

The authors of the article showed the problem of web application performance from the end user's viewpoint of the system. Comparison of the performance of web application clients using the JavaScript programming language was performed. Currently on the market there are a lot of JavaScript programming language frameworks supporting the development of client web applications. The authors of these frameworks claim that their product is the best on the market. Each of the JavaScript libraries also has its own group of supporters among programmers who often argue about which of them is the best, the most efficient. Such a wide range of existing solutions for creating web client applications means that new developers do not know which technology is worth learning, so that efficient web application clients can be implemented. The authors of this article has suggested users to familiarize themselves with the techniques used to conduct software performance tests. An important tip for the user is to become familiar with the tools available on the market that can be used during application performance tests, and the techniques for creating efficient web applications independent of the technologies used. Another important tip is to pay attention to the impact of web application performance on their real-life running in the market. Based on the impact of inefficient applications on the application manufacturer profits and application end-users (Wagner, 2020; Subraya, 2006) the authors of this article state that when conducting an software performance analysis, measures that are relevant to the end user of the application should be considered. Additionally, different types of devices with different screen sizes and networks with different data transmission parameters should be examined. The conducted performance research and analysis of the obtained data using statistical tests will be a reliable source of choice of technology for implementation by interested programmers.

References

1. Cassone, G., Elia, G., Gotta, D., Mola, F., Pinnola, A. (2001). Web Performance Testing and Measurement: a complete approach. *Telecom Italia Lab*. Retrieved from https://www.agileconnection.com/sites/default/files/article/file/2012/XDD3579filelistfileame1_0.pdf, 31.03.2020.
2. Khan, R., Mittal, K. (2018). Performance Testing and Profiling of Web based Application in Real Time. *International Journal of Computer Applications*, Vol. 180, No. 46, doi: 10.5120/ijca2018917220.

3. Krause, S. (2020). *Github repository of the JavaScript frameworks performance analysis tool*. Retrieved from <https://github.com/krausest/js-framework-benchmark>, 31.03.2020.
4. Mariano, C. L. (2017). *Benchmarking JavaScript Frameworks*. Master's thesis, 2017. doi:10.21427/ D72890.
5. Meyghani, A.J. (2020). *JavaScript Frameworks, Performance Comparison*. Retrieved from <https://medium.com/@ajmeyghani/javascript-frameworks-performance-comparison-c566d19ab65b>, 31.03.2020.
6. Ninka, I., Proko, E. (2013). Analyzing and Testing Web Application Performance. *International Journal Of Engineering And Science*, Vol. 3, Iss. 10, pp. 47-50.
7. Sharmila, S., Ramadevi, E. (2014). Analysis of Performance Testing on Web Applications. *International Journal of Advanced Research in Computer and Communication Engineering*, Vol. 3, Iss. 3.
8. Subraya, B.M. (2006). *Integrate Approach to Web Performance Testing: A Practitioner's Guide*. London: IRM Press.
9. Wagner, J. (2020). *Why performance matters*. Retrieved from <https://developers.google.com/web/fundamentals/performance/why-performance-matters>, 30.03.2020.

THE ROLE OF HIGHER EDUCATION INSTITUTIONS IN SHAPING STUDENTS' ENTREPRENEURIAL ATTITUDES – CASE STUDIES FROM POLAND AND MALTA

Joanna MACHNIK-SŁOMKA^{1*}, Nicholas BALDACCHINO²

¹ Silesian University of Technology, Faculty of Organization and Management;
Joanna.machnik-slomka@polsl.pl, ORCID: 0000-0001-5387-5909

² Malta College Arts Science and Technology, Institute of Engineering and Transport;
Nicholas.Baldacchino@mcast.edu.mt, ORCID: 0000-0002-4640-505

* Correspondence author

Purpose: Identifying the role or roles of higher education institutions in shaping students' entrepreneurial attitudes, which is the aim of the article which is increasingly becoming topical of great significance for economic development and innovative solutions in industry.

Design/methodology/approach: For the purposes of this research the case study method is based on the selected higher education institutions in Poland and Malta. The method of observation and desk research was also used.

Findings: The results of analyses and studies have confirmed the great importance and possibilities of higher education institutions in shaping entrepreneurial competences of students at different levels of education. They also highlighted the need to place greater emphasis on creating more comprehensive support programs, making wider use of the creation and development of an ecosystem for the development of academic entrepreneurship.

Research limitations/implications: Within the framework of the article, research was conducted on selected examples of higher education institutions in Poland and Malta. The presented results may be of an initial contribution towards future research in different economic and research contexts.

Practical implications: Considerations presented in this article, results of analyses and formulated recommendations can be a valuable source of information especially for higher education institutions and other decision makers dealing with the issue of creating new companies, start-ups established especially on the basis of innovative solutions.

Originality/value: The article emphasized the importance of universities to offer different scenarios as possible for the expansion and development of entrepreneurship. This indicated the role of institutions as crucial in formulating recommendations in the context of shaping entrepreneurial attitudes of students, stressing on the need to develop an entrepreneurship mindset and ecosystem with the co operation of government and private institutions.

Keywords: entrepreneurial attitudes, academic entrepreneurship, academic training.

Category of the paper: research paper.

1. Introduction

Modern market needs and evolution of the cyber era, are continuously changing the dynamics of the socio, economic, and technological scenarios at entrepreneurial levels. The aggressive competition that exists is increasingly encouraging for a more innovative and creative entrepreneurs at academic level to deliver contemporary changes that supports and equips the alumni with the necessary knowledge as future entrepreneurs. It is of particular importance in this context the need to increase and stress for more innovative mindsets in particular regions and countries to foster and adopt entrepreneurial strategies. The world of an entrepreneur is changing at a faster rate that includes the role the abilities to understand the world of networking in modern market mechanisms.

The common problems to shape and foster entrepreneurial attitudes and mindset of current students are addressed in this article focusing on the development of entrepreneurship, particularly when it comes to academic entrepreneurship in education colleges, universities and institutions (Ubulom, 2003; Uwamieye, Aduwa, 2006; Matusiak, K.B., and Matusiak, M., 2007; Banerski et al., 2009; Poznańska, 2014; Kraśnicka et al., 2014; Hayter, 2011; Hvide, Jones, 2018; Łobacz, Głodek, 2018; Cerver et al., 2020; Pasik, 2020). Contemporary entrepreneurial teachings and theories contain the abilities in understanding human or consumer behaviors and attitudes, that are characterized by the readiness to undertake various strategic ventures that will bring changes as per academic studies (Piwowar-Sulej, Kwil, 2018). Thus, students' entrepreneurial studies and attitudes, shapes the engagement in the way they do business and increased knowledge in economic activities, which will be of benefit on the development of academic entrepreneurship (Wyrwa, Sołtysiak, 2016).

One of the significant challenges facing contemporary higher education institutions is the shaping of an appropriate environment and climate for the development of entrepreneurship (Makiela, 2017). This is related to the creation of a new model in higher education institution based that coach's effectiveness and skillful use of knowledge (Wawak, 2017). Academic views on entrepreneurship and tertiary education have been quite different, mainly because of the difficulty to create an acceptable definition. This is so because of different views and research in different economic set ups that are built on different theoretical foundations in various contexts and expertise. Seminal and contemporary researchers opined that academic training in entrepreneurship should prepare students in the business world for a business career (Ubulom, 2003; Uwamieye, Aduwa, 2006).

The aim of the article is to identify the role of universities in shaping and preparing students' entrepreneurial attitudes using selected cases of higher education institutions from Poland and Malta. This paper examines how to effectively educate and shape entrepreneurial attitudes among students to prepare them to operate in modern market mechanisms, to face risks and to be ability to start a business in the future. Recommendations were also presented for higher education institutions in terms of shaping entrepreneurial attitudes and developing students' competences.

2. Shaping entrepreneurial attitudes of students – a literature review

Appropriate entrepreneurial attitudes of students have a great impact on the creation of new jobs, the formation of technology companies, start-ups and thus on the development of entrepreneurship in particular countries. In the literature, many types of entrepreneurship can be distinguished such as organizational entrepreneurship, strategic entrepreneurship, among others (Guth, Ginsberg, 1990; Bratnicki, 2008; Bratnicki, Dyduch, 2003), or technological entrepreneurship, innovative entrepreneurship, and academic entrepreneurship (Stawasz, 2007; Stachowicz, 2015; Machnik-Słomka, Kordel, 2016; Piwowar-Sulej, Kwil, 2018). In general, entrepreneurship can be understood as: an attitude (having, among other things, a direct impact on the entrepreneur's ready to take new actions), a behavior (manifested by the ability to exploit emerging opportunities and ideas) and as a process (referring to the creation of new ventures) (Wyrwa, Sołtysiak, 2016).

The issues discussed in the article are especially related to academic entrepreneurship, which is identified with the activity of higher education institutions (Pasik, 2020) to support the creation of start-ups, spin-offs, spinouts, raising awareness, knowledge, and skills, i.e., shaping entrepreneurial attitudes and competences in entrepreneurship (Banerski et al., 2009). The issue of academic entrepreneurship is more and more often taken up by scientists and practitioners due to its importance and impact on increasing innovation, transfer, and commercialization of technologies (e.g., Matusiak, K.B. and Matusiak, M., 2007; Banerski et al., 2009; Poznańska, 2014; Kraśnicka et al., 2014; Hayter, 2011; Hvide, Jones, 2018; Łobacz, Głodek, 2018; Cerver et al., 2020). Poznańska emphasized that academic entrepreneurship is a specific type of entrepreneurship focused on creative behavior of representatives of the scientific environment and the formation of skills to use the effects of these activities in economic practice (Poznańska, 2014).

Academic entrepreneurship specifically manifests in particular in the orientation towards the use of scientific knowledge in practice, economy, industry where the search for chances, the provision of appropriate resources are important dimensions of the entrepreneurial process (Łobacz, Głodek, 2018). Entrepreneurial attitudes of students of different higher education institutions in the world, which are related to the development of academic entrepreneurship are the subject of research of many authors such as Kraśnicka, Ludvik (2003); Bernat et al. (2008); Wyrwa, Sołtysiak (2016). Already Osuala (1987) stressed that the changes taking place in the world make it necessary for higher education institutions to act as catalysts for the development of entrepreneurship among students of various disciplines through appropriate programs shaping the competencies necessary for the management of start-ups in business. In a broad sense, academic entrepreneurship is in fact related to all activities of the university focused on taking action to support the commercialization of knowledge through various means

and also on raising knowledge and awareness through an educational offer that considers the practical aspect of education (Poznańska, 2014).

Therefore, it does not focus only on the creation of new companies by students or university employees. Higher education institutions should prepare students from all disciplines, especially technical and related sciences, in terms of industrial experience, ethics, attitudes and in-depth knowledge related to their future occupation in various industrial sectors, whether they are employed or are independent entrepreneurs (Otamiri, 2008).

Entrepreneurs need support at different stages of the entrepreneurial process. The literature usually distinguishes the following stages of development of entrepreneurial activities: pre-incubation (activities until the establishment of the company), incubation (includes support for the newly established company) and acceleration (the last stage of creating a company within which the product offer is subject to market verification) (Piwowar-Sulej, Kwil, 2018). Entrepreneurs, depending on the mentioned stages, need advisory, training, business, promotional, legal support, assistance in raising funds or providing office facilities. Undertaking entrepreneurial activities therefore requires specific competences related to, among other things, establishing and managing a company or developing products (Łobacz, Głodek, 2018). It also requires competencies related to the ability to build relationships with stakeholders and manage these relationships. In the context of contemporary conditions, this is an essential competence that is conducive to developing a company globally and achieving market success. Therefore, it is necessary to provide students, especially those of technical faculties, with appropriate training programs focused on the acquisition of practical skills while ensuring mentoring and coaching also later on the stage of developing a business model (based on an idea or research results) and then creating a company.

The very process of this education, shaping entrepreneurial attitudes of students should be based on cooperation with internal and external structures supporting entrepreneurship and commercialization of knowledge. In the process of learning, it is also necessary to support the higher education institution in developing specialist, scientific knowledge, and skills necessary for developing innovative solutions, conducting research, or preparing a market offer (Łobacz, Głodek, 2018). A carefully designed entrepreneurship curriculum should be based on dialogue with experienced lecturers with baggage of practical experience or with executives from the manufacturing or service sector, so that:

- All students are able to grasp the opportunities by exploring the functions of the world of business and the potential to make careers out of it.
- To assist in developing an intelligent understanding of the modern entrepreneur and the various occupations to be found in the business world and practical ways in understanding the actual functions of the national and international economic systems.
- To prepare students for the eventual future role as an entrepreneur by forming his own business and perform business activities common to many professional areas.

Modern theoretical and practical entrepreneurship education are two different areas of studies that are in continuous fusion. The demarcation line dividing the theoretical approaches and practical industrial market mechanisms are becoming more and more integrated as a single module. Dutta and Biren (2001) describes it as “brick and mortar” that work with basic tools such as:

- lecturing, mentoring, training, and coaching,
- the use of vocational tertiary education curriculum/techniques,
- creating job/or opportunity for graduates to become self-employed.

This approach has been researched by earlier work of Otamiri (2008) it was posited that modern business education is a fusion of pedagogical entrepreneurial preparation. Akpan (2010) posited that the workable integration of entrepreneurship into the curriculum of the various of fields of study, be it engineering, medicine, social science and business studies is a stem amongst the generation of new business ventures for the present and immediate future of a country's economy. Nowadays, for effective shaping of entrepreneurial attitudes of students, cooperation of higher education institutions with various stakeholders is becoming more and more important. It is important not only to cooperate with enterprises, but also with business environment institutions, especially specialized institutions, such as technology incubators, academic entrepreneurship incubators, science and technology parks, technology and innovation transfer centers and seed capital financial institutions.

Also important in this respect is the cooperation of higher education institutions with representatives of public authorities at various levels. These partners offer a various and wide range of support instruments for shaping and developing entrepreneurial competences of students and also in the scope of creating companies by students, start-ups. We can distinguish different types of support instruments for the development of academic entrepreneurship such as legal instruments (legal regulations, laws, regulations on e.g., intellectual property, commercialization), financial instruments (grants, governmental, regional and EU program, seed capital funds, business angel networks) and so called "soft" instruments related to education and specialized consulting (Borrás, Edquist, 2013). It is also valuable to cooperate with other higher education institutions, institutions of the R&D sector in order to exchange experiences and strengthen the development of entrepreneurship for the growth of competitiveness and innovation of a given region, country.

Cooperation with different partners in this field is related to the issue of creating and developing an entrepreneurial ecosystem. The importance of these ecosystems for the development of entrepreneurship is emphasized by many authors and researchers for example: Mason, Brown (2014); Hayter et al. (2018); Buła, Schroeder (2020); Bock et al. (2020). Entrepreneurship ecosystem is most often defined as a set of interconnected by different interactions of people, actors creating an enabling environment for entrepreneurship creation and development (Mason, Brown, 2014). Entrepreneurship ecosystems can significantly accelerate the processes of creating startups and commercializing research results.

3. Development of student entrepreneurship from the perspective of selected higher education institutions in Poland and Malta

One of the essential elements of the economic and innovation policy of individual countries should be the activation of cooperation between the science sector and the economy directed at the creation of spin-off, spin-out companies, commercialization of research results by students, employees, and graduates of universities (Poznańska, 2014). Due to the benefits of these activities for increasing competitiveness, human development, the importance of academic entrepreneurship in the global economy is increasing. Therefore, national policy to support this entrepreneurship is important. Due to different social, economic, cultural challenges and conditions, it differs from country to country. In addition, the COVID-19 pandemic has posed new and special challenges for higher education institutions due to a number of barriers and obstacles that have arisen also for the development of entrepreneurship and education in this area. On the other hand, the development of student entrepreneurship may become a remedy for the economic slowdown created by the coronavirus pandemic.

So, the question arises: how to effectively educate and shape entrepreneurial attitudes in this situation? Based on the cooperation undertaken, this article presents examples of selected higher education institutions in Poland and Malta in the field of entrepreneurship education, presenting initiatives and programs devoted to entrepreneurship and shaping entrepreneurial attitudes among students. There are a number of differences between the analyzed countries in terms of economy, social and cultural conditions, development of entrepreneurship as well as a different approach to the education system. However, in both countries, entrepreneurship is part of the teaching program at different levels of education. Many good practices can be cited in these countries in the area of fostering student entrepreneurship. Both Poland and Malta have public and private higher education institutions.

In Poland, the promotion of an entrepreneurial culture and its support is an increasingly important direction included in governmental, regional, and local development programs. A number of governmental and non-governmental organizations, specialized business environment institutions and R&D institutions in Poland deal with supporting entrepreneurship. At the national level an important role in promoting and developing entrepreneurship and innovativeness is played by the Polish Agency for Enterprise Development (PARP). These institutions implement many projects, programs aimed at the development of entrepreneurship, which allow young entrepreneurs to take advantage of government programs, regional programs (RPO), EU grants, subsidies, loans for creating and developing companies based on innovative ideas. The start-up environment is supported, among others, by the developing network of Academic Incubators of Entrepreneurship (AIP). An important role in this respect is also played by universities, which can provide first-cycle studies (bachelor's or

engineer's degree), second-cycle studies (master's or engineer's degree) or unified master's studies, as well as doctoral training.

For a small island in the Mediterranean like Malta, job creation remains a consistent challenge for the government. Well paid employment in Malta has been endemic for decades, where in the past entrepreneurship as a subject was more academic oriented reserved only for those who had family history in business and lacked the vocational touch and entrepreneurial values. In response to contemporary challenges, including indications from the EU, the Maltese authorities have taken more intensive measures to support entrepreneurship at the local level in relation to the education system. Universities in Malta play a significant role in this regard. The academic education pathway in Malta consists of several levels: higher vocational education (level 5), bachelor's degree (level 6), master's degree (level 7), doctorate (level 8).

Silesian University of Technology operating in Poland and Malta College Arts Science and Technology (MCAST) were selected to analyze the case studies in the context of shaping entrepreneurial attitudes.

3.1. Shaping entrepreneurial attitudes of students at the Silesian University of Technology in Gliwice

The Silesian University of Technology is one of the biggest technical universities in Poland, established in 1945. As the only university in Silesia, the Silesian University of Technology was among 10 Polish universities, laureates of the competition "Initiative of Excellence – Research University" of the Ministry of Science and Higher Education (Politechnika Śląska). Science and education at the Silesian University of Technology is conducted in 15 units including 13 faculties and 2 institutes. There are currently over 60 faculties and about 200 specializations with over 18 thousand students (Politechnika Śląska). The University offers first degree studies (engineering and bachelor's), second degree studies - master's, unified master's studies, education at doctoral school and postgraduate studies. Studies are conducted in stationary and non-stationary form. They can be conducted within the framework of the profile: practical and general academic.

Important areas of support at the Silesian University of Technology include (Research University – Education (Uczelnia Badawcza – Kształcenie):

- development of academic entrepreneurship through e.g., specialized trainings conducted by experienced managers and technology brokers,
- assistance in identifying commercialization potential,
- support in establishing and running a company,
- dual education conducted in cooperation with employers (a student takes classes alternately at the University and at a company),
- mentoring involving the student in research activities, project implementation and cooperation with industry.

At the Silesian University of Technology, activities supporting academic entrepreneurship are realized by particular faculties, institutes, and university units such as: Centre for Incubation and Technology Transfer, Student Career Office and science and technology park "Technopark Gliwice". The Centre for Incubation and Technology Transfer (CITT) of the Silesian University of Technology supports the process of management and commercialization of intellectual property, improving the implementation of research results into practice (Centrum Inkubacji i Transferu Technologii). In this field, the Silesian University of Technology has developed, among others, Regulations for management of intellectual property and a database of the Silesian University of Technology offer in the area of apparatus, laboratories, technologies, and patents. The CITT acquires and realizes many projects financed from external sources, builds, and develops networks for cooperation between science and economy.

The CITT of the Silesian University of Technology is also involved in activities aimed at the development of technological entrepreneurship, which consists mainly in assistance in setting up spinoffs and spinouts. In this respect, CITT implements a pro-quality program in accordance with the Decree of the Rector of the Silesian University of Technology thanks to which it is possible to co-finance the commencement of business activity in the form of spin-off and spin-out companies. The CITT is also supported by providing consultations at the stage of starting companies as well as their further functioning. In the aim of implementation of indirect commercialization, the Special Purpose Company Innovations of the Silesian University of Technology Ltd. was established.

The Student Career Office of the Silesian University of Technology in the field of supporting entrepreneurship meetings in the field of counselling for entrepreneurship, which aim to help to establish business activity, to prepare a business plan (Konkurs Mój Pomysł na Biznes). For many years, the Career Bureau of the Silesian University of Technology has been organizing the competition "My Business Idea", which aims to encourage entrepreneurship among employees, students, and graduates of the Silesian University of Technology. Currently, the 18th edition of the "My Business Idea" competition is already being organized. Ideas based on innovative and sustainable solutions, which can provide new jobs are promoted. Participants in the competition are provided with substantive support in the form of training on creating and managing a company, developing a business plan, innovation and individual consultations with experts. On the basis of the assessment of submitted works, the jury awards prizes in the form of financial for the implementation of ideas, training, internships, or recommendation to locate their startup in business incubators, or technology parks. The Student Career Office of the Silesian University of Technology in connection with the COVID-19 pandemic introduced new services related to the possibility of obtaining advice on psychological, professional and entrepreneurship support (Biuro Karier Studenckich). Moreover, the Student Career Office realizes a lot of programs and projects co-financed by the European Union, concludes a number of agreements on cooperation with companies and other partners, supports the organization of student practice and work placements and organizes study visits to companies for students.

Many programs promoting academic entrepreneurship have been implemented at the Silesian University of Technology, including (Politechnika Śląska): START – "Programme for the promotion of entrepreneurship in higher education institutions in the Silesian Voivodship" realized from the Human Capital Operational Programme 8.2.1; The program "Creator of Innovation – Support for Innovative Academic Entrepreneurship" realized from the funds of the Ministry of Science and Higher Education; Entrepreneurial Researcher – training and consultancy project implemented under the Human Capital Operational Programme 8.2.1 and Project: "First stage of implementation of the comprehensive development program of the Silesian University of Technology in Gliwice" implemented in the Operational Programme Human Capital 4.1.1.

The Science and Technology Park "TECHNOPARK GLIWICE" Ltd. is in turn a modern business support center, especially for academic entrepreneurship (Technopark Gliwice). It provides infrastructure for startups and mature companies based on cooperation with the Silesian University of Technology, training, and consulting services as well as implementation of international, national, and regional support programs. Technopark Gliwice has extensive cooperation with supporting institutions, universities, science parks, foreign organizations. Technopark carries out many projects financed from various sources. The Technopark has a technological and expert base, is a platform for cooperation between the spheres of science and business (Technopark Gliwice). An important objective of its activities is the transfer of modern technologies to the economy.

Activities aimed at shaping entrepreneurial attitudes of students are also initiated and realized by individual faculties and institutes of the Silesian University of Technology. Classes in subjects related to entrepreneurship are conducted. An example can be the Faculty of Organisation and Management of the Silesian University of Technology (WOIZ) which has realized, in cooperation with external partners such as business environment institutions, enterprises, Zabrze City Hall, Katowice Special Economic Zone (KSSE), many activities for the promotion of pro-innovative culture and shaping entrepreneurial attitudes. In this area, two editions of the *Innovator's Day* Conference were organized with these partners and students at the Silesian University of Technology. At WOIZ, the *Business meets students* conference was organized in cooperation with the KSSE Innovator's Club. In 2019, a Conference was organized in the cycle *Meetings with Entrepreneurship Edition#Droga do samorealizacji: dialogue of entrepreneurship with technological entrepreneurship*. On the initiative of WOIZ, a Business Advice Point was also established, which provides a platform of support for entrepreneurs and people interested in conducting business.

There are many other initiatives and undertakings aimed at shaping entrepreneurial attitudes of students at the Silesian University of Technology.

Many of them are organized in cooperation with economic and public sector partners. Students at the Silesian University of Technology themselves are involved in the organisation of many events, e.g., as part of Student Scientific Circles.

3.2. Examples of academic entrepreneurship support for students at Malta College Arts Science and Technology (MCAST)

The link that exists between Malta College Arts Science and Technology (MCAST) and Industry including the Maltese Government is maturing along with the new age of world development. MCAST has assumed the role as an agent that collaborates with its links that chains it with industrial needs that modern technology requires. Malta College of Arts, Science and Technology (MCAST) was established in 2001. It is the leading vocational education and training institution in the country. It has 6 institutes and the Gozo Campus. MCAST offers about 180 courses, vocational courses, ranging from certificates to Masters (up to level 7) (MCAST). It also offers the MCAST Professional Research Doctorate (DRes) on the Competitive Behavior of Small Organizations MQF (Level 8) (MCAST Professional Research Doctorate (DRes)).

In 2013, MCAST had to refocus on the topic of entrepreneurship by creating a new directory within its administration, the MCAST Entrepreneurship Centre (MCE). The MCE addresses entrepreneurship for all students in level 4 up to level 6 to elucidate knowledge and skills that will prepare its student population to be more employable and self-reliant for the ever-changing economic technological diversifications that were changing the country. The strategy adopted had the aim to provide MCAST students and alumni alike with the opportunity to transform their creative and innovative ideas across all institutes in level 4 diploma and degree level 6 into a profitable and sustainable business ventures. This approach had two objectives to equip the students with all the necessary knowledge skills and competencies to succeed in the modern and ever-changing entrepreneurial life. Firstly, the focus concentrates on the student's intellectual development by designing a curriculum that caters for the levels 4 and 6 in all MCAST institutes, supported by experienced mentors and lecturers with years of industrial experience in entrepreneurship. This is a contributive element in thriving an entrepreneurial mindset which provides the students with the necessary theoretical and practical tenacity in utilizing their abilities and new skills in their future careers. Secondly, the MEC which is an incubator center offers an area related to student findings, helping them to develop their innovative and creative entrepreneurial related activities which serves them to enrich and refine the ideas generated in a more business-oriented environment. The incubation center is not the only assistance that MEC offers but also provides mentors to guide them through in reaching their full potential that reflects modern entrepreneurship ethics and laws and regulatory aspects of the idea generated.

Another contribution by MEC towards its MCAST students is by giving the individual attention the needs and professional advice by offering inhouse and other activities aimed at increasing the entrepreneurial approach vis-à-vis their academic studies. The main forms of entrepreneurial support at MCAST are shown in the table below (Table 1).

Table 1.*Forms of entrepreneurship support at MCAST*

Forms of entrepreneurship support/ Level of Studies	Job- Shadowing	Work Placement	Apprenticeship
	<p>This entails the student to spend a full week 'working' with the 'Employer' to get a better understanding of the work environment.</p> <p>It is held in the early years where students have not decided exactly which career path to follow.</p> <p>So, this experience in the industry will help them decide which discipline to follow.</p> <p>During the job shadowing as the name implies students are not expected to undertake any work but observe experienced employees at their workplace. The emphasis on this 'work scheme' is for the student to learn the soft skills to be able to be ready for future employment.</p> <p>(Level 3.1)</p>	<p>The student will be placed in the industry of their choice to conduct a hands-on experience working for a minimum of 100hours and at the same time still attend academic classes at MCAST Campus.</p> <p>On this scheme the student is expected to work under supervision of a trainer and undertake the same job responsibilities as a full-time employee.</p> <p>Students get the benefit of experiencing the work environment and start working hands-on. It is also beneficial for their future employment, to add to their work portfolio, and CV.</p> <p>(Level 4.2)</p>	<p>This work experience scheme is different from the others as the student is paid the regular stipend plus a wage*.</p> <p>Although still working under supervision, as a trainee, the student will execute the same work as an 'employee' (considered as a staff member) but with less hours.</p> <p>There are two types of 'Apprenticeships', for level 4.2 it is for two days during the week (and three days at MCAST) and full workload during the summer holidays and in other cases (Level 6.3) it's for a full month and no lessons at MCAST.</p> <p>(Not all Institutes have an apprenticeship scheme for their students). (Level 4.2 i Level 6.3)</p>

Source: own elaboration.

The entrepreneurship program is offered from level 4.2 to 6.3. Payment during the apprenticeship is shared by Jobs Plus (the Maltese Government Employment Agency) and the 'Employer'. In line with international experts Obi, Otamiri (2010) asserted on the actual entrepreneurship syllabus which was adopted by MEC in MCAST database splitting it in two levels i.e., level 4 and level 6:

- Level 4 enables the student to develop a business idea and employability skills that requires the student to turn an idea into a tangible action including the reflection on what makes him more employable. At this level, the emphasis is on the activities by the discovery and exploitation of the innovation in the manufacture and services sector and the *lecturer will serve as an empathetic guide by offering suggestions and motivating the learners to self-reflect on what they have learned* (MCE, 2019). Practical implementations are not the only part of this strategy, nonetheless the study unit contains the theoretical part by an actionable theory in practice. The main objective at this level is to develop a business idea by helping the student to express the creative ideas in

developing it into a business proposal. This will instill interest amongst the students to view entrepreneurship not from a start up point of view but rather a complex journey that works on innovative and creative ideas. This strategy will also help students to work in groups, increase self-confidence and resolve conflicts by the ability in weighing risks.

- Level 6 students are helped into being more familiar especially those who had started from level 4 exempted at level 5 but has entered into a new stage in their studies. Apart from learning the main theories of the studies and business startups, an exploration opportunity is created for students to interact and learn from several firsthand situations. In this level students are encouraged to form teams from different classes and different institutes that form part of the University of MCAST. This is an opportunity to work on campus as industry with diverse team members that will help the learners to share entrepreneurial ideas from different perspectives that will generate more creative and feasible solutions. This is also a practical way to interact and to work as realistically as possible in a team by interacting with all stakeholders in industry for the future which is a realistic link with theoretical vocational studies. Experience has shown that students will have to shift out from their comfort zone and explore their entrepreneurial abilities by creating and innovating ideas by being adventurous in risk taking opportunities in their future careers.

MCAST through MEC views entrepreneurial training as a vehicle for lecturing or inculcating necessary entrepreneurial skills to its student population by enabling them to steer their creative imagination into a possible business startup as this is the mission of modern entrepreneurial teachings for vocational and tertiary education students.

4. Summary

Higher education institutions face many challenges connected with the need to shape entrepreneurial attitudes responding to market needs, labor market, development of innovativeness and competitiveness of the economy. This article explains the inevitable fusion that entrepreneurship and higher education have become a synergy for dealing with the issue of unemployment, employability, and career development. The results of the conducted analyses of selected higher education institutions from Poland and Malta indicate the use of various approaches and methods for developing entrepreneurial competences of students. This is due to a number of conditions connected with It is a result of many conditions connected, among others, with the realized policy of a given country and the realization of accepted strategies of a given higher education institution, as well as social, cultural, legal, and economic conditions. A characteristic of the both analysed university cases is a complex approach to supporting the development of students' entrepreneurship with the involvement of internal units of the

university, the use of different forms of entrepreneurship support, i.e. educational programmes, substantive support, specialist consulting, organisation of practices and work placements.

To summarize, based on the literature analysis and the case study analysis, the following recommendations can be formulated for higher education institutions in terms of their role in shaping entrepreneurial attitudes of students:

- Creating comprehensive support programs for students of all majors and disciplines covering different levels of study.
- Creating internal structures (such as incubators, innovation centers, career offices) and entrepreneurship support mechanisms open to other external structures, networks, systems.
- Shaping effective network relations with different stakeholders towards creating an entrepreneurship ecosystem.
- Using various methods and tools, such as comprehensive educational programs, lectures, trainings, conferences, workshops, coaching, mentoring, organizing internships, simulation educational games, competitions, implementing and promoting national and international programs, joining thematic networks, developing cooperation platforms, support in creating companies by students and graduates, scientific circles, grants, scholarships, etc.
- Create a good practice database and promote it locally, nationally, and internationally.
- Using various means of communication, including social media in an innovative and attractive way.
- Bringing students closer to the attitudes of enterprising managers, successful people, e.g., through the organisation of study visits to enterprises, the possibility of interviews, meetings and talks with business practitioners at universities.
- Strengthening the cooperation of universities with the business community, taking care of mutual benefits, e.g., by supporting entrepreneurs in the field of counselling, educational services, assistance in seeking sources of financing projects, opening consultation points in various areas.

The effective shaping of students' entrepreneurial attitudes will allow us to face the ever-changing needs of the market by providing highly qualified graduates with creative initiative, the ability to take risks and the courage to start a business.

References

1. Akpan, A. (2010). *NYSC boss decries sagging unemployment in Nigeria*. Lagos: The Guardian Newspaper.
2. Banerski, G., Gryzik, A., Matusiak, K.B., Mażewska, M., Stawasz, E. (2009). *Przedsiębiorczość akademicka (rozwój firm spin-off, spin-out) – zapotrzebowanie na szkolenia służące jej rozwojowi. Raport z badań*. Warszawa: Polska Agencja Rozwoju Przedsiębiorczości.
3. Bernat, T., Kordysa, J., Kunasz, M. (2008). *Przedsiębiorczość studentów w wybranych krajach Europy Środkowo-Wschodniej*. Szczecin: Wydawnictwo PRINT GROUP.
4. *Biuro Karier Studenckich*. Available online <http://www.kariera.polsl.pl/>, 27.07.2021.
5. Bock, C., Dilmetz, D.S., et al. (2020). How the university ecosystem shapes the innovation capacities of undergraduate students – evidence from Germany. *Industry and Innovation*, vol. 27, pp. 16-24.
6. Borrás, S., Edquist, C. (2013). *The Choice of Innovation Policy Instruments, Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE)*. Lund: Lund University.
7. Bratnicki, M. (2008). Konfiguracyjne ujęcie przedsiębiorczości organizacyjnej. *Ekonomika i Organizacja Przedsiębiorstwa*, Vol. 6, pp. 17-22.
8. Bratnicki, M., Dyduch, W. (2003). *Entrepreneurship Strategies and Social Capital in Polish Organizations*. Baltimore.
9. Buła, P., Schroeder, T. (2020). Wybrane aspekty koewolucji polskiego ekosystemu przedsiębiorczości, *Przegląd Organizacji*, Vol. 10, pp. 20-27.
10. *Centrum Inkubacji i Transferu Technologii*. Available online <https://www.polsl.pl/rjo4-citt/>, 27.07.2021.
11. Cerver, Romero, E., Ferreira, J., Fernandes, C. (2020). The multiple faces of the entrepreneurial university: a review of the prevailing theoretical approaches. *The Journal of Technology Transfer*, vol. 45, pp. 22-28.
12. Dutta, S., Biren, B. (2001). Business formation on the Internet, results from the year 2000 study. *European Management Journal*, Vol 19, No. 2, pp. 449-62.
13. Guth, W.D., Ginsberg, A. (1990). Corporate Entrepreneurship. *Strategic Management Journal*, Vol. 11.
14. Hayter, C. (2011). In search of the profit-maximizing actor: Motivations and definitions of success from nascent academic entrepreneurs. *The Journal of Technology Transfer*, vol. 36, pp. 347-352.
15. Hayter, C., Nelson, A., Zayed, S., et. al., (2018). Conceptualizing academic entrepreneurship ecosystems: a review, analysis, and extension of the literature. *The Journal of Technology Transfer*, vol. 43, pp. 4-7.

16. Hvide, H., Jones, B. (2018). University Innovation and the Professor's Privilege. *American Economic Review*, vol. 108, pp. 1860-1876.
17. *Konkurs Mój Pomysł na Biznes*. Available online <http://www.kariera.polsl.pl/konkurs/konkurs.ht>, 27.07.2021.
18. Kraśnicka, T., Głód, G., Ludvik, L., Peterkova, J. (2014). Uwarunkowania intencji przedsiębiorczych studentów uczelni ekonomicznych Polski i Czech. *Przedsiębiorczość – Edukacja*, no. 10, p. 316.
19. Kraśnicka, T., Ludvik, L. (2003). Poglądy studentów w kwestii przedsiębiorczości w kontekście integracji europejskiej. In: H. Bieniok (Ed.), *Przedsiębiorczość, konkurencyjność oraz kondycja małych i średnich przedsiębiorstw w obliczu integracji z Unią Europejską*. Katowice: Wydawnictwo AE.
20. Łobacz, K., Głodek, P. (2018). Przedsiębiorczość akademicka jako czynnik rozwoju kapitału ludzkiego. *Horyzonty Wychowania*, vol. 17(44), pp. 167-177.
21. Machnik-Słomka, J., Kordel, P. (2016). Significance of technological entrepreneurship and creativity in metallurgical enterprises. *Metalurgija*, vol. 55. iss. 4, pp. 855-858.
22. Makiela, Z. (2017). Przedsiębiorczość i innowacyjność akademicka w Polsce. *Przedsiębiorczość – Edukacja*, vol. 13.
23. Mason, P.C., Brown, D.R. (2014). *Entrepreneurial Ecosystems and Growth Oriented Entrepreneurship*. Program OECD LEED.
24. Matusiak, K.B., Matusiak, M. (2007). Pojęcie i ekonomiczne znaczenie przedsiębiorczości akademickiej. *Zeszyty Naukowe Uniwersytetu Szczecińskiego, Ekonomiczne Problemy Usług*, vol. 453, pp. 158-163.
25. *MCAST Entrepreneurship Centre*. Available online <https://www.maltaenterprise.com/mcast-entrepreneurship-centre-set-kbic>, 31.07.2019.
26. *MCAST*. Available online <https://www.mcast.edu.mt/about-mcast/>, 25.07.2021.
27. *MCAST Professional Research Doctorate (DRes)*. Available online https://www.mcast.edu.mt/wp-content/uploads/Professional-Research-Doctorate_V2.pdf, 25.07.2021.
28. Obi, E.C., Otamiri, S. (2010). Information and Communication Technology in Business Education: Challenges and the way forward. *Journal of Management and Enterprise Development*. Vol. 7, No. 4.
29. Osuala, E.C. (1987). *Business Education: Principles and Practice*. Onitsha: Africana Fep. Publishing Co.
30. Otamiri, S. (2008). Business Education and self-employment: A Case for Entrepreneurship Education. *Business Education Journal*.
31. Pasik, M. (2020). Przedsiębiorczość akademicka w świetle badań literatury. In: M. Ćwiklicki, A. Frączkiewicz-Wronka, A. Pacut, K. Sienkiewicz-Małyjurek (Eds.), *Współczesne problemy zarządzania publicznego i przedsiębiorczości społecznej* (pp.148-

- 165). Kraków: Małopolska Szkoła Administracji Publicznej Uniwersytetu Ekonomicznego w Krakowie.
32. Piwowar-Sulej, K., Kwil, I. (2018). Przedsiębiorczość, przedsiębiorczość akademicka i technologiczna, innowacyjność – próba systematyzacji. *Przegląd Organizacji*, No. 7(942), pp. 18-24.
33. *Politechnika Śląska*. Available online <https://www.polsl.pl/uczelnia/o-uczelni>, 26.07.2021.
34. Poznańska, K. (2014). Przedsiębiorczość akademicka: cechy i znaczenie w gospodarce światowej i polskiej. *Studia Ekonomiczne/Uniwersytet Ekonomiczny w Katowicach*, nr 183, *Innowacyjność współczesnych organizacji*. Cz. 2, *Kierunki i wyniki badań*, pp.164-172.
35. Stachowicz, J. (2015). Przedsiębiorczość technologiczna kluczową siłą rozwoju przedsiębiorstw wysokich technologii. *Zeszyty Naukowe Politechniki Śląskiej, Organizacja i Zarządzanie*, Z. 83, No. 1941, pp. 629-637.
36. Stawasz, E. (2007). Stymulowanie przedsiębiorczości środowiska naukowego w Polsce. *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, no. 453, pp. 265-276.
37. *Technopark Gliwice*. Available online <http://technopark.gliwice.pl/o-nas/>, 27.07.2021.
38. Ubulom, W.J. (2003). An Evaluation of Undergraduate Business Education Programme of tertiary institutions in Rivers State. *Business Education Journal*, Vol. 4, No. 1.
39. *Uczelnia Badawcza – Kształcenie*. Available online <https://www.polsl.pl/rjo3-ks/uczelnia-badawcza-ksztalcenie/>, 26.07.2021.
40. Uwamieye, R., Aduwa-Ogiegbean, S.E. (2006). Developing Entrepreneurship Culture among young people in Nigeria. *Journal of curriculum studies (CON)*, vol. 13, No. 3.
41. Wawak, T. (2017). *Zarządzanie w szkołach wyższych i innowacje w gospodarce*. Kraków: Wydawnictwo Uniwersytetu Jagiellońskiego.
42. Wyrwa, D., Sołtysiak M. (2016). Przedsiębiorczość akademicka – postawy przedsiębiorcze studentów. *Zeszyty Naukowe PWSZ w Płocku, Nauki Ekonomiczne*, t. XXIV.

CORPORATE SOCIAL RESPONSIBILITY REPORTS ON POLISH MARKET OVER THE YEARS – COMPARISON AND ANALYSIS

Bartosz ORZEŁ^{1*}, Radosław WOLNIAK²

¹ Silesian University of Technology, Faculty of Organization and management, Department of Economics and Informatics; Bartosz.Orzel@polsl.pl, ORCID: 0000-0003-1506-4798

² Silesian University of Technology, Faculty of Organization and management, Department of Economics and Informatics; Radoslaw.Wolniak@polsl.pl, ORCID: 0000-0003-0317-9811

* Correspondence author

Purpose: Based on the literature, a research gap was defined regarding the comparison of actual CSR reports submitted by enterprises in Poland over the years.

Design/methodology/approach: The comparison and analysis of CSR (Corporate Social Responsibility) reports from years 2007 to 2020 was conducted by obtaining available reports of various companies from individual years and comparing them in terms of the reporting approach in accordance with the reporting guidelines (Global Reporting Initiative – GRI guidelines). During the comparative analysis 184 reports were compared each other. The result is a verdict on the detail and overall "quality" of corporate CSR reports and approach to reporting over 13 years.

Findings: The conducted analysis shown that CSR reports are more and more compliant with the guidelines and these standards positively affect the standardization of the reported results. Despite, the fact that Polish organizations still do not voluntarily report in the same amount as many companies in Western Europe, they have learned and developed reporting methods and improve the quality of their reports over the years.

Research limitations/implications: The main limitation of this paper is the amount of reports, which were compared in paper. To obtain a broader picture of non-financial data reporting, including CSR reports in Poland, it is necessary to refer to a larger number of reports. It does not take into account the sector of small and medium-sized enterprises. It is worth to check which companies from each sector put the most non-financial information in their reports. The implication is the study allowed to obtain the current result CSR Reporting evolution process in Poland and the trend of reporting during last 13 years on the base of research sample.

Originality/value: The value of this paper is theoretical. This is proposal to analyze the CSR reports submitted over the years in Poland. The conducted literature analysis made it possible to determine the research gap in this area. This paper is addressed to those, who are interested in CSR reporting trend and the quality of CSR reporting in Poland. The results of analysis bases on both past and actual reports (from 2007 to 2020).

Keywords: CSR, Reports, Analysis, GRI, CSR reporting quality.

Category of the paper: Research paper.

1. Introduction

The dynamic development of CSR in Poland is dated on the beginning of XXI century (Ministerstwo Gospodarki, 2020). Reporting corporate social responsibility is the most common form of expressing and summarizing the effects of activities in the field of running a business in a socially responsible manner (Chojnacka, and Wiśniewska, 2016). Presenting the results of activities in the areas of CSR became for organizations a form of reporting to stakeholders their CSR efforts (Stępień, 2015; Freeman et. Al., 2010). The process of preparing and publishing CSR reports becomes more and more important. During last years information contained in reports is becoming more extensive and detailed (Dyląg, Puchalska, 2014). It is an approach involving a lot of pressure from the society and governments of highly developed countries to conduct business in accordance with the idea of sustainable development (Wensen et. Al., 2015). In Poland, reporting on corporate social responsibility has developed over the last 15 years. Firstly, the large international corporations that have started operating in the territory of the Republic of Poland were reporting often (Tepper, and Tepper, 2003; Wołczek, 2013; Chojnacka, and Wiśniewska, 2016; Hąbek, and Wolniak, 2015). Reporting corporate social responsibility by companies that operated on the European market in other EU countries was a well-established practice. Large companies entering the Polish market, in which reporting of non-financial data was not yet developed, had an easier task. However, small and medium-sized enterprises have started to follow this trend. Reporting corporate social responsibility by companies that operated on the European market in other EU countries was a well-established practice. Large companies entering the Polish market, in which reporting of non-financial data was not yet developed, had an easier task. Small and medium-sized enterprises, both in Poland and in Europe, began to follow this trend (Lock, and Seele, 2016; Tschopp, and Heufner, 2015; Vartiak, 2016; Borisova, 2020). In the years 2007-2015, a total of 200 reports were submitted to the competition for the best social responsibility report (Wróbel 2016). The number of reports submitted each year has changed. The trend line was shown on figure 1.



Figure 1. Amount of CSR reports submitted to competition from 2007-2015. Source: Authors' own work based on: Wróbel 2016, www.raportyspoleczne.pl.

Analyzing the enterprises of particular industries that submitted reports for the competition, it is possible to observe areas in which reporting is progressing more dynamically than in the case of others. Figure 2 shows the increase in the number of reports submitted for the competition by enterprises belong to different sectors.

It is only a small percentage of reports that have been submitted. However, it perfectly shows the growing interest of entrepreneurs operating on the Polish market in reporting on corporate social responsibility. The data presented in the chart shows that the food industry was the most reported sector in years 2007-2015. Enterprises not categorized in any of the mentioned sectors were the second most willing to report. Then services, transport and logistics, and other business sectors. Companies sometimes gave up reporting non-financial data in a certain year. However, in later years, they reported more frequent.

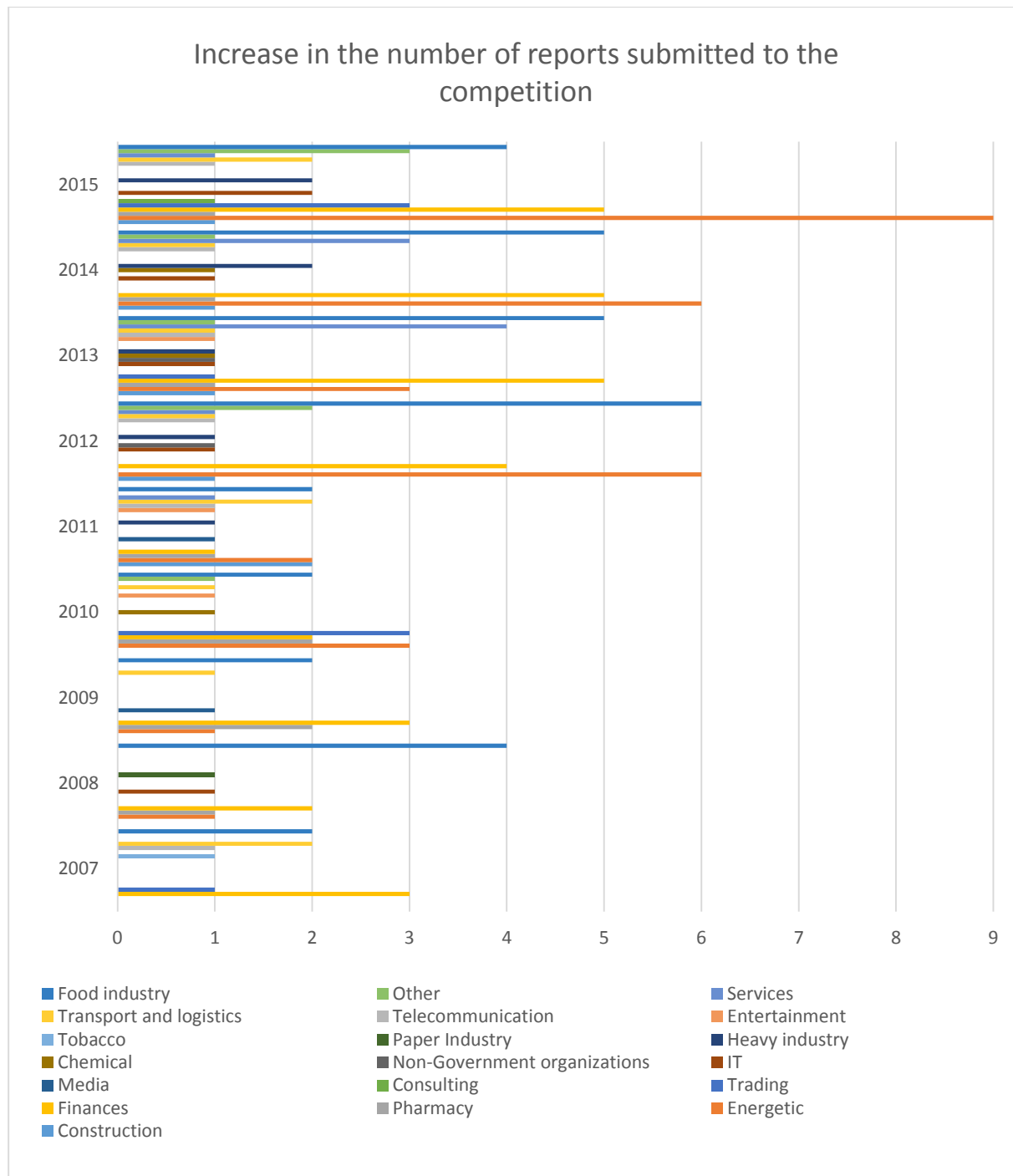


Figure 2. Amount of CSR reports submitted to competition from 2007-2015 by enterprises belong to different sectors. Source: Authors' own work based on: Wróbel 2016, www.raportyspoleczne.pl.

Ultimately, the improvement in the number of submitted CSR reports can be clearly seen in all analyzed sectors except construction. Nowadays, the enterprises both in Poland and in the world are aware of the complex and demanding environment which accompany economic and social changes. CSR reporting has become an expression of Commitment and taking an additional burden in the form of implementing areas belonging to CSR. This is of particular importance when an enterprise treats socially responsible activities as the part of its promotion (Wójcik-Jurkiewicz, 2016; Marcinkowska, 2010; Orzeł, 2020; Wolniak, and Hąbek, 2016;

Orzeł, and Wolniak, 2019; Chudy, and Nowodziński, 2007; Wolniak, 2014). Analyzing the issue of corporate social responsibility reporting, it is also worth taking into account different points of view regarding the premises of the very will to submit CSR reports by enterprises. On the one hand, there is a strong need and willingness of many business environments to relate to the improvement of the quality of life, care for the natural environment and the pursuit of sustainable development (Kim et al., 2018; Singhapakdi et al., 2015; Barnett et al., 2019; Raub, and Blunchi, 2014; Harness et al., 2018; Karaszewski, and Lis, 2014; Miller, and Eden, 2020). On the other hand, many studies take the opposite point of view (Wójcik-Jurkiewicz, 2016; Aqueveque et al., 2017; Cai et al., 2016; Rodrigo et al., 2016; Sen, and Bhattacharaya, 2001; Vanhamme, and Grobben, 2009; Barnett et al., 2019). An example may also be the study: "Role of CSR reporting. Evidence from Poland" (Wójcik-Jurkiewicz, 2016). The publication poses the following hypothesis: the reporting of information of CSR results solely from changing laws rather than from the need to disclosure significant environmental, social or economical events (Wójcik-Jurkiewicz, 2016).

In this publication the analysis of CSR reports submitted in the years 2011-2020 was conducted. Both compliance with the requirements of the guidelines according to which the reports were prepared were taken into account. The components of the reports were also analyzed to see how the content and detail of the information contained in the reports has changed, as well as the approach to publishing them in terms of distribution and availability. In addition, a study was conducted consisting in checking reports sent by enterprises of various industries to the competition for the best CSR report in 2015-2020 in order to obtain current results in the reporting trend by enterprises operating in Polish market on the basis of a research sample that is reports sent to competition listed above.

2. The trend of CSR reporting in years 2015-2020

First, the reports participating in the competition for the best CSR report in individual years were counted. The results are presented in Table 1.

Table 1.

Reports submitted to the competition "the best CSR report" in years 2015-2020

Year of competition	2015	2016	2017	2018	2019	2020	Total
Amount of submitted reports	37	31	44	49	45	56	262

Source: Authors' own work based on www.raportyspoleczne.pl.

An increase in the number of reports submitted for the competition by companies from various industries is clearly visible. In total, from 2015 to 2020, 262 reports were submitted to the competition. This is 62 reports more than the total number of reports submitted in years 2011-2015 (200 reports were submitted to competition during these years). The increase in number of submitted reports was shown on figure 3.

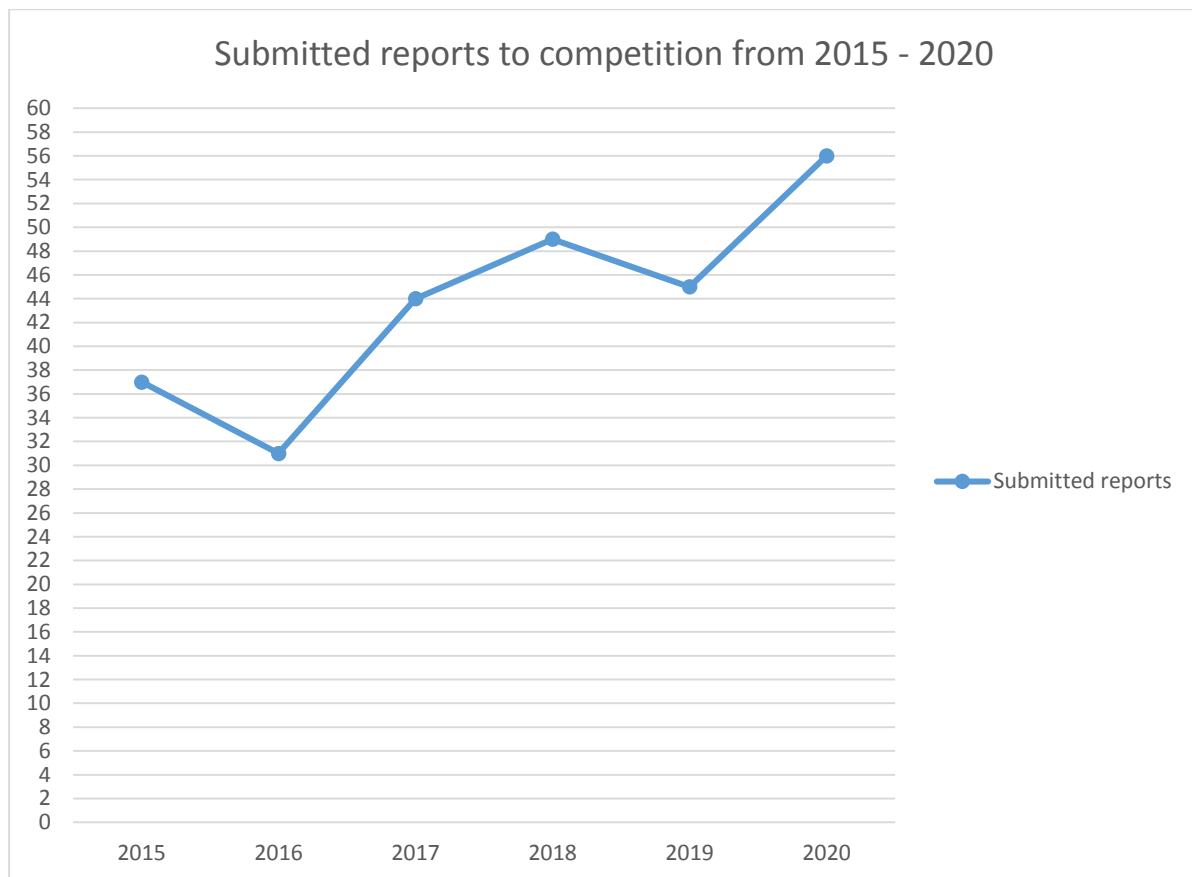


Figure 3. Amount of CSR reports submitted to competition from 2015-2020 by enterprises operating on Polish market. Source: Authors' own work based on: www.raportypoleczne.pl.

The next step was to complete the reports submitted for the competition, broken down by companies from various industries. The number of reports submitted by enterprises belonging to various industries in the following years is shown in Table 2.

Table 2.

Reports submitted to the competition "the best CSR report" in years 2015-2020 by enterprises belong to different sectors.

Year of competition		2015	2016	2017	2018	2019	2020	Total
Sector	Construction	1	3	5	4	3	5	21
	Energetics	9	5	5	7	3	6	35
	Pharmacy	1	1	1	1	0	0	4
	Finances	5	6	9	9	10	11	50
	Trading	3	0	4	2	2	8	19
	Consulting	1	0	0	0	0	1	2
	Media	0	0	0	2	2	2	6
	IT	2	2	1	0	1	1	7

Cont. table 2.

Non-government organizations	0	4	2	3	3	3	15
Chemical industry	0	0	1	3	1	1	6
Heavy industry	2	2	3	3	2	1	13
Paper industry	0	0	0	1	0	0	1
Food industry	4	2	5	3	3	4	21
Tobacco industry	0	0	0	0	0	0	0
Recycling	0	0	0	0	1	1	2
Entertainment	0	0	0	0	0	1	1
Fuels and resources	2	2	2	2	2	3	13
Telecommunication	1	0	1	1	1	3	7
Logistics and transport	2	1	1	2	1	0	7
Clothing industry	0	0	0	0	1	1	2
Services	1	3	2	3	3	3	15
Tourism	0	0	0	0	1	0	1
Other	3	0	2	3	5	1	14

Source: Authors' own work based on www.raportyspoleczne.pl.

The leaders in the number of reports submitted in the period 2015-2020 were enterprises from the financial sector (50 reports submitted in the competition). Then enterprises belonging to the energy (35 reports), construction and food sectors (21 reports). On figure 4, is presented the increase in the number of submitted reports of companies belonging to different sectors.

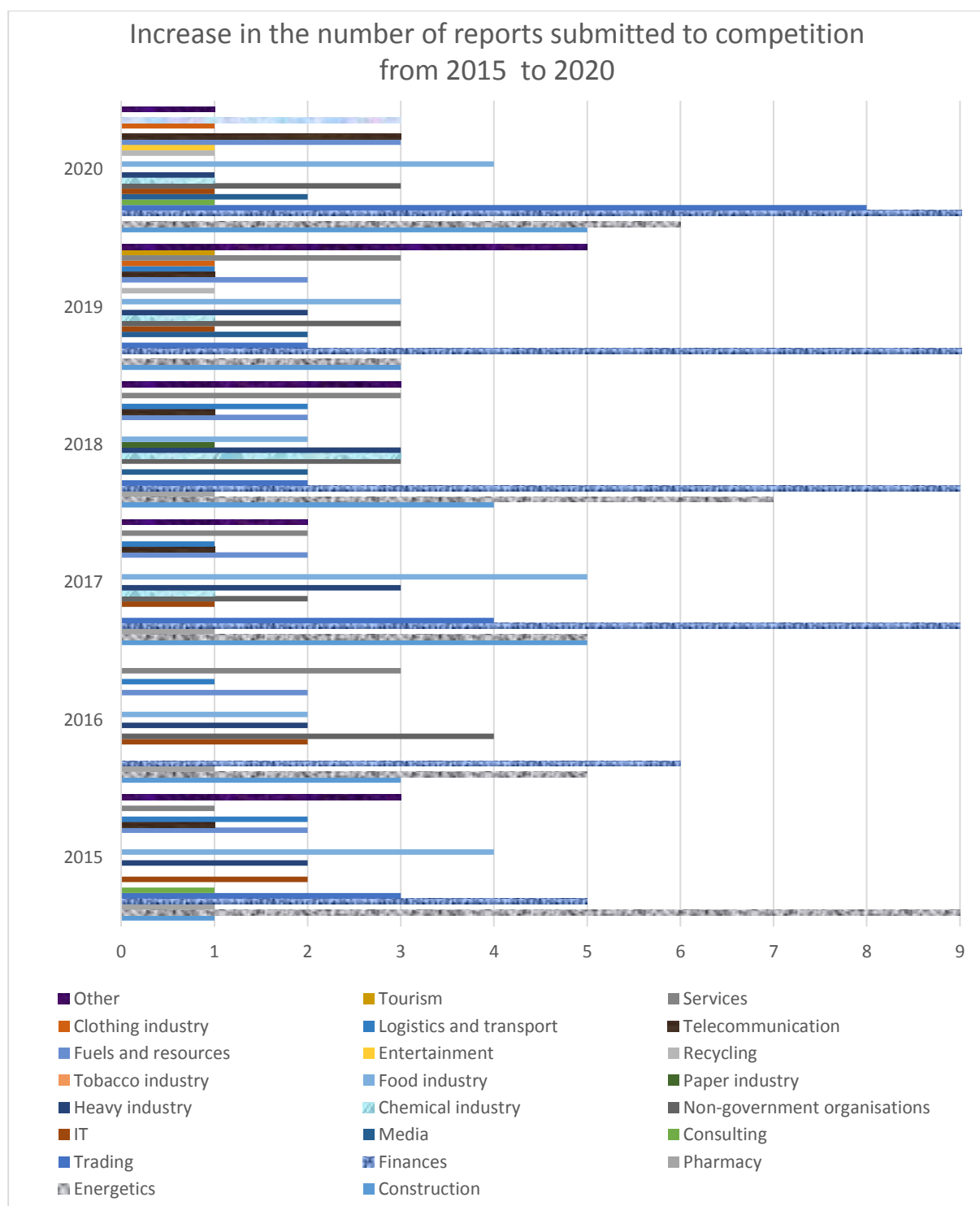


Figure 4. Amount of CSR reports submitted to competition from 2015-2020 by enterprises belong to different sectors. Source: Authors' own work based on: Wróbel 2016, www.raportyspoleczne.pl.

3. Comparison and reports analysis over the years 2007-2020

The first stage of the CSR report comparative study was based on obtaining reports from particular years. Reports submitted to the competition for the best CSR report from 2011 to 2020 were considered the "report database". The analysis consist of compared reports of all companies, which submitted their reports every year from 2007 to 2020 in food industry, finances and energetics sectors. During analysis 184 reports were compared in the terms of the applied GRI guidelines and the overall structure of the report. First, it was taken into account whether the reports for a given year was prepared according to GRI guidelines. The Table 3 shows amount of reports and versions of GRI guidelines according to, which submitted reports had been prepared.

Table 3.

Reports submitted by researched companies in years 2011-2020 prepared according to the GRI guidelines

Year	Company (reports prepared according to GRI guidelines)		
	Food production sector	Finances sector	Energetics
2007 (2,3,1 reports)	Non-GRI	Non-GRI	Non-GRI
2008 (4,2,1 reports)	Non-GRI	Non-GRI	Non-GRI
2009 (2,3,1 reports)	1 report contained UN Global Compact principles. Non-GRI (1 report)	Citing-GRI (1 report) GRI-G3 (1 report) Non-GRI (1 report)	Non-GRI (1 report)
2010 (2,2,3 reports)	GRI-G3 (both reports)	GRI-G3 (1 report) Non-GRI (1 report)	Non-GRI (3 reports)
2011 (2,1,2 reports)	GRI-G3.1 (B) (1 report) GRI-G3 (1 report)	GRI-G3 (1 report)	Non-GRI (2 reports)
2012 (6,4,6 reports)	GRI-G3.1 (B+) (2 reports) GRI-G3 (4 reports)	GRI-G3 (2 reports) Non-GRI (1 report) GRI-G3.1 (1 report)	Non-GRI (2 reports) GRI-G3.1 (4 reports)
2013 (5,5,3 reports)	GRI-G4 (Core) (2 reports) GRI-G3.1 (B+) (2 reports) Citing-GRI (1 report)	GRI-G4 (Core) (1 report) Non-GRI (1 report) GRI-G3.1 (Core) (2 reports) GRI-G3 (1 report)	GRI-G3.1 (3 reports)
2014 (5,5,6 reports)	GRI-G4 (Core) (4 reports) GRI-G3.1 (1 report)	GRI-G4 (3 reports) GRI-G3.1 (Core) (2 reports)	GRI-G4 (Core) (2 reports) Non-GRI (1 report) GRI-G4 (Core) (1 report) GRI-G3.1 (2 reports)
2015 (4,5,9 reports)	GRI-G4 (Core) (1 report) GRI-G3 (2 reports) Non-GRI (1 reports)	GRI-G4 (Core) (5 reports)	GRI-G4 (Core) (5 reports) Non-GRI (3 reports) GRI-G3.1 (1 report)
2016 (2,6,6 reports)	GRI-G4 (Core) (3 reports)	GRI-G4 (Core) (5 reports) Non-GRI (1 report)	GRI-G4 (Core) (6 reports)
2017 (5,8,5 reports)	GRI-G4 (Core) (3 reports) Non-GRI (1 report) GRI-G3 (1 report)	GRI-Standards (1 report) GRI-G4 (Core) (3 reports) Non-GRI (3 reports) GRI-G3.1 (Core) (1 report)	GRI-G4 (Core) (4 reports) Non-GRI (1 report)
2018 (2,9,7 reports)	GRI-G4 (Core) (1 report) GRI – Standards (1 report)	GRI-G4 (Core) (4 reports) GRI-Standards (5 reports)	GRI-G4 (Core) (5 reports) GRI-standards (1 report) Non-GRI (1 report)

2019 (3,9,3 reports)	GRI-G4 (Core) (1 report) GRI – Standards (1 report) Non-GRI (1 report)	Non-GRI (1 report) GRI-Standards (8 reports)	Citing-GRI (1 report) GRI-Standards (2 reports)
2020 (2,0,6 reports)	GRI – Standards (1 report) Non-GRI (1 report)	Lack of information	GRI-Standards (2 reports) Non-GRI (4 reports)

Authors' own work based on www.raportypoleczne.pl, www.database.globalreporting.org.

The analysis in terms of reporting guidelines showed that GRI indicators were used in enterprises belonging to selected sectors only from 2009. It can be noticed that the largest companies, often with a high share of foreign capital and with unprecedented patterns of organizational culture in Poland, reported non-financial data. Based on the resources available on the globalreporting.org website, it can be seen that in 2006-2008 there were 8 companies operating on the Polish market in the database. Only one of them used the GRI G2 guidelines. 2 companies used Citing GRI guidelines in 2007 and 2008. From 2016, GRI G4 became the most used guidelines. From that moment more and more frequent reporting according to the G4 until 2018 in the 3 analyzed sectors can be observed. In 2018, a similar number of reporters according to GRI-G4 and GRI-Standards can be noticed. Figure 5 shows the number of individual reporting standards in the analyzed sectors.

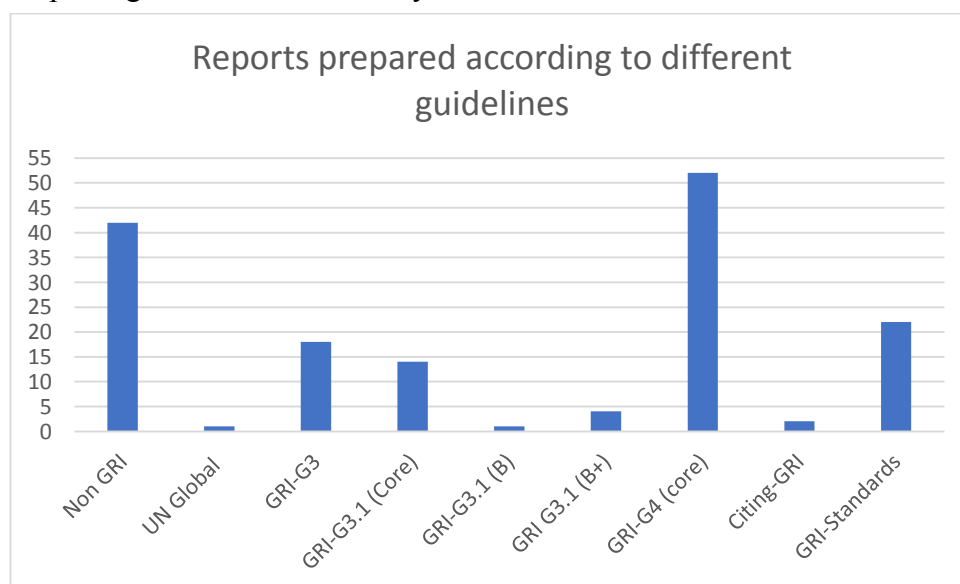


Figure 5. Reports prepared according to different guidelines. Source: Authors' own work based on www.raportypoleczne.pl, www.database.globalreporting.org.

Analyzing the number of standards according to which various reports were prepared, it is easy to notice that the GRI-G4 was most often used. However, it is worth noting that many companies reporting corporate social responsibility, especially in the early 2007-2013 period, did not use any guidelines. In later years, when reviewing the reports, it was noticed that even in later years, there were companies that did not use the guidelines but reported non-financial data at their discretion. However, it is worth noting that many companies reporting corporate social responsibility, especially in the early 2007-2013 period, did not use any guidelines.

When reviewing reports, it was noticed that even in later years, there were companies that did not use the guidelines but reported non-financial data at their discretion. This may be due to the first approaches to non-financial data reporting by companies that have not done so before. More than once, when browsing the reports collected in the database, it was noticed that in the early years of their development in Poland, non-financial reports were very often a kind of promotion or even a kind of advertising brochures for enterprises. The increase in the quality of reports revealing non-financial data can be noted along with the growing popularity of GRI-G3. Another aspect is the reporting obligation for large enterprises from 2017. Specific information on indicators and actions taken to improve the relevant aspects of the company's operations began to appear in the reports. However, large companies that had experience in reporting non-financial data in other countries were in the lead in this respect. Smaller companies and small and medium-sized enterprises reported in small amounts (several reports per year) or did not report their non-financial responsibility at all. Integrated reports have also become more and more popular in recent years. Nevertheless, such an approach to reporting was noticed in only 3 companies during the analysis of reports. It is noteworthy that in none of the surveyed reports of enterprises on the Polish market, reporting in accordance with GRI-G3.1 or GRI-G4 guidelines at the comprehensive level was noticed. Enterprises limit themselves to reporting at the core level. However, it is worth noting that non-financial data are disclosed by enterprises in more and more numbers and more willingly. In addition to GRI-G4, companies most willingly reported according to GRI-G3, GRI-G3.1 in the core version, as well as GRI-Standards.

4. Conclusions

Reporting non-financial data in Poland is relatively young activity compared to the markets of Western Europe or the United States. Nevertheless, companies operating on the Polish market have come a long way in reporting corporate responsibility over the last 13 years. The period of time analyzed in the publication coincided with the greatest development of both the reporting trend in Poland and the development of GRI indicators and guidelines. It was also a time of changes in EU law and directives related to the obligatory reporting of non-financial data of enterprises operating on the EU markets. Based on the analyzed reports of companies belonging to 3 sectors, the following conclusions can be drawn:

- Many companies may also treat CSR reports as a form of promotion and advertising.
- The development of GRI (GRI 3.1 and G-4) significantly contributed to the improvement in the quality of the reported data.
- Enterprises operating on the Polish market are reluctant to disclose their non-financial data in relation to financial ones (integrated reports).

- The best and most comprehensive reports are still produced by large companies. Small and medium-sized enterprises are not as eager to report corporate social responsibility as large enterprises.
- GRI-G4 are guidelines that enterprises used most often in the years 2007-2020.
- Most of the reports from the period 2013-2020 contained information about the quality assurance system operating in the company and information about the external verification of the CSR report.
- GRI-Standards are the most frequently used guidelines in the last 3 years in the financial sector (out of the 3 analyzed sectors).
- It can be said that in 2020 the overall quality of CSR reports, taking into account their content, indicators used, the fact of external verification is at a much higher level than in the years 2007-2013.
- On the basis of the analyzed reports, it was found that the enterprises not in the analyzed period were inclined to use the GRI-G4 in the comprehensive version. Only the Core version was decided.

The presented conclusions, which resulted from the analysis of CSR reports at the turn of 2007-2020, clearly show the growing interest and the growing number of annually published CSR reports. The data presented in the paper is also becoming more and more detailed. It is worth getting interested in this aspect in the segment of small and medium-sized enterprises, which report much less frequently than large companies. Nevertheless, the analyzed research sample is too small to be able to draw more conclusions than those presented for this sector.

References

1. Barnett, M.L., Henriques, I., Husted, B.W., & Layrisse Villamizar, F.A. (2019, July). Beyond good intentions: How much does CSR really help society? *Academy of Management Proceedings, Vol. 2019, No. 1*. Briarcliff Manor, NY 10510: Academy of Management, p. 17580.
2. Bidhan, L., Parmar, R., Freeman, E., Harrison, J.S., Wicks, A.C., Purnell, L., & de Colle, S. (2010). Stakeholder Theory: The State of the Art. *The Academy of Management Annals, 4:1*, pp. 403-445, DOI: 10.1080/19416520.2010.495581.
3. Borisova, A., Andre, P. (2020). *Measuring the Impact of the Transition to Mandatory CSR Reporting in Europe* (December 10, 2020). <https://ssrn.com/abstract=3746634> or <http://dx.doi.org/10.2139/ssrn.3746634>.
4. Cai, Y., Jo, H., & Pan, C. (2012). Doing well while doing bad? CSR in controversial industry sectors. *Journal of Business Ethics, 108(4)*, pp. 467-480.

5. Chojnacka, E., & Wiśniewska, J. (2016). Raportowanie danych CSR w Polsce. *Research Papers of the Wroclaw University of Economics/Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, 436, pp. 55-63.
6. Chudy, K., Nowodziński, P. (2007). Społeczna odpowiedzialność determinant konkurencyjności przedsiębiorstw. In: S. Lachiewicz, M. Matejun (eds.), *Problemy współczesnej praktyki zarządzania* (pp. 234–240). Łódź: Wydawnictwo Politechniki Łódzkiej.
7. Dyląg, R., Puchalska, E. (2014). Raportowanie zagadnień środowiskowych i społecznych. *Zeszyty Teoretyczne Rachunkowości*, tom 75(131). Warszawa: SKwP, pp. 23-45.
8. Hąbek, P., & Wolniak, R. (2015). Assessing the quality of corporate social responsibility reports: the case of reporting practices in selected European Union member states. *Quality & Quantity*, 50. 10.1007/s11135-014-0155-z.
9. Harness, D., Ranaweera, C., Karjaluoto, H., & Jayawardhena, C. (2018). The role of negative and positive forms of power in supporting CSR alignment and commitment between large firms and SMEs. *Industrial Marketing Management*, 75, pp. 17-30.
10. Karaszewski, R., & Lis, A. (2014). Przywództwo i CSR w kontekście pozytywnego potencjału organizacji. *Marketing i rynek*, 5(CD), pp. 1056-1062.
11. Kim, H.L., Woo, E., Uysal, M., & Kwon, N. (2018). The effects of corporate social responsibility (CSR) on employee well-being in the hospitality industry. *International Journal of Contemporary Hospitality Management*.
12. *Krajowy Program Reform Europa 2020* (2020). Ministerstwo Gospodarki.
13. Lock, I., & Seele, P. (2016). The credibility of CSR (corporate social responsibility) reports in Europe. Evidence from a quantitative content analysis in 11 countries. *Journal of Cleaner Production*, 122, pp. 186-200.
14. Marcinkowska, M. (2010). Społeczna odpowiedzialność przedsiębiorstw a ich wyniki ekonomiczne: aspekty teoretyczne. *Przegląd Organizacji*, 10, pp. 7-10.
15. Miller, S.R., Eden, L., & Li, D. (2020). CSR reputation and firm performance: A dynamic approach. *Journal of Business Ethics*, 163(3), pp. 619-636.
16. Orzeł, B. (2020). Non-financial Value Creation Due to Non-financial Data Reporting Quality. *Zeszyty Naukowe. Organizacja i Zarządzanie/Politechnika Śląska*, 148, *Contemporary management*, pp. 605-617.
17. Orzeł, B., & Wolniak, R. (2019). Overview of greenwashing methods and tools used in Polish and world enterprises. *Zeszyty Naukowe. Organizacja i Zarządzanie/Politechnika Śląska*.
18. Raub, S., & Blunschi, S. (2014). The power of meaningful work: How awareness of CSR initiatives fosters task significance and positive work outcomes in service employees. *Cornell Hospitality Quarterly*, 55(1), pp. 10-18.

19. Rodrigo, P., Duran, I.J., & Arenas, D. (2016). Does it really pay to be good, everywhere? A first step to understand the corporate social and financial performance link in Latin American controversial industries. *Business Ethics: A European Review*, 25(3), pp. 286-309.
20. Sen, S., & Bhattacharaya, C.B. (2001). Does doing good always lead to doing better? Consumer reactions to corporate social responsibility. *Journal of Marketing Research*, 38(2), pp. 225-243.
21. Singhapakdi, A., Lee, D.J., Sirgy, M.J., & Senasu, K. (2015). The impact of incongruity between an organization's CSR orientation and its employees' CSR orientation on employees' quality of work life. *Journal of Business Research*, 68(1), pp. 60-66.
22. Stępień, K. (2015). Sprawozdawczość społecznej odpowiedzialności przedsiębiorstw. In: B. Micherda (ed.), *Sprawozdawczość i rewizja finansowa. Uwarunkowania ekonomiczne, społeczne i regulacyjne* (pp. 286-294). Kraków: Wydawnictwo Uniwersytetu Ekonomicznego.
23. Tepper Marlin, A., Tepper Marlin, J. (2003). *A brief history of social reporting*, http://www.mallenbaker.net/csr/page.php?Story_ID=857, 27.08.2015.
24. Tschopp, D., & Huefner, R.J. (2015). Comparing the evolution of CSR reporting to that of financial reporting. *Journal of business ethics*, 127(3), pp. 565-577.
25. Vanhamme, J., & Grobben, B. (2009). Too good to be true! The effectiveness of CSR history in countering negative publicity. *Journal of Business Ethics*, 85(2), pp. 273-283.
26. Vartiak, L. (2016). CSR reporting of companies on a global scale. *Procedia Economics and Finance*, 39, pp. 176-183.
27. Wołczek, P. (2013). Raportowanie społecznej odpowiedzialności przedsiębiorstw w Polsce. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, nr 288, pp. 235-248.
28. Wolniak, R. (2014). Koncepcja CSR a wskaźnik dystansu wobec władzy/The concept of CSR and the power distance. *Zarządzanie. Teoria i praktyka*, 10(2), pp. 47-53.
29. Wolniak, R., & Hąbek, P. (2016). Quality assessment of CSR reports – factor analysis. *Procedia – Social and Behavioral Sciences*, 220, pp. 541-547.

ANALYSIS AND IMPROVEMENT OF THE PRODUCTION SYSTEM IN PRODUCTION ENTERPRISE

Andrzej PACANA^{1*}, Karolina CZERWIŃSKA², Lucia BEDNÁROVÁ³

¹ Rzeszow University of Technology, Faculty of Mechanical Engineering and Aeronautics, Rzeszow, Poland; app@prz.edu.pl, ORCID: 0000-0003-1121-6352

² Rzeszow University of Technology, Faculty of Mechanical Engineering and Aeronautics, Rzeszow, Poland; k.czerwinska@prz.edu.pl, ORCID: 000-0003-2150-0963

³ Technical University of Technology, Faculty of Mining, Ecology, Process Control and Geotechnologies, Košice, Slovak Republic; lucia.bednarova@tuke.sk, ORCID: 0000-0002-8582-0643

* Correspondence author

Purpose: The aim was to analyze inconsistencies in the production process of rebated internal frame and panel doors using KPIs and to identify causes of deviations from the quality plan using selected quality management tools.

Design/methodology/approach: KPIs and instruments of quality management (Pareto-Lorenz diagram, Ishikawa diagram and 5Why?) were used. The survey covered products manufactured in the third and fourth quarters of 2019.

Findings: It was found that the most serious non-compliance was the presence of an uneven rim surface (Pareto-Lorenz diagram). Potential causes were inadequate gluing of the door leaf layers and the use of worn flange processing equipment (Ishikawa diagram). On the other hand, the root cause of the quality problem turned out to be the lack of supervision and proper training of employees (5Why method).

Research limitations/implications: The presented research process has no limitations – it can be used in manufacturing companies. Further research will concern the application of the methodology to the analysis of other products offered by the company.

Practical implications: the research contributed to the identification of the causes of the lowered quality level, which will allow to implement appropriate remedial measures. As part of the improvement measures, training must be carried out at the workplace and the availability of work instructions must be ensured.

Originality/value: so far no extended quality analyses have been conducted in the company – no KPIs have been used in combination with extended analyses carried out with the use of quality management tools. The presented methodology is useful for the company where the analysis was made and for the manufacturing companies that want to effectively improve their production processes.

Keywords: mechanical engineering, quality engineering, key performance indicators (KPIs), quality management tools, manufacturing process.

Category of the paper: research paper and case study.

1. Introduction

Dynamically progressing changes in the world economy force manufacturing enterprises to permanently improve their functioning both in the aspect of management and in the production plane (Wolniak, and Skotnicka-Zasadzień, 2010; Pacana, and Czerwińska, 2017). Reorganisation, modernisation, as well as ISO standardisation (having an impact on innovativeness), are phenomena commonly occurring in production enterprises, which contribute to the increase of the effectiveness of their functioning, as well as undertaking actions compliant with the concept of sustainable development. These phenomena constitute a continuous and inevitable process of the progressive character (Mentel, Hajduk-Stelmachowicz, 2020; Hajduk-Stelmachowicz, 2014). According to the requirements of the modern market, the production process should meet the requirements related to the efficiency and flexibility of manufacturing. Such a modernly organized production process can efficiently react to: internal variability and implementation of new start-ups as well as external variability and competitive pressure. A response to such requirements is the creation and development of flexible production systems combining the diversity of production assortments (achieved in the non-rhythmic production system – production cells) and high efficiency and effectiveness (achieved in the rhythmic production system – production line automation) (Brzeziński, 2013; Krzyżanowski, 2005).

An important issue within the mature management of flexible manufacturing systems is the exercise of control in the manufacturing process which creates the opportunity to identify important manufacturing issues (Grabowska, and Hamrol, 2016; Wolniak, 2011). In the course of process analysis, it is crucial to use synthetic indicators that capture data from various sources. Key Performance Indicators (KPIs) work well for this purpose. KPIs are defined as a set of measures aimed at assessing the performance of a production system in terms of its quality, efficiency and maintenance (Bornos et al., 2016; Holender et al., 2016; Cheng, 2011). These indicators, allow to evaluate and monitor the functioning of the production system (Grabowska, 2017; Grycuk, 2010), however, to maintain the desired level of quality and solve production problems, quality management methods and tools should be applied (Czerwińska et al., 2020; Pacana, and Czerwińska, 2018; Sułkowski, and Wolniak, 2013; Wolniak, and Skotnicka, 2008).

The study aimed to perform an analysis of critical areas in the production process of rebated internal frame and panel doors with the use of key performance indicators (KPIs) and identification of causes of deviations from the quality plan using selected quality management tools. The study also focuses on the organizational activities of the company and the search for opportunities to improve the current state and conduct continuous improvement.

2. Characteristics of key performance indicators (KPIs)

The methodology for the application of measures in management, which combines both process controlling and Lean Manufacturing tools, is the concept of key performance indicators (KPIs). The idea of using key indicators is based on rationalisation and selection of an appropriate profile of indicators to facilitate the measurement of the achievement of objectives, defined in accordance with the SMART concept. (Specific, Measurable, Achievable, Relevant, Time-bound) (Mourtzis, 2018; Podgórski, 2015; Zhou, and He, 2018).

Key performance measures (KPIs) help businesses understand how well they are performing against their strategic objectives. In the broadest sense, a key performance measure provides the most important information about performance that enables companies or their stakeholders to know whether the organization is on the right track. Key performance measures are used to simplify organizational characteristics into a small number of key metrics to increase organizational effectiveness (Marr, 2010; Kang et al., 2015; Barone et al., 2011). From the range of available indicators, one should select a few or several that best reflect the level of achievement of strategic objectives (Emiliani et al., 2003). Among the frequently used quantitative indicators we can mention the measurement of the number of products meeting the quality requirements (Good Quantity – GQ), the measurement of the number of products not meeting the requirements but possible to be reprocessed (Rework Quantity – RQ), the measurement of the number of products not meeting the quality requirements and impossible to reprocess (Scrap Quantity – SQ) and the measurement of the total number of manufactured products (Processed Quantity – PQ). The parameter PQ is calculated as the sum of the parameters GQ, RQ and SQ (International Standard ISO 22400-2 2014).

With the help of direct KPIs, it is possible to determine basic and composite indicators. The basic KPIs describing the quality characteristics of products are presented in Table 1 (Sulkowski, and Wolniak, 2013):

Indicators are a reference point for employees, as they reflect the current characteristics of processes, facilitate rules of cooperation that are clearly defined and accepted by all parties. Introduction of indicators is related to building an adequate motivation system, which should be linked to the achieved results (Grycuk, 2010).

Table 1.
Basic KPIs describing quality features of products

No	Indicators KPI	
	Description	Pattern
1.	total number of manufactured products (Processed Quantity – PQ)	$PQ = GQ + RQ + SQ$
2.	percentage of good quality products QR (Quality Ratio), which is the overall percentage of good quality products manufactured	$QR = \frac{GQ}{PQ}$
3.	percentage of good-quality goods fit for sale QBR (Quality Buy Rate), i.e. the overall percentage of goods of good quality along with elements of recycled products	$QBR = \frac{GQ + RQ}{PQ}$
4.	percentage of compliance of the quantity of products (good-quality products) with the production plan (defined as WJ for the purposes of the development)	$WJ = \frac{SPQ - SQ}{SPQ}$
5.	percentage of quantitative deviations in the product manufacturing process (defined as IP for the purposes of the development)	$WI = \frac{PQ}{SPQ}$

Note. International Standard ISO 22400-2 2014.

3. Subject and scope of research

The research was conducted in the Agmar company, whose product range includes wooden interior and exterior doors with frames and a wide range of door accessories. The company headquarters is located in the south-eastern part of Poland. So far the company has not used KPIs in combination with extensive analyses performed with the use of quality management tools.

The object of research was rebated interior door with the panel, which standard equipment includes: leaf thickness 40 mm, fixed frame with dimensions 105 mm x 60 mm, the gasket on the perimeter of the frame, glued milk glass or transparent, one lock (key, insert), two hinges adjustable in three planes and hinge covers. The doors are finished by varnishing in a four layer system using a hydrodynamic method with transparent paints.

In view of the significant reduction in the level of quality and an increase in the number of complaints about internal doors, it was decided to analyse the problem. The analysis covered batches of products manufactured in Q3 and Q4 2019.

4. Research methodology

The research methodology included an indicator-based analysis of the manufacturing process of rebated internal doors with the use of qualitative KPIs within the framework of supervising the process quality level and the implication of quality management tools in order to identify the causes of quality deviations (Figure 1).

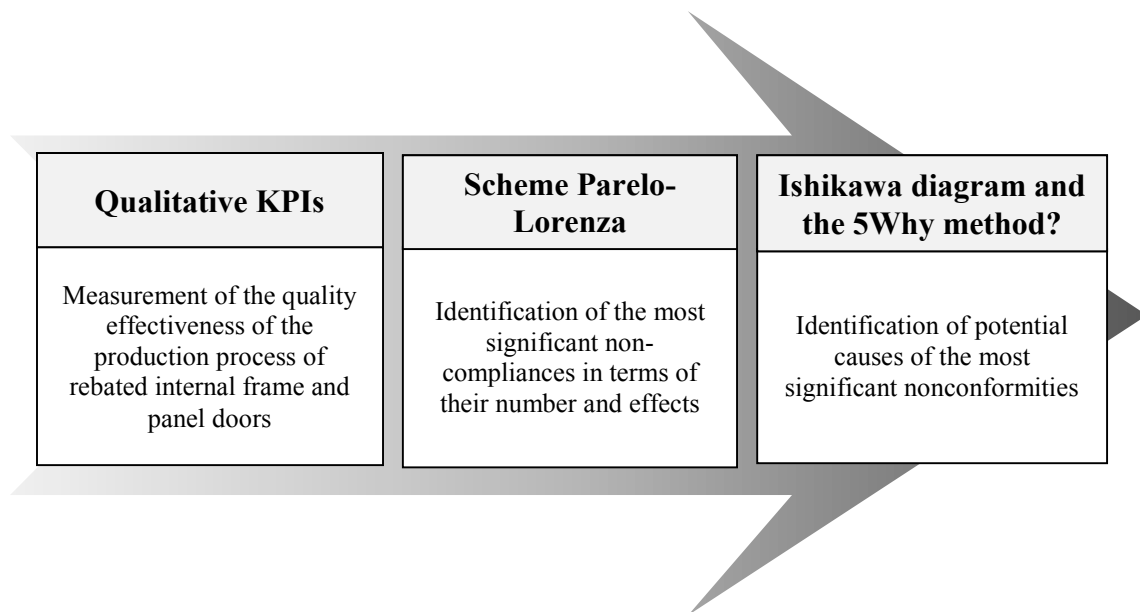


Figure 1. Methodology of studies used to analyse non-compliances and identify their causes

In order to diagnose the level of the qualitative efficiency of the process, the following indices were used: number of manufactured products (PQ), number of good quality products (QR), number of good quality products including elements reworked (QBR), compliance of the production quantity with the production plan (WJ) and the index of quantitative deviations in the process of manufacturing products (WI).

The analysis of the defectiveness of the product batches was carried out using the Pareto-Lorenz diagram, the cause-effect diagram and the 5Why? The Pareto-Lorenz diagram was used to identify the most significant inconsistencies in terms of the number of occurrences and their consequences, while the cause-effect diagram and the 5Why? were used to identify the potential causes of the most serious non-compliances.

5. Research results and analysis

A qualitative analysis of the production process was performed using the KPIs presented in the paper. The total number of manufactured products – indicator PQ, in the period considered is shown in Figure 2. The graphic includes a breakdown into: products that meet quality requirements (GQ), products that do not meet quality requirements but can be reprocessed (RQ), and products that do not meet quality requirements and cannot be repaired (SQ).

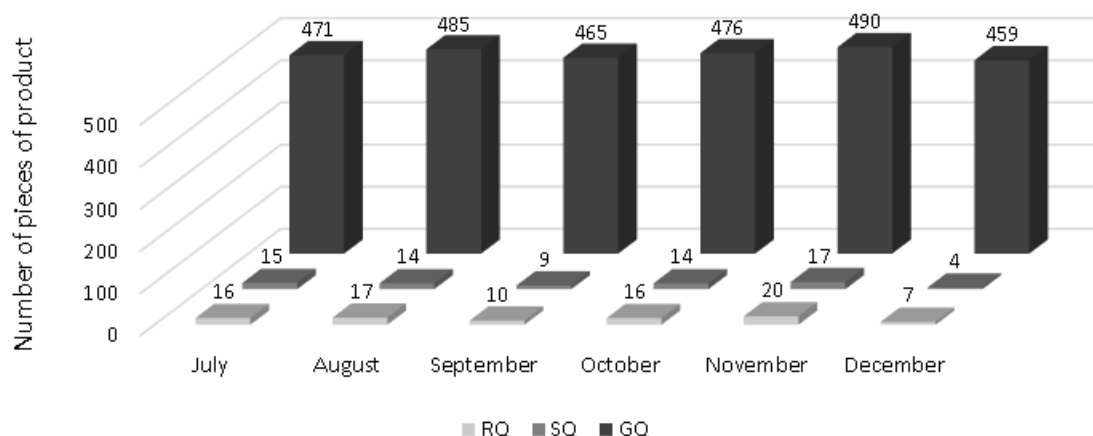


Figure 2. Production volume of the tested product. Source: Own elaboration based on: Agmar Door materials. Unpublished materials. Chwałowice, 2019.

Based on figure 2 it can be seen that the sum of all the nonconforming products manufactured amounted to 159 pieces, which constituted 5% of all the produced door panels. The highest number of nonconforming products was manufactured in November (37 pieces, 46% of which were not repaired), while the lowest number of nonconforming products was manufactured in December (9 pieces, 36% of which were not repaired). It may be assumed that the relatively low values for non-compliant products in December are influenced by the decrease in the total number of products manufactured.

Figure 3 shows the values of the indicators used in the study: the percentage of products achieving the desired quality level (QR) the percentage of products with the desired quality level including reprocessed elements (QBR), the percentage of conformity of production quantities (WJ) and the percentage of quantity deviations in the manufacturing process of products (WI).

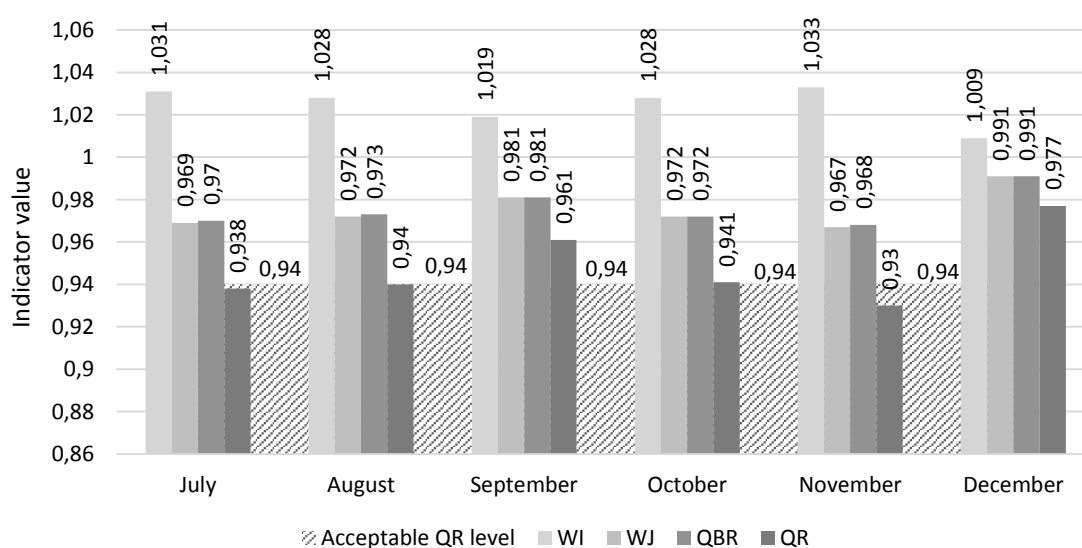


Figure 3. Values of qualitative indicators. Source: Own elaboration based on: Agmar Door materials. Unpublished materials. Chwałowice, 2019.

WJ index values are equal or slightly lower than QBR index values. The WI values also deviate from the assumed values, as its desired value is 1. Exceeding this value indicates overproduction and failing to achieve it indicates the production of too few products in relation to the assumptions of the production plan. The company's qualitative target for rebated frame and panel interior doors is 0.94 (QR ratio). The summary in Figure 3 shows that only in one month, september, the target was clearly exceeded. In the other months, the QR index reached equal or lower values. The QBR taking into account the number of non-conforming but repairable products each month exceeded the acceptable value. Nevertheless, the achieved result should not be interpreted as a result that does not require adjustments, since the necessity to reprocess the products (repair) generates additional costs for the company. With the current number of nonconforming products, in order to meet the customers' requirements, the company is forced to produce more products than assumed in the prediction plans.

As part of the improvement activities of the production process, the sources of disturbances should be identified and their validity determined. The complaint data shows that the most frequent reasons for complaints were production discrepancies.

Recognition of the most significant inconsistencies from the point of view of the number of their occurrence and their effects was carried out using a Pareto-Lorenz diagram. Figure 4 shows the developed diagram for the problem of decreasing the quality level of rebated internal frame and panel doors.

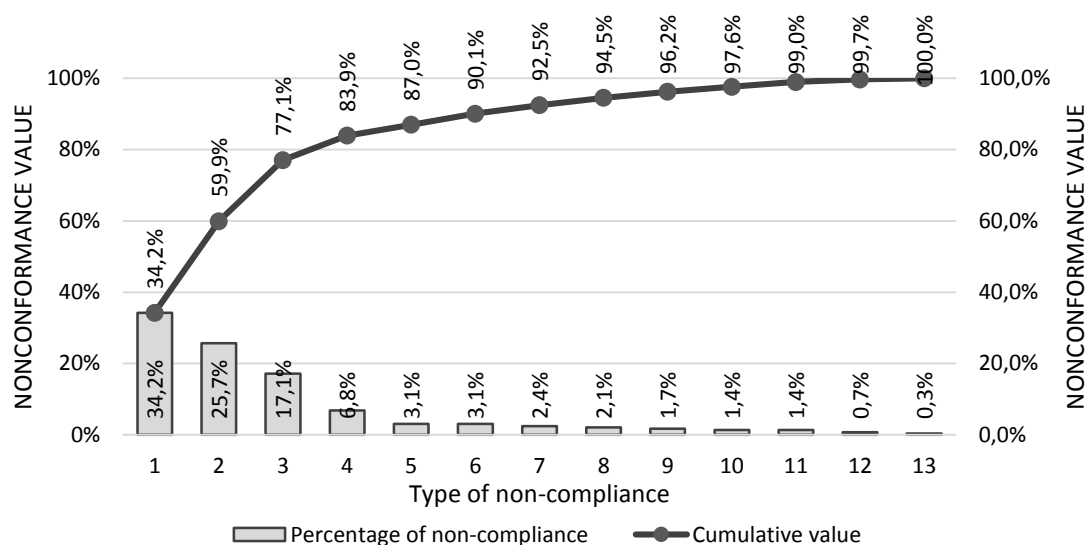


Figure 4. Pareto Lorenz plot for interior door incompatibility. Source: Own elaboration based on: Agmar Door materials. Unpublished materials. Chwałowice, 2019.

The incompatibilities included in the diagram of the non-conformities present in the test products are determined in turn: 1 – the uneven surface of the rim under the adhesive; 2 – inadequate geometry of the rim under the adhesive; 3 – inadequate installation of hinges; 4 – incorrectly mounted seal; 5 – inappropriate dimensions of the rim under the adhesive; 6 – scratches on the surface of the door leaf; 7 – no hinge overlays; 8 – inadequate geometry of the door leaf; 9 – damage/bruising of the door leaf; 10 – discolouration on the door wing;

11 – 2 – air blisters between layers of varnish; 12 – gasket defects on the door wing; 13 – adhesive leakage from under the seal.

The analysis of the batches of products has shown that the most serious nonconformity concerns the uneven surface of the rim under the rebate (34.2%). Critical discrepancies also included the presence of inadequate rim geometry under the rebate (25.7%) and incorrectly installed hinges (17.1%). Critical nonconformities, in the analyzed period, contributed to 77% of all nonconforming products. Immediate remedial action should be taken in relation to identified non-conformities and the process should be monitored.

The next step in the analysis of the decline in the quality of interior doors involved identifying the potential causes of the most significant nonconformance using an Ishikawa diagram. Figure 5 covers the key areas (material, machine) within which the most likely causes of a significant number of products with an uneven flange surface under the rebate have been identified.

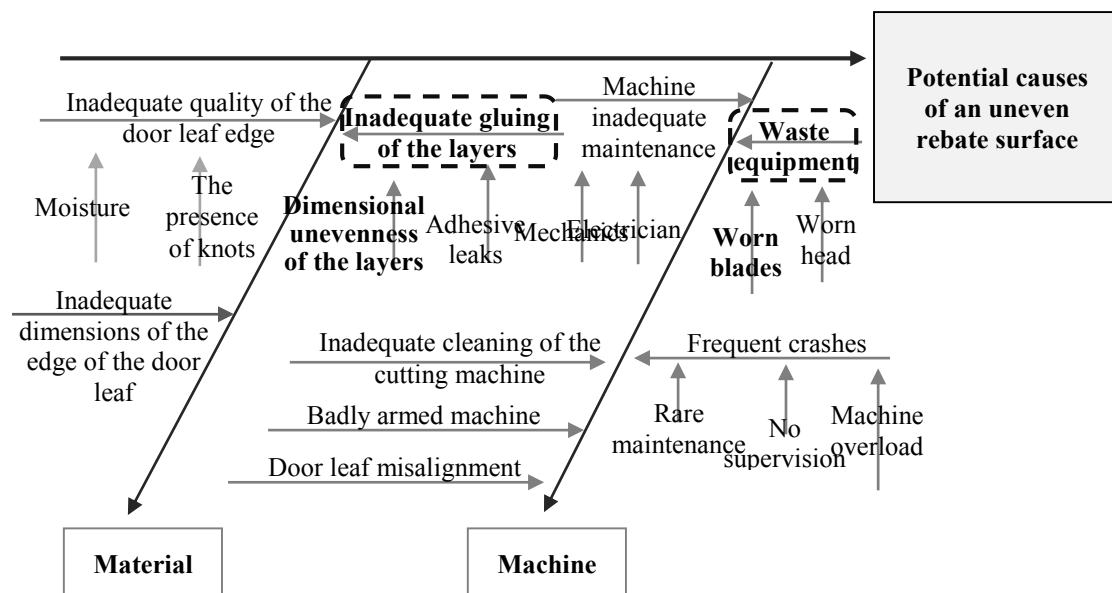


Figure 5. Cause-effect diagram for the most serious internal door non-conformities

Among the factors influencing the occurrence of nonconformities in the finished product, the use of worn-out equipment (worn-out blades) was singled out in the "machine" area. The improper condition of the blades in the machine used to make the flute for the rebate most likely contributed to the cutter not being made following the dimensional and surface roughness requirements. The second potential cause of this situation was inadequate glueing of the door leaf layers, which contributed to the unevenness in the edge area. In combination, these variables contributed to a significant number of products with uneven rim surfaces.

As a further analysis, the 5Why method was performed? for the problem of using used fittings in the saw and improper glueing of the door leaf layers. The result of the 5Why method? is shown in Figure 6, from which it was concluded that the root cause of both the use of worn hardware in the saw and the inadequate glueing of the door leaf layers was the lack of supervision, control and proper training of the worker. Inadequate employee management

resulting in a lack of instructional training at the door leaf flange realization workstation contributed to a significant decrease in the quality of the production process.

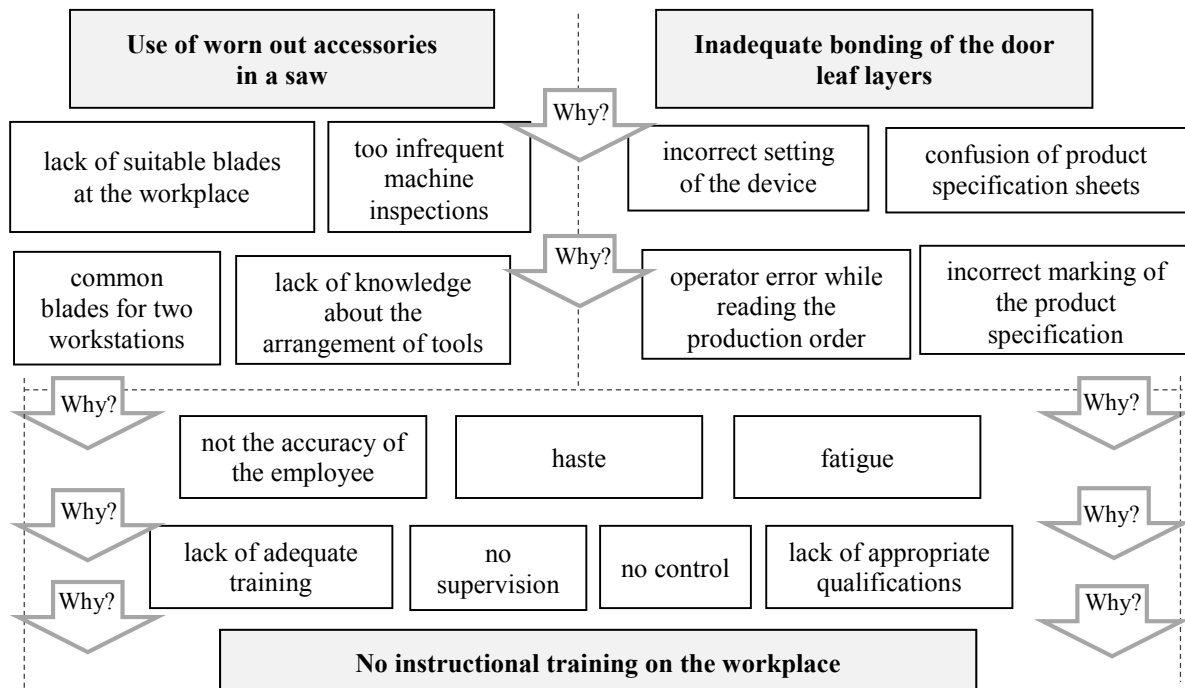


Figure 6. 5WHY method for the problem of using used accessories in a saw and inadequate bonding of the door leaf layers

As part of the improvement activities, a training plan should be developed for all production positions that are located within the production line of rebated internal frame and panel doors. In addition, develop and ensure the availability of job instructions at all workstations.

6. Conclusions

Properly selected indicators are the key element in the proper use of controlling in the organization. The indicators used in the production process require their incorporation into the structure and management system of the company. On the other hand, correlation of the supervision system with mutually complementary quality tools allows to ensure an appropriate level of quality of the offered products.

The paper presents research relating to the batch of rebated internal doors with frame and panel elements. The analysis conducted focused on the decline in quality levels and adverse events.

Frequencies and types of causes of incidents were presented by means of a Pareto-Lorenz diagram, which enabled the hierarchy of causes of product nonconformities, thus indicating the priority on which to focus remedial actions. The most common nonconformity was the presence of an uneven rim surface under the rebate. The next stages of the analysis were concerned with

identifying potential causes of the identified non-conformity. After developing the Ishikawa diagram, it was found that the potential causes related to the material and machine area were inadequate gluing of the door leaf layers and the use of worn equipment for the rim processing. As part of further analysis, the 5Wh method was performed. On the basis of which, it was concluded that the root cause of both the use of a worn accessory in the saw and inadequate gluing of the layers of the door leaf was the lack of supervision, control and proper training of the worker. Therefore, as a remedial measure, responsibilities should be evenly distributed among employees and supervision and job training should be provided and job instructions should be available at all workstations.

Monitoring and correcting the production process through the use of KPIs and quality management tools is a methodology that helps to improve, steer the organization and indicate the emergence of problems in the company, thus enabling a dynamic response and documentation of actions and effects. The methodology presented in the study is a universal method of analysis, which can be used in any manufacturing company focused on continuous improvement.

References

1. Barone, D., Jiang, L., Amyot, D., Mylopoulos, J. (2011). *Reasoning with key performance indicators*. Proceedings of the 4th IFIP WG8.1 Working Conference on the Practice of Enterprise Modeling (PoEM11).
2. Borsos, G., Iacob, C.C., Calefariu, G. (2016). *The use KPI's to determine the waste in production process*. 20th Innovative Manufacturing Engineering And Energy Conference (Imanee 2016), IOP Conference Series-Materials Science and Engineering, Vol. 161.
3. Brzeziński, M. (2013). *Organizacja produkcji w przedsiębiorstwie*. Warszawa: Difin.
4. Cheng, H.J. (2011). *Research on the Multiple Level Performance Management System Based on KPI*. Proceedings Of The 8th International Conference On Innovation And Management, 8th International Conference on Innovation and Management, Yamaguchi Univ, Kitakyushu, Japan.
5. Czerwińska, K., Dwornicka, R., Pacana, A. (2020). *Improvement of the surface of the combustion chamber of a piston using selected techniques of production organization*. Terotechnology XI, 11th Conference on Terotechnology, 27-28 September 2019, Kielce.
6. Emiliani, B., Stec, D., Grasso, L., Stodder, J. (2003). *Better thinking, better results. Using power of lean as a total business solution*. Center for lean business management llc.
7. Grabowska, A., Hamrol, A. (2016). Badanie dojrzałości procesów zarządzania jakością w przedsiębiorstwach produkcyjnych. *Przedsiębiorstwo we współczesnej gospodarce – teoria i praktyka, nr 1*.

8. Grabowska, S. (2017). Kluczowe wskaźniki efektywności – studium przypadku. *Zeszyty Naukowe Politechniki Śląskiej, Seria: Organizacja i Zarządzanie*, z. 108.
9. Grycuk, A. (2010). Kluczowe wskaźniki efektywności (KPI) jako narzędzie doskonalenia efektywności operacyjnej firm produkcyjnych zorientowanych na lean. *Przegląd Organizacji*, nr 2.
10. Hajduk-Stelmachowicz, M. (2014). Znaczenie strategii proekologicznych w kontekście budowania przewagi konkurencyjnej przedsiębiorstw. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, Zarządzanie strategiczne w teorii i praktyce*, nr 366.
11. Hollender, M., Chioua, M., Schlake, J., Merkert, L., Petersen, H. (2016). *KPI-based Process Operation Management of highly automated processes*. Institut für Regelungs- und Steuerungssysteme (IRS).
12. International Standard ISO 22400-2 (2014). Automation Systems and Integration – Key Performance Indicators (KPIs) for Manufacturing Operations Management – Part 2: Definitions and Descriptions. Geneva: International Standard Organization (ISO). *International Journal of Production Research*, 54(21). DOI: 10.1080/00207543.2015.1136082.
13. Kang, N., Zhao, C., Li, J., Horst, J.A. (2015). *Analysis of key operation performance data in manufacturing systems*. Proceedings – 2015 IEEE International Conference on Big Data.
14. Krzyżanowski, J. (2005). *Wprowadzenie do elastycznych systemów wytwórczych*. Wrocław: Wydawnictwo Politechniki Wrocławskiej.
15. Marr, B. (2010). *How to design Key Performance Indicators, Management Case Study*. London: The Advanced Performance Institute.
16. Materiały Agmar Drzwi (2019). Materiały niepublikowane. Chwałowice.
17. Mentel, U., Hajduk-Stelmachowicz, M. (2020). Does standardization have an impact on innovation activity in different countries? *Problems and Perspectives in Management*, 18(4).
18. Mourtzis, D., Fotia, S., Vlachou, E., Koutoupes, A. (2018). A Lean PSS design and evaluation framework supported by KPI monitoring and context sensitivity tools. *The International Journal of Advanced Manufacturing Technology*, vol. 94.
19. Pacana, A., Czerwińska, K. (2017). Wykorzystanie metody 8D do rozwiązania problemu jakościowego. *Zeszyty Naukowe Politechniki Częstochowskiej*, nr 28, ss. 73-86.
20. Pacana, A., Czerwińska, K. (2018). Zastosowanie narzędzi zarządzania jakością do analizy przyczyn wadliwości wyrobu. *Zeszyty Naukowe. Organizacja i Zarządzanie*. Politechnika Śląska.
21. Podgórski, D. (2015). Measuring operational performance of OSH management system – A demonstration of AHP-based selection of leading key performance indicators. *Safety Science*, no. 73.

22. Sułkowski, M., Wolniak, R. (2013). Przegląd stosowanych metod oceny skuteczności i efektywności organizacji zorientowanych na ciągłe doskonalenie. *Zeszyty Naukowe. Organizacja i Zarządzanie*. Gliwice: Politechnika Śląska.
23. Wolniak, R. (2011). *Parametryzacja kryteriów oceny poziomu dojrzałości systemu zarządzania jakością*. Gliwice: Wydawnictwo Politechniki Śląskiej.
24. Wolniak, R., Skotnicka, B. (2008). *Metody i narzędzia zarządzania jakością, Teoria i praktyka*. Gliwice: Wydawnictwo Politechniki Śląskiej.
25. Wolniak, R., Skotnicka-Zasadzień, B. (2010). *Zarządzanie jakością dla inżynierów*. Gliwice: Wydawnictwo Politechniki Śląskiej.
26. Zhou, H., He, Yl. (2018). *Comparative Study of OKR and KPI*. 2018 International Conference On E-Commerce And Contemporary Economic Development (Eced 2018), DEStech Transactions on Economics Business and Management.

RESOURCES, DYNAMIC CAPABILITIES, AND PERFORMANCE: EVIDENCE FROM POLISH GREEN INNOVATIVE COMPANIES

Magdalena PICHLAK

Faculty of Organization and Management, Silesian University of Technology, Zabrze;
magdalena.pichlak@polsl.pl, ORCID: 0000-0002-8898-7393

Purpose: The paper examines the mediating effect of dynamic capabilities (sensing, seizing, and reconfiguring) on the relationship between critical resources (financial, human, and physical) and Polish green innovative companies' performance.

Design/methodology/approach: The paper combines the Resource-Based View of the Firm with Dynamic Capabilities View and applies them to eco-innovation performance. The study is quantitative and was conducted among 54 Polish green innovative companies. Hierarchical regression analysis was used to test the research hypotheses.

Findings: The results indicate that sensing and seizing opportunities mediate the relationship between all types of resources and eco-innovators' performance. Moreover, reconfiguring the resource base mediates the relationship between human resources and Polish green innovative companies' economic output.

Research limitations/implications: The results of the study indicate that a specific set of resources is not always enough to enhance green innovative companies' performance. Therefore, there is a need for dynamic capabilities. Such capabilities lead to the development of resources and their dynamic adaptation to technological and market changes. The findings may contribute to a broader scientific discussion on the specificity of eco-innovative activity and its conditions in the Polish economy.

Originality/value: The paper is the first to examine – to the author's best knowledge – the mediating effect of multidimensional dynamic capabilities on the relationship between critical resources and Polish green innovative companies' performance.

Keywords: resources; dynamic capabilities; performance; eco-innovation.

Category of the paper: Research paper.

1. Introduction

Frequently used in academic research, the Resource-Based View (RBV) emphasizes the importance of the firm's resources as the basis for gaining competitive advantage (Barney, 1991; Epelbaum, and Martinez, 2014; Andersén, 2021). RBV (which is relatively static)

considers the firm as a set of diverse resources that differentiate it from its competitors. Moreover, this approach assumes that these resources are heterogeneously distributed among competing firms (Helfat, and Peteraf, 2003; Li-Ying et al., 2016). An extension of the RBV is the Dynamic Capabilities View (DCV), which (consistent with its dynamic nature) describes how a company's resources evolve to provide a relatively sustainable competitive advantage (Teece, 2007; Liao et al., 2017). Several alternative approaches to dynamic capabilities have been offered in the literature (Teece et al., 1997; Eisenhardt, and Martin, 2000; Zollo, and Winter, 2002; Zahra et al., 2006). These views differ concerning the nature of dynamic capabilities, their role, their effects, and the context they are developed (cf. Barreto, 2010). Despite the existing differences, most researchers agree on the purpose of building dynamic capabilities as a response to a changing environment.

As companies operate in a constantly changing environment (characterized by unpredictability and discontinuity), there is a need to build dynamic capabilities. It is particularly important in developed countries (e.g. EU countries), where companies have to deal with the technological changes and the increasingly environmental challenges generated by growing emissions of pollutants. The increasing scope of environmental restrictions, including high and unstable energy prices, restrictiveness of environmental regulations (resulting from the European Green Deal adopted by the European Commission), and the growing ecological awareness of consumers imply the need to include environmental issues in companies' activities. In such conditions, excessive concentration only on the resources may lead to – in Leonard-Barton's (1992) terminology – core rigidities, i.e. restriction of the scope and directions of their future development.

The paper attempts to make a value-added contribution by integrating RBV and DCV and extending them to the eco-innovation literature. The paper's objective is to empirically examine the relationship between key resources, dynamic capabilities, and performance among the 54 most innovative companies in Poland that develop globally new green technology solutions.

The results of the studies conducted in the literature indicate that, compared to conventional innovation, eco-innovation requires a more significant commitment of resources (Horbach, 2008; Zhang, and Walton, 2017) and their new combinations due to the higher level of uncertainty of the generated ecological solutions (Poznańska, 2018). Moreover, the specific nature of these innovations and the resources used in their development create a 'natural' imitation barrier for competitors. Second, the diversity of eco-innovative changes indicates that green strategies are not limited to maintaining the status quo but include proactive actions to anticipate future regulations or consumer demands (Klewitz, and Hansen, 2014). Such a posture, as Meredith (1995) notes, constitutes a defensive strategy of a proactive nature and, by definition, requires specific capabilities through which firms can build, integrate, and reconfigure their resources, adapt them to a changing environment, and transform them into efficiencies (cf. Bartoszczuk, 2018; Wysocki, 2019). Simultaneously, despite the growing

number of studies treating the importance of dynamic capabilities, many researchers (Ambrosini et al., 2009; Easterby-Smith et al., 2009; Barreto, 2010) emphasize that the concept still needs empirical confirmation. Moreover, embedding a multidimensional view of dynamic capabilities in eco-innovation (at the micro-level of analysis) is a matter explored to a relatively limited extent (del Rio et al., 2016; Hazarika, and Zhang, 2019). This study seeks to fill this gap in theoretical (research framework) and empirical (verification of research hypotheses) layers.

2. Theoretical Framework

2.1. Resource-Based View and Dynamic Capabilities View

Both RBV and DCV are very popular in the literature for explaining the sources of a firm's competitive advantage and enhancing performance. The RBV, developed by Penrose (1959), argues that a firm's competitive advantage is determined by its critical resources, which, according to Barney's VRIN framework, should be: valuable (should have value), rare, and firm-specific (meaning that they cannot be widely distributed in a given sector and must be closely identifiable with a specific firm, making them difficult for competitors to acquire), imperfectly imitable (due to their intangible and unique nature), and non-substitutable. Resources are categorized in the literature into several specific typologies and include financial resources, human resources, physical resources, and technological resources (Grant, 1991). The other typology is to distinguish tangible resources (financial and physical) and intangible re-sources (del Río et al., 2016), including the qualifications and skills of organizational members that require learning and accumulating difficult to replicate experiences.

The RBV perspective, although sometimes criticized for being tautological (Chahal et al., 2020), provides an effective strategy based on the unique resources that define the firm position relative to competitors (Li-Ying et al., 2016). The assumption of the leading role of critical resources and the explanation of their synergistic impact on firm performance are also the basis of other related theories, i.e., Knowledge-Based View of the Firm (KBV) (Grant, 1996); Relational RBV (Andersén, 2021) according to which resources can extend beyond organizational boundaries and can be embedded in inter-organizational activities and procedures; and Natural RBV (Hart, 1995; Hart, and Dowell, 2010) which emphasizes the environmental impact of firm's resources.

Since RBV is relatively static and fails to explain the sources of a company's competitive advantage operating in a dynamically changing environment (Barreto, 2010), the Dynamic Capabilities View (Teece et al., 1997; Teece, 2007; Liao et al., 2017) has attracted increasing attention from researchers. This view suggests that resources can be a source of competitive advantage only to the extent that a firm can develop, integrate, and configure them using

specific capabilities. Because DCV is based on similar assumptions as RBV, researchers conceptualize them as complementary perspectives that explain the multidimensional effects of resource configuration on firm performance (Ambrosini, and Bowman, 2009; Li-Ying et al., 2016).

2.2. Conceptualization of Dynamic Capabilities

The literature emphasizes that dynamic capabilities are a subset of a broader construct – organizational capabilities (Wojcik-Karpacz, 2017), defined by Helfat and Peteraf (2003, p. 999) as the abilities ‘to perform a coordinated set of tasks, utilizing organizational resources, for the purpose of achieving a particular end result’. Following the impact of capabilities on the company’s development, dynamic capabilities (second-order capabilities) can be distinguished from operational capabilities (ordinary, substantial, functional, first-order). Teece et al. (2016) indicate that a firm’s ordinary capabilities are a measure of its technical fitness and, by definition, do not prevent creative destruction processes. Developing the typology proposed by Collis (1994) and relating it to innovation, Danneels (2002) distinguishes (1) first-order capabilities that involve the tangible and intangible resources needed for innovation, and (2) second-order capabilities (dynamic capabilities) crucial to identify, evaluate, and incorporate new technological and customer competences, as well as new knowledge and skills that lie beyond the specific domain. Similarly, Ambrosini et al. (2009) capture the first category as the resource base, and Winter (2003) suggests that building higher-order capabilities depends on the costs and benefits of investments relative to ad hoc problem-solving.

The most commonly cited definition of dynamic capabilities provided by Teece et al. (1997, p. 516) states that dynamic capabilities are ‘the firm’s ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments’. The researchers emphasize the role of path dependencies, and organizational learning, referring to the evolutionary perspective. Moreover, they argue that dynamic capabilities are usually built rather than bought; hence (as in RBV), they are heterogeneous and can be a source of relatively sustainable competitive advantage in a rapidly changing market environment (Teece et al., 1997; Teece, 2007; Barreto, 2010).

A different research context adopted by Eisenhardt and Martin (2000) indicates that the nature of dynamic capabilities depends on the firms’ environment characteristics. In moderately dynamic markets, dynamic capabilities can be viewed as organizational routines; in high-velocity markets, they manifest as simple, highly experiential, and fragile processes that rely on rapidly created new knowledge.

The paper refers to the most popular in the literature view of dynamic capabilities by Teece et al. (1997) and Teece (2007), who distinguish sensing, seizing, and reconfiguring capabilities. Building on the studies of Wilden et al., (2013), and Fainshmidt and Frazier (2017), it is assumed that sensing and seizing are immanently related; moreover, as Danneels (2016) argues, they can even be captured as antecedents of resource reconfiguration.

Sensing involves scanning, searching, and exploring both technological and market changes. It requires maintaining close relationships with customers, suppliers, and R&D partners, and other stakeholders (Wilden et al., 2013) and understanding latent demand, the structural evolution of sectors and markets, and the anticipated responses of various parties (Teece, 2007). Seizing involves evaluating and exploiting identified technological and market opportunities. It requires investing in selected projects and technologies that are most likely to be accepted by the market (Teece, 2007; Wilden et al., 2013). Finally, once an opportunity is identified, the firm may need to reconfigure its resources to adapt to the changing reality. Reconfiguring, therefore, involves a firm's ability to recombine and reconfigure its resources in response to both internal and external changes (Teece, 2007). The described conceptualization of dynamic capabilities is well-established. It has been used both in theoretical (Teece, 2007; Fallon-Byrne, and Harney, 2017) and empirical studies (Wilden et al., 2013; Gajendran et al., 2014; Fainshmidt, and Frazier, 2017). Therefore, it was also used in the empirical studies presented in this paper.

3. Research model and hypotheses

Pacheco et al. (2017) indicate that financial, human, and physical resources are crucial for eco-innovation. Based on the systematic literature review, the researchers conclude that generating new solutions is connected to organizational R&D expenditures. Similarly, Horbach (2008), Segarra-Oña et al. (2011), and Doran and Ryan (2016) argue that the total spending increasing the stock of technical knowledge (as a result of undertaking R&D activities) determines the eco-innovative orientation of firms. Regarding human resources, Bossle et al. (2016) and Damanpour (1991) note that the diversity of skills and experiences of organizational members allows for the creation of more diverse teams in which innovation (and eco-innovation) is more likely to be generated. Del Brío and Junquera (2003) emphasize the need for training organizational members to strengthen their environmental awareness, and Dangelico (2016) highlights the critical role of recruiting environmental professionals. Similarly, Triguero et al. (2013) indicate that highly qualified staff (including managers and employees with environmental knowledge) increases eco-innovation. Effective eco-innovation activities also require physical resources, including machines and equipment, laboratories, and other R&D units and technical infrastructure, i.e., energy and infrastructure facilities, essential in high-technology sectors. Physical resources ensure the protection of organizational processes from disruptions (Lichtarski, 2007) and their stability, reflected in the continuity of conducted eco-innovative activities.

However, a firm's resources may lose the VRIN characteristic in a dynamically changing environment. Failure to match resources to changing external conditions may result in core rigidity (Leonard-Barton, 1992). Based on the Dynamic Capabilities View, this paper assumes that all interrelated dimensions of dynamic capabilities – i.e., sensing and seizing opportunities as well as reconfiguring the firm's resource base – enhance the efficiency of resource allocation necessary for eco-innovation performance (figure 1).

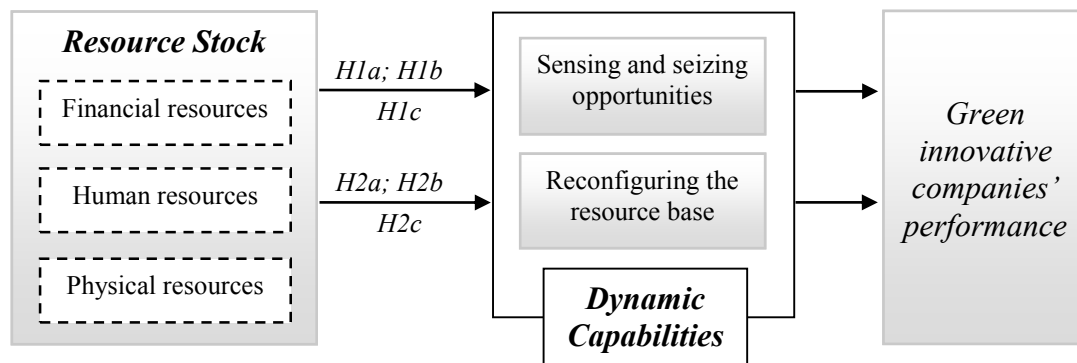


Figure 1. Theoretical framework.

Sensing and seizing opportunities are critical for effective innovation development (Gajendran et al., 2014; Liao et al., 2017). Such activities do not occur independently of a firm's existing resource base (Teece, 2007; Wilden et al., 2013). Instead, they result from the knowledge and skills of employees and the financial and physical resources within the firm. Without a critical base of resources, a company lacks the essential ingredients to enter into effective relationships with customers, suppliers, and universities, participate in professional associations, and follow best practices (Teece, 2007; Wilden et al., 2013). Often, it is possessed resources that make a firm more responsive and take full advantage of the opportunities and threats in its environment (Liao et al., 2017). For example, better technical equipment and higher levels of R&D investment enable firms to pursue multiple green research projects simultaneously. Such a strategy often leads to their crossover. A condition for this strategy is developing innovative human resources, embodying the creativity of organization members with their expertise in specific domains.

On the other hand, both sensing and seizing are crucial to mobilize the resources necessary for the effective generation of eco-innovation (Dangelico et al., 2013; Huang, and Li, 2017). Firms that scan and explore the environment for technological and market changes and then seize the identified opportunities can increase their environmental knowledge and strengthen the efficiency of their use of financial and physical capital. In summary, the greater a firm's ability to sense and seize opportunities, the greater the degree of resource utilization. Based on the above argumentation, it can therefore be assumed that:

H1: Sensing and seizing opportunities mediate the relationship between (a) financial resources; (b) human resources; (c) physical resources and green innovative companies' performance.

Reconfiguring involves recombining the existing resource base to respond to technological and market changes (Teece, 2007). Besides, because resources are generally dispersed within a firm, reconfiguration requires efficient communication and employee engagement (Fainshmidt, and Frazier, 2017) and internal accumulation and mobilization of financial and physical resources (Gajendran et al., 2014). Reconfiguring capabilities support firms in maintaining evolutionary fitness (Zhou et al., 2019) and strengthening organizational change (Gajendran et al., 2014; Dangelico et al., 2017), leading to increased efficiency of the resource base. This occurs through intra-organizational knowledge sharing, including but not limited to establishing new departments focused on creating eco-innovation or interdisciplinary teams dedicated to developing new environmental technologies (Dangelico et al., 2017). In summary, the greater a firm's ability to recombine and reconfigure financial, human, and physical resources, the greater the degree to which they are effectively used in the process of generating eco-innovation. Based on the above argumentation, it can therefore be assumed that:

H2: Reconfiguring the resource base mediates the relationship between (a) financial resources; (b) human resources; (c) physical resources and green innovative companies' performance.

4. Research methodology

To test the developed research hypotheses, a survey was conducted among 54 of the most eco-innovative Polish companies. The respondents are the winners of the 2009-2015 Program of the Ministry of Climate and Environment 'GreenEvo Green Technology Accelerator' (1st round of research) as well as they were selected by the Specialist Observatory in Technologies for Environmental Protection (2nd round of research). This research is part of a re-search project on eco-innovation management in Polish companies and was carried out in early 2019 using the CATI (Computer Assisted Telephone Interview) method. Due to the desire to research the most eco-innovative Polish companies, a non-random sampling was decided. However, this results in limited representativeness of the sample due to its purposeful selection and relatively small size.

The measurement scales used in the conducted survey research are derived from the literature and include statements concerning multidimensional dynamic capabilities, resources, and performance of the companies. For measuring sensing and seizing, the operationalization by Wilden et al. (2013) was used. An important reason for the choice was that the developed scales were retested (for reliability and validity) and then used in a study by Fainshmidt and Frazier (2017). To measure reconfiguring, a research scale developed two years later by Wilden and Gudergan (2015) was adapted. This scale is more detailed than the 2013 scale and therefore

captures a broader range of issues. All items were measured on an interval Likert scale ranging from 1 – ‘strongly disagree’ to 7 – ‘strongly agree’ with a statement.

The estimated level of R&D expenditures measured financial resources compared to the main competitors in the sector; human resources – the number of eco-innovative employees in the total number of organizational members, and physical resources – owned machinery and equipment, technical infrastructure and laboratories, and other R&D units compared to the main competitors in the sector. A similar measurement of resources was used in their study by Xu et al. (2010) and Pichlak (2012).

Finally, the performance measurement was based on five statements relating to average net profit rate, return on equity, return on assets, return on sales, and the ability to finance growth from profits in 2017-2019. The measurement scale used is an operationalization of the performance developed by Eddleston et al. (2008). Again, a seven-point Likert scale was used – respondents were asked to rate their own company compared to major competitors in the sector (from 1 – ‘much worse’ to 7 – ‘much better’).

5. Analyses and Results

The first step in data analysis was to conduct a Confirmatory Factor Analysis (CFA) to check the proposed structure of dynamic capabilities. The results showed that the values of the chi-square statistic do not exceed three times the number of degrees of freedom, which is an acceptable result. Moreover, the approximation errors (RMSEA) remain below the limit level of 0.1, while TLI and CFI exceed or are close to 0.9. The obtained results indicate that the degree of matching of the model to empirical data is satisfactory.

In the next step, a reliability and validity analysis of the measurement scales was conducted. For this purpose, the following parameters were estimated: Cronbach’s Alpha (CA), composite reliability (CR), average variance extracted (AVE), and maximum shared variance (MSV). The analysis showed that the reliability parameters (CA and CR) exceeded the thresholds of 0.7 (Wilden, and Gudergan, 2015), whereas the AVE reached values above the required threshold of 0.5 (Wilden et al., 2013). Moreover, the condition assuming that AVE should be higher than MSV was met. The results of the reliability and validity analysis are presented in Table 1.

Table 1.
Reliability of the measurement scales

Construct	Mean	SD	CA	CR	AVE	MSV
Sensing capability	4.42	1.17	0.725	0.815	0.527	0.069
Seizing capability	5.69	0.48	0.825	0.854	0.595	0.069
Reconfiguring capability	3.45	0.97	0.863	0.878	0.510	0.048

In summary, the analysis showed that all scales have a satisfactory level of validity and reliability.

To test the research hypotheses, an analysis based on hierarchical regression models was conducted. Following Aiken and West (1991), the variables were centered to reduce the potential problem of multi-collinearity. Table 2 shows the results of hierarchical multiple regression.

Table 2.
The results of the Hierarchical Regression Analysis

		Mediation – Condition I		Mediation – Condition II				Mediation – Condition III	
		Model 1		Model 2A		Model 2B		Model 3	
		β	p	β	p	β	p	β	p
Control Variables	Firm Age[^]	0.139	0.295	0.046	0.774	0.424	0.010	0.041	0.756
	Firm Size[^]	-0.386	0.031	-0.204	0.341	-0.200	0.343	-0.288	0.080
	Techn. domain 1	-0.132	0.274	-0.110	0.452	0.032	0.823	-0.111	0.315
	Techn. domain 2	-0.055	0.639	-0.114	0.422	-0.064	0.645	-0.007	0.948
Financial Resources		-0.345	0.049	0.373	0.073	0.095	0.603	0.266	0.051
Human Resources		0.425	0.021	0.348	0.041	0.378	0.043	0.435	0.060
Physical Resources		0.260	0.036	0.377	0.048	-0.103	0.633	0.176	0.302
Mediators	Sensing and seizing							0.269	0.030
	Reconfiguring							0.213	0.034
R²		0.442		0.375		0.325		0.671	
ΔR^2		0.357		0.280		0.222		0.594	
F (7,46)		5.203		4.391		2.596		5.728	
p		0.000		0.001		0.024		0.000	

[^] natural logarithm. Technological domain: 1 – Water and sewage management. Technological domain 2 – Biodiversity conservation. The estimation of the parameters for adjusting models to empirical data is based on the use of the least squares' method.

The data presented in Table 2 show that the direct relationships between financial, human, and physical resources and Polish green innovative companies' performance are statistically significant (Model 1). This result represents the first mediation condition's fulfillment according to the standard procedure proposed by Baron and Kenny (1986). The estimation of Model 2A indicates that the relationship between human and physical resources and the mediating variable (sensing and seizing opportunities) is statistically significant at the probability level of 0.041 ($\beta = 0.348$) and 0.048 ($\beta = 0.377$), respectively. Regarding financial resources, given the small size of the research sample, the estimation of model 2A only allows to assume that there is a tendency for these resources to directly affect the analyzed dimensions of dynamic capabilities ($\beta = 0.373$, $p = 0.073$). Moreover, the results of model 2B (estimated for reconfiguring) indicate that only human resources directly affect the third dimension of dynamic capabilities ($\beta = 0.378$, $p = 0.043$). Such results represent a partial fulfillment of the second condition of mediation, according to which the relationship between independent variables and mediators should be statistically significant.

Essential for testing the research hypotheses is the estimation of model 3 showing the fulfillment of the third condition of mediation, according to Baron and Kenny (1986). This condition states that the relationship between the independent variables and the dependent

variable should be weaker after the mediating variables are included in the model. The mediation analysis results (Model 3) indicate that the relationship between sensing and seizing opportunities and performance is statistically significant at $p = 0.030$ ($\beta = 0.269$). Such results – In the absence of statistically significant relationships between the independent variables (resources) and the dependent variable (performance) – confirm Hypothesis H1 assuming that sensing and seizing opportunities mediate the relationship between (a) financial resources; (b) human resources; (c) physical resources, and green innovative companies' performance. On the other hand, the existence of a direct and statistically significant relationship between reconfiguring and performance ($\beta = 0.213$, $p = 0.034$) and the absence of a relationship between resources and performance (Model 3) only confirms Hypothesis H2b assuming that reconfiguring the resource base mediates the relationship between human resources and green innovative companies' performance. As mentioned earlier, concerning financial and physical resources, the second mediation condition in Model 2B was not found. Therefore, the obtained results do not confirm Hypotheses H2a and H2c assuming that reconfiguring the resource base mediates the relationship between financial and physical resources, and green innovative companies' performance.

6. Discussion and Conclusion

The objective of the paper was to empirically examine the relationship between crucial resources, dynamic capabilities, and eco-innovators performance. Based on Teece et al. (1997) and Teece (2007), the paper focuses on examining the mediating role of dynamic capabilities (sensing and seizing, reconfiguring) on the relationship between financial, human, and physical resources and the performance of Polish green innovative companies.

The results indicate that sensing and seizing mediate the relationship between all types of resources (financial, human, and physical) and firms' performance. Such results confirm the theoretical findings according to which sensing capability (related to scanning, searching, and exploring technological and market changes) strengthens the use of various resources. It allows the collection of information necessary for the effective generation of eco-innovation by learning about markets, customers, competitors, and the external environment (Horbach, 2008; del Rio et al., 2016; Doran, and Ryan, 2016; Sopińska, and Dziurski, 2018). Similarly, seizing capability (related to systemic assessment of existing capabilities) (Wilden et al., 2013; Gajendran et al., 2014; Liao et al., 2017) entails making investments in owned tangible and intangible assets (Fainshmidt, and Frazier, 2017).

Surprisingly, the results indicate that reconfiguring mediates the relationship between human resources and Polish green innovative companies' performance. Thus, it appears that employees' environmental knowledge (as a result of sensing and seizing opportunities) most

likely triggers subsequent resource reconfiguration processes and thereby reduces organizational inertia. In other words, reconfiguring capability generates value by building problem teams, periodically changing the organizational structure, etc. All these actions extend the knowledge necessary for developing new green technological solutions. Moreover, such results confirm the findings of other studies according to which attitudes, behaviors, and interpersonal relationships among organizational members are essential factors that enable reconfiguration (Fainshmidt, and Frazier, 2017). It is the knowledge of employees that facilitates the mobilization of relevant resources when there is a real need to make organizational changes.

In summary, the study results indicate that dynamic capabilities (representing a company's potential for systematic problem solving) may determine the effective use of resources crucial for generating eco-innovation. Such results may be an important indication for management practice despite several of their limitations (purposeful selection of the research sample and its small size and subjective methods of measuring variables). Thus, an extension of the analysis and the most important direction for future research may be to conduct longitudinal studies as well as repeat quantitative research in other contexts and on other (larger) populations.

The findings presented in this paper support the argument of Eisenhardt and Martin (2000) that firms with similar dynamic capabilities may create and develop different bundles of resources and consequently have different levels of performance. It is essential concerning Polish green innovative companies, whose activities are conditioned not only by institutional pressure (Green Deal) but also by the need for a more significant commitment of resources than the development of conventional innovation.

References

1. Aiken, L.S., and West, S.G. (1991). *Multiple Regression: Testing and Interpreting Interactions*. Newbury Park, CA: Sage Publications.
2. Ambrosini, V., and Bowman, C. (2009). What are dynamic capabilities and are they a useful construct in strategic management? *International Journal of Management Reviews*, Vol. 11(1), pp. 29-49. doi: 10.1111/j.1468-2370.2008.00251.x.
3. Ambrosini, V., Bowman, C., and Collier, N. (2009). Dynamic Capabilities: An Exploration of How Firms Renew their Resource Base. *British Journal of Management*, Vol. 20(1), pp. 9-24. doi: 10.1111/j.1467-8551.2008.00610.x.
4. Andersén, J. (2021). A relational natural-resource-based view on product innovation: The influence of green product innovation and green suppliers on differentiation advantage in small manufacturing firms. *Technovation*. doi: 10.1016/j.technovation.2021.102254.

5. Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, Vol. 17(1), pp. 99-120. doi: 10.1177/014920639101700108.
6. Baron, R.M., and Kenny, D.A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, Vol. 51(6), pp. 1173-1182. doi: 10.1037/0022-3514.51.6.1173.
7. Barreto, I. (2010). Dynamic Capabilities: A Review of Past Research and an Agenda for the Future. *Journal of Management*, Vol. 36(1), pp. 256-280. doi: 10.1177/0149206309350776.
8. Bartoszczuk, P. (2018). *Mechanizmy powstawania efektów ekoinnowacji w przedsiębiorstwach w Polsce*. Warszawa: Oficyna Wydawnicza SGH.
9. Bossle, M.B., de Barcellos, M.D., Vieira, L.M., and Sauvée, L. (2016). The drivers for adoption of eco-innovation. *Journal of Cleaner Production*, Vol. 113, pp. 861-872. doi: 10.1016/j.jclepro.2015.11.033.
10. Chahal, H., Gupta, M., Bhan, N., and Cheng, T.C.E. (2020). Operations management research grounded in the resource-based view: A meta-analysis. *International Journal of Production Economics*, Vol. 230. doi: 10.1016/j.ijpe.2020.107805.
11. Collis, D.J. (1994). Research Note: How Valuable are Organisational Capabilities? *Strategic Management Journal*, Vol. 15(S1), pp. 143-152. doi: 10.1002/smj.4250150910.
12. Damanpour, F. (1991). Organizational Innovation: A Meta-Analysis Of Effects Of Determinants and Moderators. *Academy of Management Journal*, Vol. 34(3), pp. 555-590. doi: 10.5465/256406.
13. Dangelico, R.M. (2016). Green Product Innovation: Where we are and Where we are Going. *Business Strategy and the Environment*, Vol. 25(8), pp. 560-576. doi: 10.1002/bse.1886.
14. Dangelico, R.M., Pontrandolfo, P., and Pujari, D. (2013). Developing Sustainable New Products in the Textile and Upholstered Furniture Industries: Role of External Integrative Capabilities. *Journal of Product Innovation Management*, Vol. 30(4), pp. 642-658. doi: 10.1111/jpim.12013.
15. Dangelico, R.M., Pujari, D., and Pontrandolfo, P. (2017). Green Product Innovation in Manufacturing Firms: A Sustainability-Oriented Dynamic Capability Perspective. *Business Strategy and the Environment*, Vol. 26(4), pp. 490-506. doi: 10.1002/bse.1932.
16. Danneels, E. (2002). The dynamics of product innovation and firm competences. *Strategic Management Journal*, Vol. 23(12), pp. 1095-1121. doi: 10.1002/smj.275.
17. Danneels, E. (2016). Survey measures of first-and second-order competences. *Strategic Management Journal*, Vol. 37(10), pp. 2174-2188. doi: 10.1002/smj.2428.
18. del Brío, J.Á., and Junquera, B. (2003). A Review of the literature on environmental innovation management in SMEs: implications for public policies. *Technovation*, Vol. 23(12), pp. 939-948. doi: 10.1016/s0166-4972(02)00036-6.

19. del Río, P., Peñasco, C., and Romero-Jordán, D. (2016). What drives eco-innovators? A critical review of the empirical literature based on econometric methods. *Journal of Cleaner Production*, Vol. 112, pp. 2158-2170. doi: 10.1016/j.jclepro.2015.09.009.
20. Doran, J., and Ryan, G. (2016). The Importance of the Diverse Drivers and Types of Environmental Innovation for Firm Performance. *Business Strategy and the Environment*, Vol. 25(2), pp. 102-119. doi: 10.1002/bse.1860.
21. Easterby-Smith, M., Lyles, M.A., and Peteraf, M.A. (2009). Dynamic Capabilities: Current Debates and Future Directions. *British Journal of Management*, Vol. 20, pp. S1-S8. doi: 10.1111/j.1467-8551.2008.00609.x.
22. Eddleston, K.A., Kellermanns, F.W., and Sarathy, R. (2008). Resource Configuration in Family Firms: Linking Resources, Strategic Planning and Technological Opportunities to Performance. *Journal of Management Studies*, Vol. 45(1), pp. 26-50. doi: 10.1111/j.1467-6486.2007.00717.x.
23. Eisenhardt, K.M., and Martin, J.A. (2000). Dynamic capabilities: what are they? *Strategic Management Journal*, Vol. 21(10-11), pp. 1105-1121. doi: 10.1002/1097-0266(200010/11)21:10/11<1105::aid-smj133>3.0.co;2-e.
24. Epelbaum, F.M.B., and Martinez, M.G. (2014). The technological evolution of food traceability systems and their impact on firm sustainable performance: A RBV approach. *International Journal of Production Economics*, Vol. 150, pp. 215-224. doi: 10.1016/j.ijpe.2014.01.007.
25. Fainshmidt, S., and Frazier, M.L. (2017). What Facilitates Dynamic Capabilities? The Role of Organizational Climate for Trust. *Long Range Planning*, Vol. 50(5), pp. 550-566. doi: 10.1016/j.lrp.2016.05.005.
26. Fallon-Byrne, L., and Harney, B. (2017). Microfoundations of dynamic capabilities for innovation: a review and research agenda. *Irish Journal of Management*, Vol. 36(1), pp. 21-31. doi: 10.1515/ijm-2017-0004.
27. Gajendran, T., Brewer, G., Gudergan, S., and Sankaran, S. (2014). Deconstructing dynamic capabilities: the role of cognitive and organizational routines in the innovation process. *Construction Management and Economics*, Vol. 32(3), pp. 246-261. doi: 10.1080/01446193.2013.845306.
28. Grant, R.M. (1991). The Resource-Based Theory of Competitive Advantage: Implications for Strategy Formulation. *California Management Review*, Vol. 33(3), pp. 114-135. doi: 10.2307/41166664.
29. Grant, R.M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, Vol. 17(S2), pp. 109-122. doi: 10.1002/smj.4250171110.
30. Hart, S.L. (1995). A Natural-Resource-Based View of The Firm. *Academy of Management Review*, Vol. 20(4), pp. 986-1014. doi: 10.5465/amr.1995.9512280033.

31. Hart, S.L., and Dowell, G. (2010). A Natural-Resource-Based View of the Firm: Fifteen Years After. *Journal of Management*, Vol. 37(5), pp. 1464-1479. doi: 10.1177/0149206310390219.
32. Hazarika, N., and Zhang, X. (2019). Evolving theories of eco-innovation: A systematic review. *Sustainable Production and Consumption*, Vol. 19, pp. 64-78. doi: 10.1016/j.spc.2019.03.002.
33. Helfat, C.E., and Peteraf, M.A. (2003). The dynamic resource-based view: capability lifecycles. *Strategic Management Journal*, Vol. 24, pp. 997-1010. doi: 10.1002/smj.332.
34. Horbach, J. (2008). Determinants of environmental innovation – New evidence from German panel data sources. *Research Policy*, Vol. 37(1), pp. 163-173. doi: 10.1016/j.respol.2007.08.006.
35. Huang, J.W., and Li, Y.H. (2017). Green Innovation and Performance: The View of Organizational Capability and Social Reciprocity. *Journal of Business Ethics*, Vol. 145(2), pp. 309-324. doi: 10.1007/s10551-015-2903-y.
36. Klewitz, J., and Hansen, E.G. (2014). Sustainability-oriented innovation of SMSs: a systematic review. *Journal of Cleaner Production*, Vol. 65, pp. 57-75. doi: 10.1016/j.jclepro.2013.07.017.
37. Leonard-Barton, D. (1992). Core capabilities and core rigidities: A paradox in managing new product development. *Strategic Management Journal*, Vol. 13(S1), pp. 111-125. doi: 10.1002/smj.4250131009.
38. Liao, J., Kickul, J.R., and Ma, H. (2017). Organizational Dynamic Capability and Innovation: An Empirical Examination of Internet Firms. *Journal of Small Business Management*, Vol. 47(3), pp. 263-286. doi: 10.1111/j.1540-627X.2009.00271.x.
39. Lichtarski, J. (2007). *Podstawy nauki o przedsiębiorstwie*. Wrocław: Wydawnictwo Akademii Ekonomicznej we Wrocławiu.
40. Li-Ying, J., Wang, Y., and Ning, L. (2016). How do dynamic capabilities transform external technologies into firms' renewed technological resources? – A mediation model. *Asia Pacific Journal of Management*, Vol. 33(4), pp. 1009-1036. doi: 10.1007/s10490-016-9469-9.
41. Meredith, S. (1995). Environmental Strategies in the Paint and Coatings Industry. *Business Strategy and the Environment*, Vol. 4, pp. 1-8. doi: 10.1002/bse.3280040102.
42. Pacheco, D.A.J., ten Caten, C.S., Jung, C.F., Ribeiro, J.L.D., Navas, H.V.G., and Cruz-Machado, V.A. (2017). Eco-Innovation determinants in manufacturing SMSs: Systematic review and research directions. *Journal of Cleaner Production*, Vol. 142, pp. 2277-2287. doi: 10.1016/j.jclepro.2016.11.049.
43. Penrose, E.T. (1959). *The Theory of the Growth of the Firm*. New York: John Wiley.
44. Pichlak, M. (2012). *Uwarunkowania innowacyjności organizacji. Studium teoretyczne i wyniki badań empirycznych*. Warszawa: Difin.
45. Poznańska, K. (2018). *Nowe formy innowacji*. Warszawa: Oficyna Wydawnicza SGH.

46. Segarra-Oña, M.V., Peiró-Signes, A., Albors-Garrigós, J., and Miret-Pastor, M. (2011). Impact of Innovative Practices in Environmentally Focused Firms: Moderating Factors. *International Journal of Environmental Research*, Vol. 5(2), pp. 425-434. doi: 10.22059/IJER.2011.327.
47. Sopińska, A., and Dziurski, P. (2018). Postawy wobec zarządzania wiedzą w otwartych innowacjach. *Przegląd Organizacji*, nr 7, ss. 25-30.
48. Teece, D.J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, Vol. 28(13), pp. 1319-1350. doi: 10.1002/smj.640.
49. Teece, D.J., Peteraf, M.A., and Leih, S. (2016). Dynamic Capabilities and Organizational Agility: Risk, Uncertainty, and Strategy in the Innovation Economy. *California Management Review*, Vol. 58(4), pp. 13-35. doi: 10.1525/cmr.2016.58.4.13.
50. Teece, D.J., Pisano, G., and Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, Vol. 18(7), pp. 509-533. doi: 10.1002/(sici)1097-0266(199708)18:7<509::aid-smj882>3.0.co;2-z.
51. Triguero, A., Moreno-Mondéjar, L., and Davia, M.A. (2013). Drivers of different types of eco-innovation in European SMEs. *Ecological Economics*, Vol. 92, pp. 25-33. doi: 10.1016/j.ecolecon.2013.04.009.
52. Wilden, R., and Gudergan, S.P. (2015). The impact of dynamic capabilities on operational marketing and technological capabilities: investigating the role of environmental turbulence. *Journal of the Academy of Marketing Science*, Vol. 43(2), pp. 181-199. doi: 10.1007/s11747-014-0380-y.
53. Wilden, R., Gudergan, S.P., Nielsen, B.B., and Lings, I. (2013). Dynamic Capabilities and Performance: Strategy, Structure and Environment. *Long Range Planning*, Vol. 46(1-2), pp. 72-96. doi: 10.1016/j.lrp.2012.12.001.
54. Winter, S.G. (2003). Understanding dynamic capabilities. *Strategic Management Journal*, Vol. 24, pp. 991-995. doi: 10.1002/smj.318.
55. Wójcik-Karpacz, A. (2017). Zdolności dynamiczne versus zdolności operacyjne. *Organizacja i Kierowanie*, nr 1(175), ss. 51-70.
56. Wysocki, J. (2019). *Ekologizacja działalności produkcyjnej w strategiach rozwoju przedsiębiorstw w Polsce*. Warszawa: Oficyna Wydawnicza SGH.
57. Xu, K., Sirmon, D.G., and Gao, S. (2010). *R&D Resources, R&D Management, and Innovation: Evidence of Mediation*. Paper presented at the American Academy of Management Conference, Montreal.
58. Zahra, S.A., Sapienza, H.J., and Davidsson, P. (2006). Entrepreneurship and Dynamic Capabilities: A Review, Model and Research Agenda. *Journal of Management Studies*, Vol. 43(4), pp. 917-955. doi: 10.1111/j.1467-6486.2006.00616.x.

59. Zhang, J.A., and Walton, S. (2017). Eco-innovation and business performance: the moderating effects of environmental orientation and resource commitment in green-oriented SMEs. *R&D Management*, Vol. 47(5), pp. E26-E39. doi: 10.1111/radm.12241.
60. Zhou, S.S., Zhou, A.J., Feng, J., and Jiang, S. (2019). Dynamic capabilities and organizational performance: The mediating role of innovation. *Journal of Management & Organization*, Vol. 25(5), pp. 731-747. doi: 10.1017/jmo.2017.20.
61. Zollo, M., and Winter, S.G. (2002). Deliberate Learning and the Evolution of Dynamic Capabilities. *Organization Science*, Vol. 13(3), pp. 339-351. doi: 10.1287/orsc.13.3.339.2780.

PROPOSITION OF A METHOD OF VERIFICATION OCCUPATIONAL RISK ASSESSMENT

Adam PISARCZUK

Bezpieczeństwo Pracy, Pszczyna; kontakt@bezpieczenstwo-pracy.eu, ORCID: 0000-0001-5675-1485

Purpose: The aim of this article is to propose a method allowing for an objective verification method of prepared occupational risk assessment in companies.

Design/methodology/approach: The methodology of presented method consists from two steps including hazards checking according to presented unified template and counting the result of the indicator of verification according to prepared indicators presented in this article.

Findings: Proposal of method included in this article allows to ease leading the process of verification occupational risk assessment thanks to standardized way of verification process.

Practical implications: Application of the proposed method as the basic internal audit or inspection tool in the area of occupational risk management for checking propriety of functioning risk assessment in organizations.

Originality/value: Unique method of verification prepared risk assessment results.

Keywords: risk assessment, hse audits, risk assessment process.

Category of the paper: Conceptual paper.

1. Introduction

Providing safe and hygienic working conditions is the main obligation of every employer. This obligation is laid down in the most important legal act of the Republic of Poland, confirmed in article of number 66 of the Republic of Poland Constitution. Giving such a high priority to occupational health and safety issues means, that the right to work safely is one of the fundamental and inalienable rights of every employee. In addition to the official confirmation of this inalienable right, the legal system in the field of labor law in Poland regulates certain obligations, the implementation of which by the employer is to guarantee the health and life protection of employees. One of the legally required obligations of the employer is to provide information on health and life hazards occurring in the workplace, at individual workplaces and during the work performed, as well as on protective and preventive measures taken to eliminate these risks.

Besides the above facts, the employer is obliged to assess the occupational risks related to the work performed, inform employees about this risks and apply preventive measures reducing this risks. At this point, it should be noted that an incomplete (deficiencies in important components) or, even worse, an incorrectly prepared assessment may disturb the proper information process by misleading the employee and indirectly cause an accident at work.

At present time there is no objective method of verifying the correctness of the occupational risk assessment, which can be used by supervisors, internal health and safety audits or country inspectors. This makes the problem which causes in the field of verifications some gaps, which can make some problems with proper management of risk assessment. The objective method should be clearly used in order to check if the assessment is prepared well and it may be also used as an additional method of proper identification process of hazards and risks.

The process of occupational risk assessment itself should include five steps, the last of which is periodic verification of the occupational risk assessment. Periodic verification may cause the need of update the risk assessment but not always has to. Presented method is aimed only on verification process and allows to indicate the need of updating risk assessment and may help to identify properly the hazards and risks as well.

2. Management of risk assessment

2.1. Hazards during risk assessment process

Occupational risk is defined as the probability of occurrence of undesirable work-related events causing losses, in particular the occurrence of adverse health effects in employees as a result of occupational hazards occurring in the work environment or the manner of performing work.

An inseparable element of any occupational risk assessment is the identification of hazards. The concept of a hazard is understood as a working environment that may cause an accident or illnesses.

According to Polish law, hazards are divided into physical, chemical, biological hazards. Additionally, there is possibility to involve fourth category of hazards called psychophysical. They constitute the conditions of the working environment, understood as the conditions of the working place in which the work process is made. Additional to the environmental conditions, there is needed to point that hazards of the work environment causing the risk of accident or illnesses are classified as dangerous, harmful or nuisance. Distinguishing each of the factors of the material work environment is important for the proper identification of these factors for the purposes of occupational risk assessment.

A hazardous factor is a factor whose impact on a worker may lead to an injury. A harmful factor is a factor which influence on a worker can lead to an illness. On the other hand, a nuisance factor is a factor which influence on the worker may cause malaise or excessive fatigue without leading to a permanent deterioration of human health. Each group of hazards contains factors that characterize a given group.

The developed occupational risk assessment should be documented. When documenting the occupational risk assessment, it should be remembered that its content as a document is strictly defined and must include the following minimum requirements in its structure:

- description of the assessed workstation, including the specification of the machines, tools and materials used, the tasks performed, hazardous, harmful and nuisance factors in the work environment, collective and individual protections against hazards used and people working in this position;
- results of the occupational risk assessment for each of the work environment factors and the necessary preventive measures to reduce the risk;
- the date of the assessment and the assessors team.

2.2. Necessary steps which are needed to follow during risk assessment

The formal process of occupational risk assessment can be included in five steps. The first step is to identify the kind of work (and workplace) to be assessed. The workplace is understood as the working space, along with the equipment and objects of work, in which an employee or a team of employees performs work. The following workplaces can be distinguished:

- single-workplace position with constant working conditions,
- single-workplace position with variable working conditions,
- multi-workplace position with constant working conditions,
- multi-workplace position with variable working conditions.

Single-workplace positions with constant working conditions are those in which employees perform the same, repetitive activities. An example of such a position is a milling station in a large workplace, to which items are delivered for processing. The milling cutter is constantly exposed to the same risks during its work (Romanowska-Słomka, and Słomka, 2008).

Single-workplace positions with variable working conditions are those in which employees perform the same activities, but working conditions change periodically. Changing working conditions can be the result of a mobile workplace, weather conditions and progress of the work. An example of such a position is the position of a bricklayer performing bricklaying works on a construction site (Romanowska-Słomka, and Słomka, 2008).

Multi-workplace positions with constant working conditions are those where employees perform the same activities periodically for different conditions. Such a situation may take place in small workplaces. An employee who is, e.g. a turner, periodically performs activities in other professions for various reasons. He often has to prepare the blanks himself for machining on a lathe. Takes the roller from the warehouse or storage yard and transports it to the saw –

performs the activities of a transport worker; cuts the required shaft element on the frame saw – performs the activities of the saw operator; turns the cut-off element on a lathe – performs the activities of a turner (Romanowska-Słomka, and Słomka, 2008).

Multi-professional workplaces with variable working conditions are those where repetitive work is performed for various professions in changing working conditions. An example of such work organization may be work in a company, usually small, performing finishing and furnishing works in the construction industry. The employee may perform depending on periodic needs, e.g. window fitting, plastering plaster or painting rooms. In addition, depending on the facility, these works can be carried out under different conditions. Embedding windows can take place in a one-story and multi-store building. Depending on the conditions, it is exposed to other threats (Romanowska-Słomka, and Słomka, 2008).

The second step is to identify the hazards presented at the workplace. Identification can be made using generally accepted methods of hazard identification, that is:

- checklists, including sets of questions relating to the examined fact, phenomenon or process in order to check the actual state with the required pattern (e.g. a legal act, procedure, instruction),
- analysis of documents relating to the threat, consisting in the analysis of all documents constituting a source of information on the basis of which judgments about facts, phenomena or processes can be made,
- observations, through intentional, planned and systematic perception as well as collection and analysis of facts, phenomena or processes,
- surveys, including verbal data collection as a result of interviews with employees,
- surveys, consisting in an organized method of obtaining information using a form,
- interviews, i.e. conducting a planned and organized conversation,
- brainstorming.

The third step is to assess the existing threats in terms of the probability of their occurrence and their potential effects, along with the indication of preventive methods that will minimize the risk of an accident at work or an occupational illnesses. Risk assessment is performed with the use of occupational risk assessment methods, which are divided into estimation methods and advanced methods.

The fourth step is the formal documentation of the occupational risk assessment in accordance with the legal requirements in force in Poland which include:

- description of workplace,
- results of risk assessment with protection methods,
- the date of preparation and a team taking part in the risk assessment process.

Documentation of risk assessment should not cover only pointing hazards, but must include the description of hazards.

The fifth step is to review it periodically. This review is equated with the updating or verification of the occupational risk assessment. The review should take place as part of internal controls in the area of health and safety or internal audits in the field of health and safety management. The concepts of updating and verification should be clearly distinguished and appropriate methods should be used for a specific activity. In this step, however, there is a gap in the frequency, necessity and method of verifying the occupational risk assessment. It should also be mentioned that the concepts of verification and updating of the occupational risk assessment are used improperly, although they are used equally.

3. Risk assessment review

As mentioned above, the concept of occupational risk assessment review include two concepts related to appropriate occupational risk assessment review – the concept of update and the concept of verification.

The concepts of verification and updating of occupational risk are often used unambiguously, while in terms of the appropriate process of occupational risk management, they should be clearly distinguished. Updating refers to adjusting something to prevailing, current standards or conditions. The concept of verification means checking the truthfulness, suitability or correctness of something. When we talk about updating the occupational risk assessment, there is possibility to gain informations about requirement concerning the update. In terms of verification, on the other hand, a gap can be observed in the way of verification of the assessment due to the lack of guidelines regarding the control of its correctness. In other words, there is no method that would allow to verify the correctness of the obtained results of which are presented in risk assessment documentation.

3.1. Risk assessment updating

Polish law do not specify the requirements for the need to review the occupational risk assessment. More informations about the need of update the risk assessment we can find in the Polish Standard PN-N 18002:2011: Occupational health and safety management systems – General guidelines for occupational risk assessment. The standard, which is not obliged to follow, indicates "good practices" in the field of occupational risk management. This standard determinates the cases that should result in updating occupational risk assessment document. Therefore, the cases constituting good practice in occupational risk management and its updating include:

- introducing changes at work positions (e.g. technological or organizational),
- changes in the applicable requirements relating to the assessed workstations,
- a statement that the protective measures in place are not sufficiently effective in the light of new information available about them,
- determining the need to make changes to the applied protective measures.

In terms of the professional practice, the following situations can be additionally specified, where there is the need of update of the occupational risk assessment. These situations include cases related to undesirable situations taking place at workplaces, with the proviso that the occurrence of a given type of case will not always require updating the assessment, but only confirmation of its verification e.g.:

- an accident at work,
- occupational or para-occupational disease,
- occurrence (if such a solution is introduced in the workplace) of near misses or identification of a new hazard or occurrence of an event related to a specific material loss.

Obviously, the above catalog is not a closed catalog, but only guidelines which indicate the need of the update the occupational risk assessment.

3.2. Risk assessment verification

The verification of the occupational risk assessment should be treated as an individual process during the occupational risk management review. Verification of the occupational risk assessment is obligatory at workplaces that have a formalized occupational health and safety management system in place.

The situation is different when the workplace does not have a formal health and safety management system implemented. It should be noted here that such a situation may take place both when a health and safety department is established in the workplace and when the tasks of the health and safety department are performed by the employer, a designated employee or a specialist provided by outsourcing.

As mentioned earlier, at present time there are no guidelines on how to check the reliability of the obtained results of the occupational risk assessment. The method presented below is a guideline for all persons involved in the risk assessment process, which will enable it to verify the correctness of the results of the occupational risk assessment.

4. The method of verification occupational risk assessment

4.1. Methodology

Presented method uses comparative elements derived from an objective template and assigning weight indicators to a given hazards combining with its potential effects. The results prepared in this way are the basis for verifying the correctness of the occupational risk assessment. In other words, we need only two steps in order to verify occupational risk assessment.

First step is comparison documented hazards defined in risk assessment with the template presented in this article and with assigned indicators. Of course, some hazards pointed in risk assessment document may differ from presented template. When the situation will appear, a verifier must choose the closest hazard to described in the risk assessment document (very helpful is using the description of potential negative results of the hazards – table 2). Indicators are divided according to potential danger caused by hazards and the duration of exposition of the hazards. Second step is the requirement to count the indicator of verification according to simple formula:

$$I = R \times D$$

where:

I – indicator of verification,

R – indicator of potential negative results,

D – indicator of duration of the hazards.

Given result will inform about the propriety of prepared occupational risk assessment.

4.2. Templates and indicators

The tables below present indicators which are obliged to use in order to receive the result of indicator of verification. Beside the numbers, for easier use, they represent description of potential negative results and the expositions of hazards influencing on workers which are dependent on the length of worker shift (Table 2 and Table 3).

Table 2.

Indicators depending on the negative results (R) of unified hazards, assigned to template of hazards

Item	Potential negative results	Indicator
1	First aid, injuries without the need of visiting a doctor	1
2	Individual accident required a visit to a doctor, occupational or para-occupational illnesses, sick leave caused by some hazard	2
3	Serious accident, accident with two workers (at least), cancerogenic potential of some hazards	3
4	Death because of accident or disease	4

Table 3.*Indicators depending on duration of the hazards (D)*

Item	Length of a day shift	Indicator
1	Less than 2 hours	1
2	Between 2 and 4 hours	2
3	Between 4 and 8 hours	3
4	More than 8 hours	4

Next step of presenting the assumption of the method is the template of unified hazards required to choose for proper verification of a risk assessment (Table 4).

Table 4.*The template of unified hazards required to be chosen for proper verification with assigned indicators*

Item	Factors and consisting hazards	Indicator
1	Physical hazardous factors	
	Moving parts of machines:	
	- a highly risk machines	4
	- a multi-operators machines	4
	- a machines with the need of coming inside to them	4
	- a power tools, especially designed for hard work (cutting, drilling, grinding and so on)	3
	- a power tools designed for general work (housekeeping, cleaning and so on)	2
	- caught between	3
	Electricity	
	- work near or even under voltage	4
	- every contact with electrical equipment	2
	Sharp edges	2
	Uneven and slippery surfaces	2
	Fire	
	- work with open flames	2
	- supposed situations of potential fire	1
	Explosion	
	- work in the zones with the danger of explosion	3
	- work with gas containers	2
	- electrostatic	3
	Thermal	2
	Moving vehicles, machines	4
	Falling objects	
	- falling objects up to 2 m height	2
	- falling objects falling above 2 m height	4
	Pressure	2
	Stationary objects	1
	Faulty equipment	2
	Working at height	
	- up to 2 meters	2
	- above 2 meters	4
	Confined space	3

Cont. table 2.

2	Physical harmful and nuisance factors	
	Noise	
	- above 0,5 the highest acceptable intensity	3
	- between 0,2-0,5 the highest acceptable intensity	2
	- less than 0,2 the highest acceptable intensity	1
	Vibrations	
	- above 0,5 the highest acceptable intensity	3
	- between 0,2-0,5 the highest acceptable intensity	2
	- less than 0,2 the highest acceptable intensity	1
	Ionizing radiation	3
	Electromagnetic radiation	
	- intermediate zone	1
	- hazardous or dangerous zone	3
	Laser radiation	
	- above 0,8 maximum exposure allowed	3
	- between 0,4-0,8 exposure allowed	2
	- less than 0,4 exposure allowed	1
	Visible radiation	
	- above 0,7 maximum exposure allowed	3
	- between 0,4-0,7 exposure allowed	2
	- less than 0,4 exposure allowed	1
	Dust	
	- above 0,5 maximum allowed concentration	3
	- between 0,1-0,5 maximum allowed concentration	2
	- less than 0,1 maximum allowed concentration	1
	- cancerogenic dust	3
	Asbestos	3
	Microclimate	2
3	Chemical harmful and nuisance factors	
	Allergic	2
	Irritating	2
	Toxic	3
	Mutagenic	4
	Cancerogenic	4
	Impaired reproductive functions	3
	Flammable/Highly flammable	2
	Explosive	4
	The maximum permissible threshold concentration of chemical factors	4
4	Biological harmful and nuisance factors	
	Microorganisms in general	1
	- group 2	2
	- group 3	3
	- group 4	4
	Macroorganisms in general	1
	- category 1	2
	- category 2	3
	- category 3	4
5	Psychophysical harmful and nuisance factors	
	Repetitive motions	2
	Stress causing sick leave	2
	Lifting	2
	High need of focusing	2
	Work underload or overload	2
	Some professions at risk of losing life	3
	Body position without possibility to change during work shift	2

After choosing proper hazard all we need to do is verification. An example of verification is presented in appendix but the results of verification are presented (Table 5).

Table 5.
Results of verification

Item	Results	Description
1	Less than 9	Category of risk should be low
2	9-16	Category of risk should be medium or high

Note. The results at high of 16 should be considered as high risk work and beside the fact of verification, risk assessment may require an update if the result in risk assessment document is high risk as well.

After verification process it is worthy to formally document the results of verification. Documentation of the process may be helpful to show that risk management process is well proceeded, because contains either verification or updating process when it is required and it is a part of great improvement of occupational risk management.

5. Summary

During risk assessment process we can differ five main steps which the last one is verification of the risk assessment. As it was presented in the article, verification and update processes should be differed from one another, because the purposes of the two terms are not the same. When we think about verification we should take into consideration only the fact if the occupational risk assessment is prepared well what means if identified hazards and the results of risk are counted and pointed properly. If the results of verification show the need of update, than people responsible should update the whole process or risk assessment including all last steps of risk assessment process.

Beside the fact above, improvement of the method allows to use unified standard for identifying hazards which may appear in work environment. Great advantage of the fact is that nowadays prepared standards may not cover today's knowledge and evolution of the processes of working conditions. Thanks to unified template every person which manage the risk assessment process is up to date with hazards.

Presented indicators associated with general statements guarantee simplicity and clarity of the method thanks to referring to general and measurable or visible conditions which happen in the companies during the process of working. They cover all main factors and included hazards which may appear in workstations and come from required legal conditions.

Presented method may be helpful tool for everyone who is involved in inspection process of reviewing occupational risk assessment, especially country inspectors or internal auditors. Thanks to the method there is filled a gap in the management process of risk assessment. The method shows that verification process may be easy to lead, helpful in risk management system and can be used as the way of improving whole process of identifying hazards which

may appear in work environment. Simple example of using presented method is shown in appendix.

References

1. Dyrektywa 2006/42/WE Parlamentu Europejskiego i Rady z dnia 17 maja 2006 r. w sprawie maszyn, zmieniająca dyrektywę 95/16/WE (przekształcenie), Dziennik Urzędowy Unii Europejskiej, 2006.
2. Górską, E., Kossobudzka-Górska, A. *Ocena ryzyka zawodowego*. Retrieved from www.misiak.edu.pl/pliki/wyklady/ebhp/Ocena_Ryzyka_EG_AK.pdf, 12.03.2021.
3. Krause, M. (2011). *Praktyczne aspekty doboru metod oceny ryzyka zawodowego*. Retrieved from www.wioz.polsl.pl/znwoiz/z59/M.%20Krause.pdf, 12.03.2021.
4. Pisarczuk, A. (2018). *Kodeks pracy. Bezpieczeństwo i higiena pracy. Komentarz*. Pszczyna.
5. PN-Z-08052:1980: Ochrona pracy. Niebezpieczne i szkodliwe czynniki występujące w procesie pracy. Klasyfikacja.
6. Polska Norma PN-18002:2011: Systemy zarządzania bezpieczeństwem i higieną pracy.
7. Romanowska-Słomka, I., Słomka, A. (2018). *Ocena ryzyka zawodowego*. Tarnobrzeg.
8. Romanowska-Słomka, I., Słomka, A. (2008). *Zarządzanie ryzykiem zawodowym*. Tarnobrzeg.
9. Rozporządzenie Ministra Pracy i Polityki Socjalnej z dnia 26 września 1997 roku w sprawie ogólnych przepisów bezpieczeństwa i higieny pracy, Dziennik Ustaw, 2011.
10. Rozporządzenie Ministra Środowiska z dnia 10 grudnia 2003 r. w sprawie bezpieczeństwa i higieny pracy w ogrodach zoologicznych, Dziennik Ustaw, 2003.
11. Rozporządzenie Ministra Zdrowia z dnia 22 kwietnia 2005 roku w sprawie szkodliwych czynników biologicznych dla zdrowia w środowisku pracy oraz ochrony zdrowia pracowników zawodowo narażonych na te czynniki, Dziennik Ustaw, 2020.
12. Ustawa z dnia 26 czerwca 1974 roku Kodeks pracy, Dziennik Ustaw, 2020.

Appendix

Table 6.

Example of documented risk assessment referred to a hazard

Identified hazard	Description of the hazard	Probability	Exposition	Results	Protective methods
Moving parts of machines	Wood milling machine	3	6	7	126 Medium

Note. The method above is Risk Score.

Table 7.

Example of verification

Identified hazard	Description of the hazard	H	D	I	Description
Moving parts of machines	Wood milling machine	4	3	12	Risk assessment is proper

Note. The result of verification indicates that prepared risk assessment result is proper and verification is done and the update of risk assessment is not necessary. Wood milling machine is considered as a high risk machine.

INDIVIDUAL ENTREPRENEURIAL ORIENTATION AND ENTREPRENEURIAL INTENTION. COMPARATIVE RESEARCH ON POLISH AND BULGARIAN STUDENTS

Joanna RUDAWSKA^{1*}, Daniel PAVLOV², Miroslava BONEVA³

¹ Jan Kochanowski University in Kielce, Faculty of Law and Social Sciences, Poland;
joanna.rudawska@ujk.edu.pl, ORCID: 0000-0003-1484-8283

² University of Ruse "Angel Kanchev" Bulgaria; dpavlov@uni-ruse.bg, ORCID: 0000-0002-4515-2206

³ University of Ruse "Angel Kanchev" Bulgaria; mboneva@uni-ruse.bg, ORCID: 0000-0003-3732-5733

* Correspondence author

Purpose: The aim of the study was to measure and understand the relationship between Individual Entrepreneurial Orientation (IEO) and Entrepreneurial Intention (EI) among students from Poland and Bulgaria within the country context.

Design/methodology/approach: The respondents were 1,199 students, including 681 students from Bulgaria and 518 students from Poland. The respondents were selected randomly. The research was conducted online using a CAWI method. The existing tools for measuring constructs, i.e. IEO and EI, in the subject-matter literature were used. The questionnaire developed by Bolton and Lane (2012) relying on Covin and Slevin's (1986) conceptualisation was used to diagnose the level of students' IEO. EI was measured using a single-item measure developed by Liñán and Chen (2009).

Findings: The empirical results show relationships and a positive impact of individual entrepreneurial orientation dimensions upon entrepreneurial intentions. In both countries, there is a statistically significant relationship between entrepreneurial intention and risk-taking, innovativeness, and proactivity. Countries determine the strength of such a correlation, but these relationships, although statistically significant, have been defined as weak.

Research limitations/implications: The results cannot be generalised to the entire population, but they are a good contribution to further research on the antecedence of IEO and EI and the differences based on such variables as gender, age, level of education, or field of study.

Practical Implications: The results can be used for further research on the factors influencing entrepreneurial attitudes and motivations. They can also be used for entrepreneurial education at universities by supporting the evaluation of the strength of orientation and intentions of students towards entrepreneurship and transferring good practice among countries.

Originality/value: This study focuses on young adult respondents from two countries who are able to provide new references to factors which may encourage or hamper their interest in becoming entrepreneurs.

Keywords: entrepreneurship, entrepreneurial orientation, entrepreneurial intention.

Category of the paper: Research paper.

Introduction

Entrepreneurship may be defined through the prism of the process of initiating, creating and implementing various projects, as well as through the personality and character of an entrepreneurial person (Baran, Bąk, 2016). Due to the multidimensionality of such a definition, it is analysed from many perspectives, including economic, psychological, and sociological ones. Entrepreneurship plays an important role, especially now in such a dynamically changing and turbulent environment being full of uncertainties and risks. The issue of entrepreneurship is particularly important from the point of view of universities and their role in shaping entrepreneurial attitudes among students. Researchers are still looking for answers to questions about the entrepreneurial potential of students and the factors influencing students' decisions to start or not to start their own business during or after the process of education. The answers are being sought in the process, but also in the socio-psychological predispositions of respondents. Individual Entrepreneurial Orientation (IEO) and Entrepreneurial Intention (EI) are constructs recognised in the subject-matter literature, serving as measures of entrepreneurial behaviour and attitudes (Wiklund et al., 2011). Researchers are looking for answers to the question about the factors influencing the entrepreneurial behaviour of young people by focusing, among others, on the antecedents of entrepreneurial attitudes and decisions. They consider the field of study, acquired business education (Lee et al., 2005), and structural support offered outside universities (Turulja et al., 2020; Farashah, 2015). The research results indicate that behaviours, entrepreneurial attitudes, as well as tendencies and motivations to undertake entrepreneurial activity differ in individual countries (The Global Entrepreneurship Monitor, GEM, 2020). It has been proven many times that situational or demographic factors specific to countries have an impact on Individual Entrepreneurial Orientation (IEO) (Grilo, and Irigoyen, 2006; Vinig, and Dorresteijn, 2007) or Entrepreneurial Intentions (EI) (Iakovleva, Kovreid, Stephan, 2011; Lee, and Wong, 2004). Given that IEO and EI are two different constructs (Thompson, 2009), there is a need to analyse these constructs together. Moreover, cross-country research are taking into account, thus there is also a need to look for similarities and differences. Such questions as what is the level of Individual Entrepreneurial Orientation of students in comparison of two countries, i.e. Poland and Bulgaria, and whether the relationship of Individual Entrepreneurial Orientation and Entrepreneurial Intention of students to choose a career as an entrepreneur exists remain unanswered. The aim of the study was to measure and understand the relationship between Individual Entrepreneurial Orientation (IEO) and Entrepreneurial Intention (EI) among students of institutions of higher education in Poland and Bulgaria. This study involves a comparative analysis between these two countries and updates the findings based on the Theory of Planned Behaviour (TPB) (Ajzen, 1991).

Literature review

Entrepreneurial orientation (EO) seems to be one of the most well-established concepts in the field of research on entrepreneurship (Karpacz, 2018). Initially, it was defined only at the organisational level, and Miller (1983) is known as its precursor who defined an entrepreneurship-oriented enterprise as an entity characterised by a pioneering and active approach to the implementation of product strategy, willingness to implement risky business ventures, as well as innovativeness. A three-dimensional construct, based on proactivity, innovativeness, and risk-taking, has become a permanent part of the trend of entrepreneurship research and was popularised by Covin and Slevin (1989) who have developed it in terms of entrepreneurial strategic posture (ESP). Proactivity may be operationalised at the level of organisation by asking managers about enterprise's tendency to be the first on the market with a new product, technology, or service. Innovativeness is willingness to be innovative and to present original ideas. Risk-taking, in turn, is defined as an acceptable level of managers to undertake uncertain activities (Rudawska, 2020).

In later years, Lumpkin and Dess (1966) further refined EO and suggested the necessity to expand this construct by two other dimensions, i.e. autonomy and competitive aggressiveness. Autonomy is understood as independence in action and decision-making, while competitive aggressiveness as a tendency to direct aggressiveness towards competition and intense challenges to enter the market (Dyduch, 2006). As defined by Lumpkin and Dess, EO is best to describe the concept involving processes, practices, and decision making towards a new entrance with the intention to form a new venture by an enterprise. It refers to enterprise's strategic position, taking into account specific entrepreneurial aspects of decision-making styles, methods, and ways of behaviour (Wójcik-Karpacz et al. 2018). In the subject-matter literature there are many examples proving that high entrepreneurial orientation at the organisational level ensures high results; thanks to it, the EDC theme is treated as an effective tool to achieve market advantage (see: Bratnicki, Gabryś, 2011; Rauch et al., 2009; Gupta, Gupta, 2015; Wales, 2016).

In recent years, researchers have also suggested that the EDC construct may be used to measure entrepreneurial orientation at the individual level. Researchers treat IEO as a psychological construct capturing beliefs, values, and practices which shape decisions and actions in response to change (which is always connected with entrepreneurship) (Tautila, and Down, 2012; Karpacz, 2018, Robinson, and Stubberud, 2014). According to Goktan and Gupta (2013), IEO involves a holistic assessment of individual, and specific for each one, tendency to be navigated in ambiguity and complexity. Bolton and Lane (2012) justified the possibility of using EO measures at the individual level with reference to the research on organisations such as sole proprietorships, i.e. one-person enterprises. They concluded that IEO could be tested using Covin and Slevin's (1989) tool by adapting it to the individual level. They defined

proactivity at the individual level as *an opportunity-seeking, forward-looking perspective characterised by new products and services ahead of the competition and acting in anticipation of future demand*. They referred innovativeness to creativity and openness to experimentation, and risk-taking to an inclination to take *bold actions by venturing into the unknown, borrowing heavily and/or committing significant resources to ventures in uncertain environments* (Bolton, and Lane, 2012). In their research, they concluded that innovativeness, risk-taking, and proactivity are statistically correlated factors with entrepreneurial intentions at the individual level (Bolton, and Lane, 2012).

As IEO is a relatively new construct, researchers should pay attention to the operationalisation of its elements in their research and correlations with different variables.

Apart from IEO, a construct inextricably linked with individual behaviour and entrepreneurial attitudes is Entrepreneurial Intention (EI). According to Bird (1988), intention is a state of mind that directs attention as well as action towards a goal chosen. The Theory of Planned Behaviour (TPB) developed by Ajzen (1991) consists of three main components which, according to the author, predict the formation of intentions: 1) attitude towards behaviour; 2) subjective norms; and 3) degree of perceived behavioural control (self-efficacy). According to TPB, each behaviour requires more or less planning and can be predicted precisely on the basis of intention to implement this behaviour. The first of the components, i.e. attitude towards behaviour, is understood as the degree of evaluation of entrepreneurship in a positive or negative way. Subjective norms measure perceived social pressure, taking into account pressure from family, friends, and other people from our environment who are important to us, among others. Perceived behavioural control referring to the perception of situational competence and reflecting the perceived ability to become self-employed is described as self-efficacy. The Entrepreneurial Intention (EI) construct is building its assumptions on TPB. Krueger (1993) defines EI as a commitment to start a new activity and treats it as the antecedent of entrepreneurial behaviour. Lee and Wong (2004) recognise EI as the first step in an evolving and, sometimes, long-term process of venture creation. It is most often studied through the dimensions of TPB (personal attraction, perceived social norms, self-efficacy, and intention), but a one-dimensional construct is more and more often used in the subject-matter literature (see Krueger et al., 2000; Peterman, and Kennedy, 2003; Veciana et al., 2005). Researchers argue that both individual and situational variables play an important role as predictors of entrepreneurial behaviour, e.g. entrepreneurial skills, environmental factors, entrepreneurial education (Lee, Wong, 2004).

Research methods

The research was conducted by universities from Poland and Bulgaria, under a cooperation agreement between the Jan Kochanowski University in Kielce and the University of Ruse “Angel Kanchev”. The target population consisted of students at various higher educational institutions in Poland and Bulgaria. The questionnaire was sent to undergraduate, graduate and post-graduate students of all faculties. Filling out the questionnaire was voluntary and anonymous.

The questionnaire was prepared using the relevant subject-matter literature to ensure its validity and reliability. A total of 16 items researching IEO and IE were used. Table 1 shows the items used to measure both main constructs.

Table 1.
Items used to measure of IEO and EI

Construct	Dimension	Question	Adopted from (author/year)
Individual Entrepreneurial Orientation (IEO)	Risk-taking	A. I like to take bold action by venturing into the unknown. B. I am willing to invest a lot of time and/or money on something that might yield a high return. C. I tend to act 'boldly' in situations where risk is involved.	Bolton, and Line, 2012
	Innovativeness	D. I often like to try new and unusual activities that are not typical but not necessarily risky. E. I tend to do things the same and not try different, unproven approaches. F. I prefer to try my own unique way when learning new things rather than doing it like everyone else does. G. I favour experimentation and original approaches to problem solving rather than using methods others generally use for solving problems.	
	Proactiveness	H. I usually act in anticipation of future problems, needs, or changes. I. I tend to plan ahead on projects. J. I prefer to 'step up' and get things going on projects rather than sit and wait for someone else to do it.	
Entrepreneur Intention (EI)	Entrepreneur Intention (EI)	1. I make every effort to start and run own business 2. My professional goal is to become entrepreneur 3. I'm determined to create a business 4. I'm ready to do anything to be entrepreneur 5. I have a very serious thought of starting a business 6. I have intention to start a business	Liñán, and Chen, 2009

Source: own elaboration based on Bolton, and Line, 2012; Liñán, and Chen, 2009.

The IEO measurement was based on a questionnaire developed by Bolton and Lane (2012). Individual Entrepreneurial Orientation was included in the context of a three-dimensional construct consisting of innovativeness (4 items), proactivity (3 items), and risk-taking (3 items). The division into three dimensions refers to the research on entrepreneurial orientation at the organisational level according to Miller (1983) and Covin and Slevin (1989), which Bolton and Lane used in their tool at the individual level. The IE construct, consisting of six items, was adopted from Liñán and Chen (2009). In this case, a one-dimensional construct was used. The single-item regarding the EI scale are more and more popular in the subject-matter literature (Krueger et al., 2000; Peterman, and Kennedy, 2003; Veciana et al., 2005; Liñán, and Chen, 2009). The scales were adapted and tested. Reliability analysis showed the presence of good-quality orientation as well as entrepreneurial intention: Cronbach's alpha for entrepreneurial orientation: 0.69, and Cronbach's alpha for entrepreneurial intention: 0.95. A five-point Likert type scale measuring all items were gauged on five- point Likert scale ranged from 1 = "strongly disagree" to 5 = "strongly agree".

Quantitative empirical research was conducted from 1st April 2020 to 30th June 2020. The research, carried out with own funds, was conducted using a CAWI (Computer Assisted Web Interviews) method. This technique is based on sending the questionnaire online to respondents via universities' employees. The responses were collected and encoded in an electronic version in a spreadsheet document, and that facilitated further statistical analyses. This technique was chosen due to the fact that it allows to easily and quickly reach a wide group of respondents, especially when conducting research in two countries. PAPI (Paper and Pencil Interview) research would be more time-consuming, costly and more difficult in the case of the Covid-19 pandemic.

Statistical analysis was performed using the IBM SPSS Statistics 25 package. The multivariate analysis of variance allowed to check whether there is a statistically significant main effect of the country, i.e. concerning entrepreneurial intention, risk-taking, innovativeness, and proactivity. In the case of a statistically significant interaction, simple main effects analysis was used to investigate it in detail. The analysis of Spearman's correlation allowed to find out whether there is a statistically significant relationship between the analysed variables. By using a chi-squared test, it was checked whether the compared groups of people were equal, and whether there was a statistically significant relationship between the nominal variables. The mean and standard deviation were used in a statistical analysis of results.

Results

The questionnaire was filled out by 1,199 students, including 681 students from Bulgaria and 518 students from Poland. The research sample was dominated by women (81%), while in Bulgaria it was 93.4% of the respondents and in Poland – 64.7%. The structure of the respondents by gender and age is presented in Table 2.

Table 2.

Structure of the research sample according to the country, gender, age, and level of education

Variables		Country				In total	
		Bulgaria		Poland		sample	%
		sample	%	sample	%		
Gender	Female	636	93.4	335	64.7	971	80.98
	Male	45	6.6	183	35.3	228	19.02
Age	< 20	98	14.4	69	13.3	167	13.93
	21-30	315	46.3	425	82	740	61.72
	31-40	174	25.6	17	3.3	191	15.93
	> 40	94	13.8	7	1.4	101	8.42

Source: own elaboration.

In both countries, the greatest number of respondents was aged from 21 to 30 and accounted for 62% (including Bulgaria 46% and Poland 82%). In Bulgaria, compared to Poland, more people were between 31 and 40 years old (26% and 3%, respectively) and over 40 (19% and 1%, respectively).

As part of the research, it was analysed whether there is a statistically significant relationship between entrepreneurial intention and proactivity, risk-taking, and innovativeness in the research sample. Questions included in individual indicators are marked with numbers or letters in accordance with the tool indicated in Table 1. The relationships between entrepreneurial intention and individual IEO dimensions are summarised in Table 3.

In terms of risk-taking, all relationships were statistically significant (positive), but they were stronger in Poland, when compared to Bulgaria. A similar situation applies to innovativeness, although in the case of Bulgaria, the question E. "I tend to do things the same and not try different, unproven approaches" shows only one (weak) statistically significant relationship, namely the question 5. „I have a very serious thought of starting a business”. When it comes to proactivity, here also all the relationships were statistically significant, but most of them (not all as in the case of risk-tasking) were stronger for Poland.

Table 3.

Relationship of entrepreneurial intention with risk-taking, innovativeness, and proactivity in the research sample

Indicator	Variable		Entrepreneurial Intention (EI)					
			1	2	3	4	5	6
Risk-taking	A	Bulgaria	0.2*	0.27*	0.24*	0.25*	0.25*	0.26*
		Poland	0.36*	0.37*	0.37*	0.33*	0.37*	0.37*
	B	Bulgaria	0.2*	0.25*	0.26*	0.26*	0.24*	0.25*
		Poland	0.39*	0.39*	0.41*	0.37*	0.42*	0.42*
	C	Bulgaria	0.17*	0.21*	0.2*	0.25*	0.23*	0.23*
		Poland	0.37*	0.39*	0.39*	0.36*	0.36*	0.36*
Innovativeness	D	Bulgaria	0.13*	0.17*	0.12; p = 0.002	0.13; p = 0.001	0.14	0.15
		Poland	0.25*	0.26*	0.24*	0.22*	0.24*	0.26*
	E	Bulgaria	0.002; p = 0.95	-0.04; p = 0.35	-0.06; p = 0.11	-0.02; p = 0.11	-0.08; p = 0.047	-0.07; p = 0.08
		Poland	-0.23*	-0.2*	-0.24*	-0.19*	-0.23*	-0.23*
	F	Bulgaria	0.13; p = 0.001	0.07; p = 0.09	0.15*	0.09; p = 0.02	0.16*	0.17*
		Poland	0.26*	0.25*	0.27*	0.27*	0.27*	0.28*
	G	Bulgaria	0.16*	0.16*	0.2*	0.21*	0.22*	0.21*
		Poland	0.33*	0.32*	0.33*	0.28*	0.34*	0.34*
Proactvitiy	H	Bulgaria	0.22*	0.13; p = 0.001	0.14*	0.09; p = 0.02	0.15*	0.15*
		Poland	0.27*	0.26*	0.21*	0.19*	0.26*	0.21*
	I	Bulgaria	0.2*	0.13; p = 0.001	0.1; p = 0.01	0.1; p = 0.007	0.11; p = 0.006	0.14*
		Poland	0.17*	0.14*	0.14*	0.12; p = 0.007	0.15*	0.13; p = 0.002
	J	Bulgaria	0.29*	0.13; p = 0.001	0.16*	0.11; p = 0.002	0.17*	0.19*
		Poland	0.23*	0.2*	0.13; p = 0.002	0.14*	0.17*	0.16*

*p < 0.001; Spearman's correlation.

Source: own elaboration.

In both countries, there was a statistically significant relationship between entrepreneurial intention and risk-taking, innovativeness, and proactivity (Table 4).

Table 4.

Relationship between entrepreneurial intention and risk-taking, innovativeness, and proactivity in the research sample

Variable	Entrepreneurial Intention (EI)		
	Bulgaria	Poland	Both countries
Risk-taking	0.35*	0.5*	0.42*
Innovativeness	0.18*	0.29*	0.26*
Proactvitiy	0.25*	0.25*	0.28*
Entrepreneurial Orientation (EO)	0.38*	0.48*	0.45*

*p < 0.001; Spearman's correlation.

Source: own elaboration.

In the case of Poland, stronger relationships were characteristic of risk-taking and innovativeness, and these were positive relationships, which means that as the value of one variable increases, the value for the other increases, as well. The strongest relationship concerns entrepreneurial intention with risk-taking in the research sample from Poland (0.5). In the case of Bulgaria, stronger relationships of entrepreneurial intention were characteristic of risk-taking and proactivity, rather than innovativeness.

Discussion

Universities play an important role in shaping the attitudes, knowledge and skills of young people, also in the area of entrepreneurship. The conducted research shows that in both countries, Poland and Bulgaria, there is a statistically significant relationship between entrepreneurial intention and individual entrepreneurial orientation considered in three dimensions, i.e. risk-taking, innovativeness and proactivity. The results provide evidence that individual entrepreneurial orientation is related to entrepreneurial behaviour and intentions to run one's own business, which is related, among others, to risk-taking being one of the examined dimensions. Differences due to the respondents' country of origin were reported, and that is intriguing for further analysis. In further research, it is worth analysing whether there is a statistically significant interaction of a country with sociodemographic data, i.e. gender, age and level of education, and how economic education affects the level of individual entrepreneurial orientation and the intentions of young people. Our research contributes to studies looking for answers whether there is a relationship between these constructs that are important in determining what influences entrepreneurial activities and starting own business by people at the beginning of their professional career

The survey was conducted on the bases of the project agreement PL-BG-2019-UJK-URAK-02 between Jan Kochanowski University in Kielce and University of Ruse "Angel Kanchev.

References

1. Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179-211.
2. Baran, G., Bąk, J. (2016). Przedsiębiorczość jako proces stawania się. In: M. Kosała, M. Urbaniec, A. Żur (red.), *Współczesne dylematy badań nad przedsiębiorczością. Przedsiębiorczość Międzynarodowa*, vol. 2, nr 1 (ss. 83-98). Kraków: Uniwersytet Ekonomiczny.

3. Bird, B. (1988). Implementing entrepreneurial ideas: the case for intention. *Academy of Management Review*, 13(3), 442-453.
4. Bolton, D.L., & Lane, M.D. (2012). Individual entrepreneurial orientation: development of a measurement instrument. *Education Training*, 54(2/3), 11-11.
5. Dyduch, W. (2006). Badanie poziomu przedsiębiorczości organizacyjnej w polskich firmach. In: M. Romanowska, P. Wachowiak (eds.), *Koncepcje i narzędzia zarządzania strategicznego* (pp. 93-106). Warszawa: Oficyna Wydawnicza Szkoły Głównej Handlowej.
6. Farashah, A.D. (2015). The effects of demographic, cognitive and institutional factors on development of entrepreneurial intention: Toward a socio-cognitive model of entrepreneurial career. *Journal of International Entrepreneurship*, 13(4), 452-476. 10.1007/s10843-015-0144-x.
7. Goktan, A.B., & Gupta, V.K. (2013). Sex, gender, and individual entrepreneurial orientation: evidence from four countries. *International Entrepreneurship and Management Journal*, 1-18.
8. Grilo, I., Irigoyen, J.-M. (2006). Entrepreneurship in the EU: To Wish and Not to Be. *Small Business Economics*, 26(4), 305-318.
9. Iakovleva, T., Kolvereid, L., Stephan, U. (2011). Entrepreneurial Intentions in Developing and Developed Countries. *Education and Training*, 53(3), 353-370. DOI: 10.1108/00400911111147686.
10. Karpacz, J. (2018). Indywidualna orientacja przedsiębiorcza: konceptualizacja, pomiar i ocena. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, 538, p. 172-182.
11. Krueger, N.F. (1993). The impact of prior entrepreneurial exposure on perceptions of new venture feasibility and desirability. *Entrepreneurship Theory & Practice*, 5, 5-21.
12. Lee, S.M., Chang, D., Lim, S.B. (2005). Impact of entrepreneurship education: a comparative study of the U. S. and Korea. *Int. Entrepreneurship. Manage. J.*, 1, 27-43.
13. Lee, S.H., & Wong, P.K. (2004). An exploratory study of technopreneurial intentions: A career anchor perspective. *Journal of Business Venturing*, 19(1), 7-28.
14. Liñán, F., Chen, Y. (2009). Development and cross-cultural application of a specific instrument to measure entrepreneurial intentions. *Entrepreneurship Theory Pract.*, 33(3), 593-617.
15. Robinson, S., & Stubberud, H.A. (2014). Elements of entrepreneurial orientation and their relationship to entrepreneurial intent. *Journal of Entrepreneurship Education*, 17(2), 1-12.
16. Rudawska, J. (2020). In search of mediators in the relationship between entrepreneurial orientation and performance: the mediating role of technology park support. *Optimum. Economic Studies*, 1(99), 128-143.
17. Taatila, V., & Down, S. (2012). Measuring entrepreneurial orientation of university students. *Education Training*, 54(8/9), 744-760.

18. The Global Entrepreneurship Monitor 2019/2020, Global Report, <https://www.gemconsortium.org/report/gem-2019-2020-global-report>.
19. Thompson, E.R. (2009). Individual Entrepreneurial Intent: Construct Clarification and Development of an Internationally Reliable Metric. *Entrepreneurship Theory and Practice*, 33, 669-694, <https://doi.org/10.1111/j.1540-6520.2009.00321.x>.
20. Turulja, L., Veselinovic, L., Agic, E., & Pasic-Mesihovic, A. (2020). Entrepreneurial intention of students in Bosnia and Herzegovina: what type of support matters? *Economic Research – Ekonomska Istraživanja*. DOI: 10.1080/1331677X.2020.1730216.
21. Vinig, Tsvi, G., and Dorresteijn, W. (2007). Determinants of Entrepreneurial Orientation Among Students – A Comparative Study of Dutch, Norwegian and Israeli Students, <https://ssrn.com/abstract=1020576>.
22. Wiklund, J., Davidsson, P., Audretsch, D.B., Karlsson, C. (2011). The future of entrepreneurship research. *Entrepreneurship Theory and Practice*, 35, 1, 1-9.
23. Wójcik-Karpacz, A., Karpacz, J., Pavlov, D., and Rudawska, J. (2018). Entrepreneurial orientation and performance in the context of market dynamism: similarities and differences between Polish and Bulgarian companies. *Management Forum*, 6, 41-47, doi: 10.15611/mf.2018.4.06.

DYNAMICS OF BEARING OF COSTS IN PROCESSES LEADING TO REVITALIZATION OF MINE ASSETS IN SRK S.A.

Janusz SMOLIŁO¹, Andrzej CHMIELA^{2*}, Aleksander LUBOSZ³, Paweł WRÓBLEWSKI⁴

¹ Spółka Restrukturyzacji Kopalń S.A., Bytom; jsmolilo@srk.com.pl, ORCID: 0000-0003-4987-2881

² Spółka Restrukturyzacji Kopalń S.A., Bytom; achmiela@srk.com.pl, ORCID: 0000-0002-0833-0923

³ Spółka Restrukturyzacji Kopalń S.A., Bytom; aleksander.lubosz@srk.com.pl, ORCID: 0000-0001-9461-924X

⁴ Spółka Restrukturyzacji Kopalń S.A., Bytom; p.wroblewski@srk.com.pl, ORCID: 0000-0001-8555-7171

* Correspondence author

Purpose: The restructuring of hard coal mines needs significant financial outlays. Carrying out the rationalization and minimization of the costs requires a complex scientific approach.

Design/methodology/approach: A statistical analysis of the liquidation processes in SRK S.A. on an annual basis was carried out as well as panel surveys and direct interviews with the Management Board of SRK S.A. and Directors of Branches.

Findings: The presented method of signalling of leaving the acceptable cost zone is a useful tool while implementing a process approach in the issue of the liquidation of the mine.

Research limitations/implications: The assessment method is based on the analysis of the total cost of liquidation. Further research will require the analysis of the connection between the structure and size of costs incurred in subsequent years of the liquidation processes.

Practical implications: The method can be used in the initial cost estimation of liquidated mining plants as a cost management tool.

Social implications: The method can be used as a comparison for a detailed analysis and a multi-criteria cost estimation of planned mining plants liquidation. After some modification, the methodology can also be applied by any entity carrying out the liquidation of mines.

Originality/value: The presented procedure may help to monitor incurred costs (rationalization and minimization of the costs). The tool can be useful in effective liquidation of mining plants.

Keywords: process management, restructuring of mining enterprises, liquidation of a hard coal mine.

1. Introduction

The Polish hard coal mining industry has been restructured since the beginning of the 1990s (Korski, Korski, 2015; Marek, 2006; Paszcza, 2010). Revitalization and restructuring activities are carried out mainly by Spółka Restrukturyzacji Kopalń S.A. The supervision and post – industrial property management of the liquidated mining plants are carried out by Coal Mines

in Liquidation Branches of SRK S.A. and the Housing Resource Administration is responsible for the management of non-industrial assets (apartments, garages, commercial premises, etc.). Besides, the Central Department of the Mine Dewatering Plant is responsible for the securing of neighbouring mines against flooding due to the pumping out water from sites of previously closed mines. SRK S.A. as the legal successor of restructured mining plants not only deals with the liquidation and securing of excavation gates and construction facilities but also copes with prevention of threats related to their liquidation. It is carried out by 8 branches of SRK S.A. (www.srk.com.pl).

The mine liquidation is the last stage of mining activity and the liquidation process itself is a natural stage of mining activity. The decision about the liquidation may be issued as a result of depletion of the resources of the exploited deposit, unprofitability of extraction, expiry of a concession or excessive environmental degradation (Duda, 2018, Wójcik, 2018). After the end of active mining exploitation, the abandoned mine infrastructure may be a problem for the former communities connected with mining industry. Based on the decisions of the European Union, it is possible to finance the hard coal mine liquidation from the state budget by the end of 2023.

2. Research Problem

The activity of the Management Board of SRK S.A. is to spend rationally obtained budget subsidy. The scientific research aimed at improving the rationalization and effectiveness of the processes of revitalization and restructuring mining plants is very scarce (Smoliło, Chmiela, 2021), although the average cost of mine liquidation may reach 300 million PLN. The available literature connected with mine liquidation refers only to general issues (Grajewski, 2012; Riesgo et al., 1997, 2000, 2001, 2003). Difficulties in improving the efficiency of processes of revitalization or mine liquidation may result from the lack of instruments supporting cost management. The presented publication is a continuation of research on the tools to support the cost management of liquidation processes. The proposed method of assessing the correctness of estimated costs on an annual basis may improve the efficiency of a mining enterprise that liquidates hard coal mines (Brilman, 2002; Dźwigoł, 2007; Grajewski, 2012; Smoliło, Chmiela, 2021; Skrzypek, Hofman, 2010).

3. Research methods

The aim of the research was to develop and propose another tool to access the course of liquidation process in the case of assessing the estimated costs on an annual basis. An additional aim of the research was to identify research areas and problems related to the rationalization and effectiveness of the restructuring processes, the revitalization processes and mining plants liquidation processes. The aim was achieved in two stages (Table 1). The research plan was implemented on the basis of updated liquidation programs of seventeen examples of liquidated mining plants or their separate parts. The analysis refers to the period from 2015 to 2023, in which the period from 2015 to 2019 presents incurred costs and the period from 2020 to 2023 shows planned costs.

Table 1.

Research methods and the results of their use in particular stages of research

Research stage	Research Methods	Results of the use of research methods
I	<ul style="list-style-type: none"> - Study of literature - Analysis - Synthesis - Panel studies - Direct interview 	<ul style="list-style-type: none"> - A statistical analysis of the researched liquidation process - Preparation of the data form - Proposition of an evaluation method - Indication of research areas and problems
II	<ul style="list-style-type: none"> - Face-to-face interview - Analysis - Synthesis 	<ul style="list-style-type: none"> - A verification of correctness of operations of the assessment method - Modification of the assessment method of the course of liquidation processes - An identification of research areas and problems that need to be solved

Source: An own study.

In the first stage, the available literature referring to the management of processes was analysed and compared with SRK S.A. experience connected with restructuring post- mining assets. The results of analysis made it possible to propose the idea of a method of managing the costs of the processes of releasing industrial areas from unnecessary infrastructure. During this stage, a direct interview with experts was conducted concerning technical aspects related to the correctness of the course of individual processes in following years. The cause of larger deviations from the average values was clarified on an ongoing basis. The course of the process was presented in Figure 1. The preliminary cost estimation method was used in the second stage of the research.

In the second stage, the basic statistical analysis of the mining plants restructuring processes in SRK S.A. was carried out in the case of years of their course. Any ambiguities were consulted with experts. The correct operation of the proposed tool for assessing the cost structure of liquidation processes was carried out on the basis of hypothetical new branches of SRK S.A. As expected, the research revealed new areas and research problems that need to be solved.

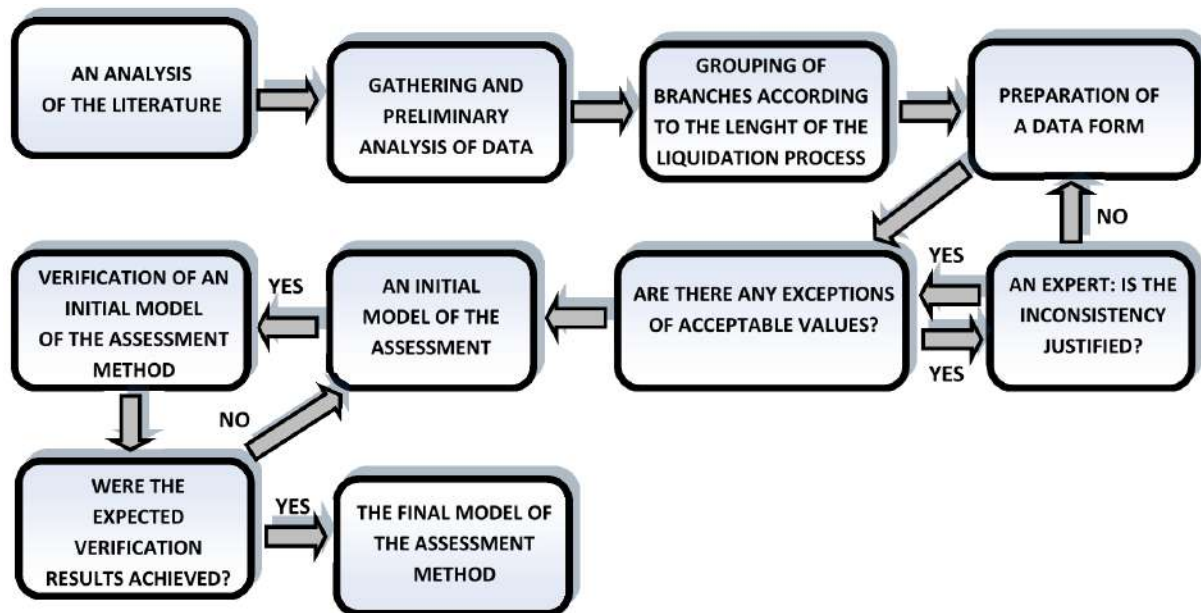


Figure 1. A research method. Source: An own study.

4. Findings

The research was carried out on the basis of updated mine liquidation programs currently conducted in SRK S.A. and on the basis of data of previously performed processes and activities. Restructuring in SRK S.A. is divided into ten component processes (Table 2). According to the updated liquidation programs, they should be completed by the end of 2023. Figure 2 shows the schedule of liquidation process with an unscaled timeline.

Table 2.

The mine liquidation processes in SRK S.A.

1.	Liquidation and securing of excavation gates
2.	Liquidation and securing of shafts and pits
3.	Protection of neighbouring mines against water, gas and fire hazards
4.	Liquidation of the mine's infrastructure
5.	Land reclamation
6.	Maintaining the facilities for liquidation in sequence ensuring safe liquidation of the mining plant
7.	Carrying out security works and measures to prevent hazards in connection with the liquidated mining plant
8.	Development of the required projects, documentation, opinions, expertise and analyses related to the closure of the mine
9.	Repair of damage caused by mining plant operations
10.	General management of the tasks performed during the mine closure

Source: Data from SRK S.A.

A statistical analysis of six mining plants was carried out where the liquidation processes have already been fully completed. Moreover, the statistical analysis of a group of eleven mines currently being liquidated by 8 Branches of SRK S.A. (www.srk.com.pl) was carried out. Due to the inflation and incomparability of costs in different years, a proprietary correction coefficient (based on the data of the Central Statistical Office) was used to convert costs into the realities of the end of 2020. All costs were given as a percentage of the total liquidation costs.



Figure 2. The schedule of the liquidation process. Source: Data from SRK S.A.

SRK S.A. liquidates mining plants in average of less than 5 years. The average cost of liquidation of the branch is 5,88% of the total liquidation cost, while in real this value ranges from 0,32% to 16%. The liquidation of a mine is an individual case which results in different lengths of their liquidation and the cost of their liquidation itself. The shortest liquidation time is 2 years and the longest liquidation time is 8 years. This dependence may change due to COVID-19 and it should be assumed that because of that fact the liquidation processes may last longer. Each subsequent year of extension of liquidation process of the statistical mining plant increases expenditures to about 1,2% of the total costs of liquidation.

Table 3.

The number of liquidated mining plants depending on the length of the liquidation process

Liquidation time	The average cost of branch liquidation	The maximum cost of branch liquidation	The minimum cost of branch liquidation	The total cost of liquidation of branches	Number of cases
8 years	11,37%	10,33%	10,33%	10,33%	1
7 years	12,53%	16,12%	8,93%	25,06%	2
6 years	8,63%	12,73%	6,18%	25,88%	3
5 years	4,86%	9,95%	1,62%	14,57%	3
4 years	3,25%	5,89%	0,32%	19,49%	6
3 years	2,36%	2,79%	2,79%	2,79%	1
2 years	2,31%	1,88%	1,88%	1,88%	1

Source: An own study.

Certain regularities can be found in such a diverse ‘population’. The differences between the liquidation time and the associated costs most often result from the size of the task. The length of liquidation processes and their costs usually depend on the amount, size and type of liquidated facilities. Due to the length of the liquidation process the restructured branches have been divided into seven reference groups. The most numerous and the most diverse group is the group of mines liquidated for 4 years. This range includes both small and medium-sized mines. Due to the operational conditions of the neighbouring mines the liquidation time of a part of analysed branches was extended. From the point of view of the technical liquidation, the smallest units could be liquidated earlier and could increase the amount of mines liquidated for 2 or 3 years. It is similar with the example of the mine that has been liquidated for 8 years. In this case also the operational considerations of the neighbouring active mine lengthened artificially the restructuring process.

In the groups of mines liquidated for 4, 5, 6 and 7 years there are at least two similar cases and it is possible to obtain an average value. On the other hand, in the case of mines liquidated for 2, 3 and 8 years only one case can be statistically analysed. Due to the similarities between the neighbouring groups, the average value of the costs of mines population liquidated for 8 years was determined as the weighted average value with the group of mines liquidated for 7 years, giving this group a weight of 0,9. The same was done with mines liquidated for 2 and 3 years. In these cases, the second group was the reference point for the analysed group. When calculating the weighted average of the cost of mines liquidated for 2 years it was given a weight of 1 and when calculating the weighted average of the cost of mines liquidated for 3 years it was given a weight of 0.9. Similarly the average value of the cost of mines liquidated for 3 years obtained as the weighted average of the liquidation cost of this mine with a weight of 1 and for the mines liquidated for 2 years with a weight of 0.9.

Table 4.

Total restructuring costs on an annual basis

Process costs	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	SUM
Process 1	0,30%	0,37%	0,30%	0,11%	0,08%	0,11%	0,03%	0,02%	1,3%
Process 2	0,03%	1,04%	0,71%	1,99%	0,45%	0,33%	0,00%	0,06%	4,6%
Process 3	0,00%	0,00%	0,56%	1,71%	2,71%	2,32%	0,29%	0,00%	7,6%
Process 4	0,13%	0,54%	0,88%	1,71%	1,25%	0,57%	0,01%	0,07%	5,2%
Process 5	0,00%	0,04%	0,33%	1,34%	0,52%	0,16%	0,34%	0,03%	2,7%
Process 6	6,74%	5,15%	3,20%	1,82%	1,09%	0,52%	0,07%	0,07%	18,7%
Process 7	4,94%	6,35%	6,32%	5,74%	4,72%	4,07%	2,27%	1,10%	35,5%
Process 8	0,17%	0,22%	0,16%	0,16%	0,10%	0,06%	0,00%	0,00%	0,9%
Process 9	0,83%	1,50%	1,64%	2,79%	0,60%	0,20%	0,06%	0,03%	7,7%
Process 10	3,79%	3,48%	3,09%	2,59%	1,59%	0,91%	0,35%	0,11%	15,9%
SUM of costs	16,93%	18,69%	17,18%	19,95%	13,11%	9,24%	3,43%	1,48%	100%
Liquidation costs (Processes 1, 2, 4)	0,45%	1,96%	1,89%	3,80%	1,78%	1,00%	0,05%	0,15%	11,09%

Source: An own study.

The total costs of liquidation processes on an annual basis are presented in Table 4. Only 11,1% of the budget subsidy is allocated to the processes of physical liquidation of underground and surface facilities (Processes 1, 2 and 4). The remaining 89% of the total cost of liquidation is related to ensure the correct course of these liquidation processes. In the mining plant liquidation processes, potential optimization and rationalization opportunities can be considered. About 5 billion PLN is spent from the budget on liquidation of unnecessary hard coal mines production facilities. This amount results only from the liquidation of seventeen analysed mining plants. Each percentage reduction in the liquidation cost can result in measurable savings. The most obvious factor in reducing expenses is the intensification of liquidation processes and shortening liquidation time. Due to the correct sequence of the liquidation of facilities it may not be possible. Nevertheless it should be taken into account that only the part of expenses results from the passage of time.

Processes carried out by SRK S.A. are complex and their size is caused by numerous factors. Only the most important components of individual processes were indicated in the analysis. Any estimation of future liquidation costs must also take into account other cost components.

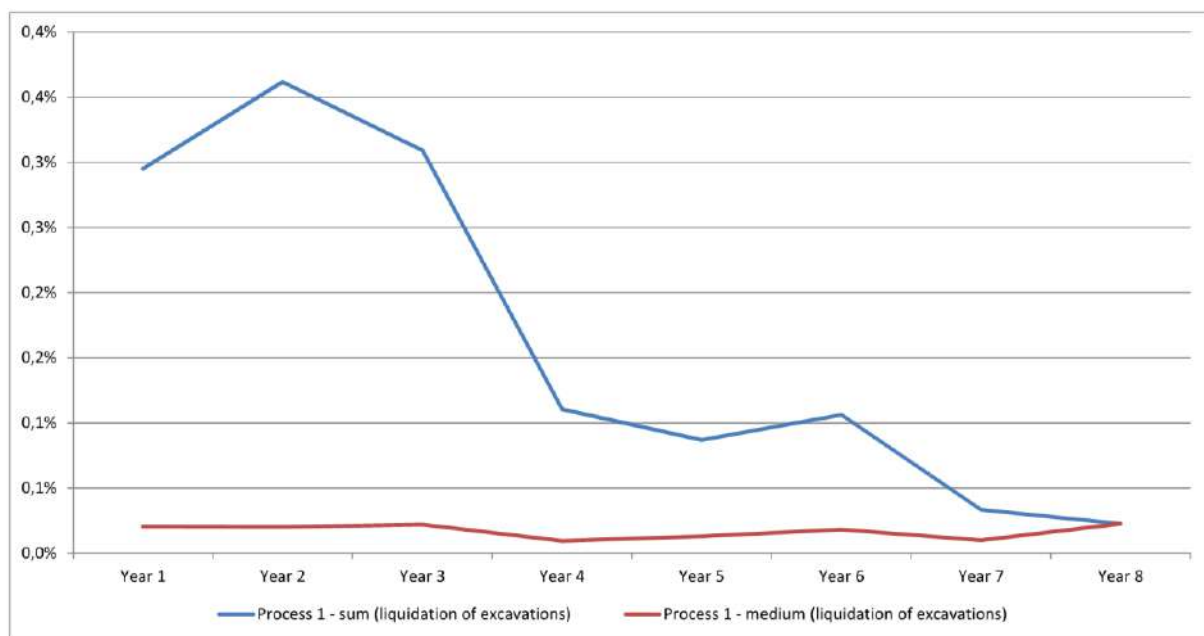


Figure 3. Process 1 – Liquidation and securing of excavation gates. Source: An own study.

Process 1 – Liquidation and securing of excavation gates consumes about 1,32% of the total costs, with the average value for a branch that is 0,08% (Figure 3). The cost of this process depends on the number of sidings in the ventilation network and natural hazards (mainly methane hazard) which increases costs because of the need to use explosion – proof insulation structures there. According to predictions, the total outlays incurred in this process in the following years are decreasing due to the earlier ending of the liquidation of smaller mining plants. In the first year, lower outlays may result from the need to develop expert opinions on the necessary changes of the ventilation networks. The cost of carrying out this process for individual branches ranges from 1,1% to 1,8%.

Process 2 – Liquidation and securing of shafts and pits (Figure 4) is approximately 4,61% of the total liquidation costs and approximately 0,27% on average. According to experts' opinions, the amount of this cost is a derivative of the number of shafts, their length and diameter, the occurring hazards and the number of available levels. This process is usually slightly delayed in relation to Process 1 and should be completed after its completion, because the entire underground infrastructure of the mine is liquidated using these shafts. Statistically, the auxiliary shafts are liquidated in the second year and the main shafts are liquidated in the penultimate year. The average time of branch liquidation is around 5 years, so it should not be surprising that the expenditures will increase in the fourth year of liquidation. The average value of a branch does not exceed 0,1% of costs per year.

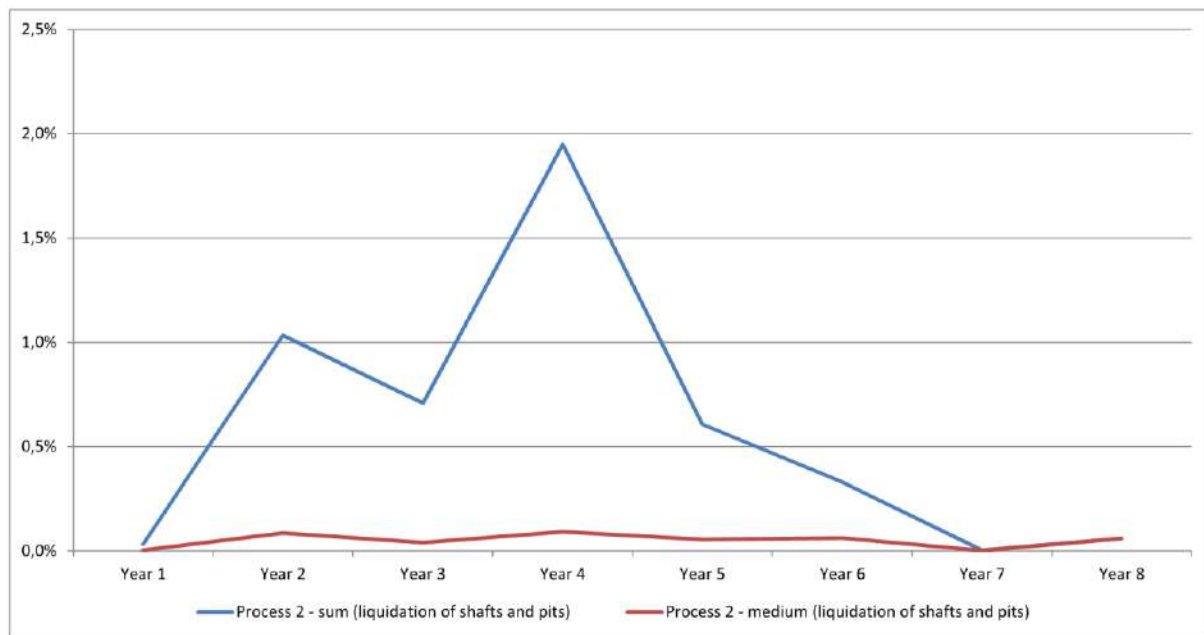


Figure 4. Process 2 – Liquidation and securing of shafts and pits. Source: An own study.

The cost of protection of neighbouring mines (Process 3) depends on the shape of the deposit and the decisive factor of the necessity to conduct this process is securing neighbouring mines against water hazards (Figure 5). SRK S.A. allocates 7,59% of liquidation costs to carry out this process, the most in fifth year (the average time of the branch existence is approximately 5 years). In this case, it is hard to interpret the mean value. Part of the branches of SRK S.A. secures neighbouring mines and some of them do not which results from the target mine model. Additionally, if there are already activities in this process, they are usually carried out in the last years of the branch existence. The average value of 0,2% is calculated only for the branches that incur costs in this case.

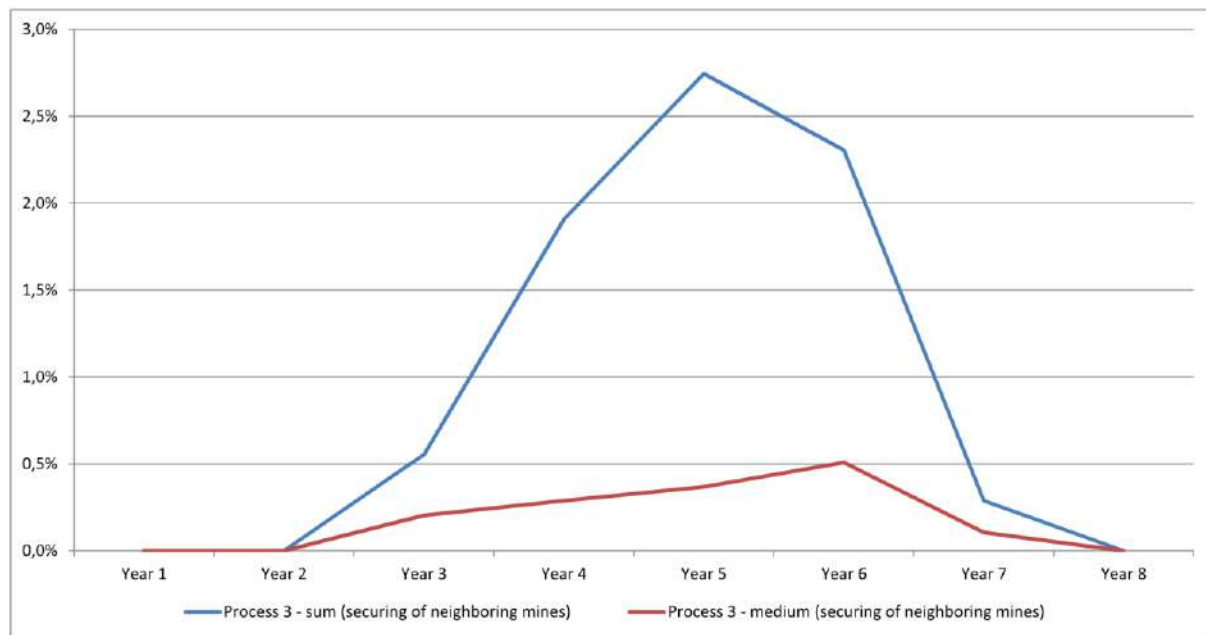


Figure 5. Process 3 – Protection of neighbouring mines against water, gas and fire hazards. Source: An own study.

Process 4 – Liquidation of the mine's infrastructure reaches its maximum values in the fourth or fifth year of the branch liquidation (Figure 6). As in the previous processes, it is related to the statistical size of the mining plant. 5,16% of the total budget subsidy is allocated to this process. The average value fluctuates around 0,06%. In the years from 1 to 3, lower values result from the size of liquidated branches. During this period, the population of small branches with low liquidation costs is included in the average value. Experts' opinions indicate that the cost of this process results from the amount of objects, their structure and cubature. Small branches liquidate similar objects as large ones, however they are smaller objects with a lower liquidation cost.

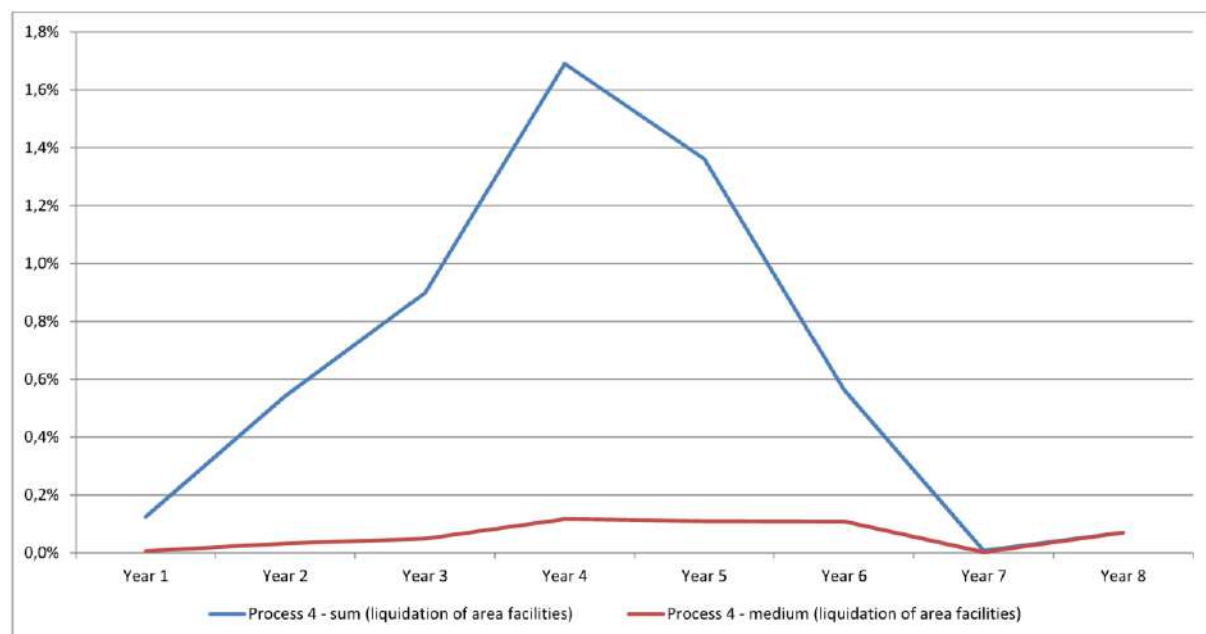


Figure 6. Process 4 – Liquidation of the mine's infrastructure. Source: An own study.

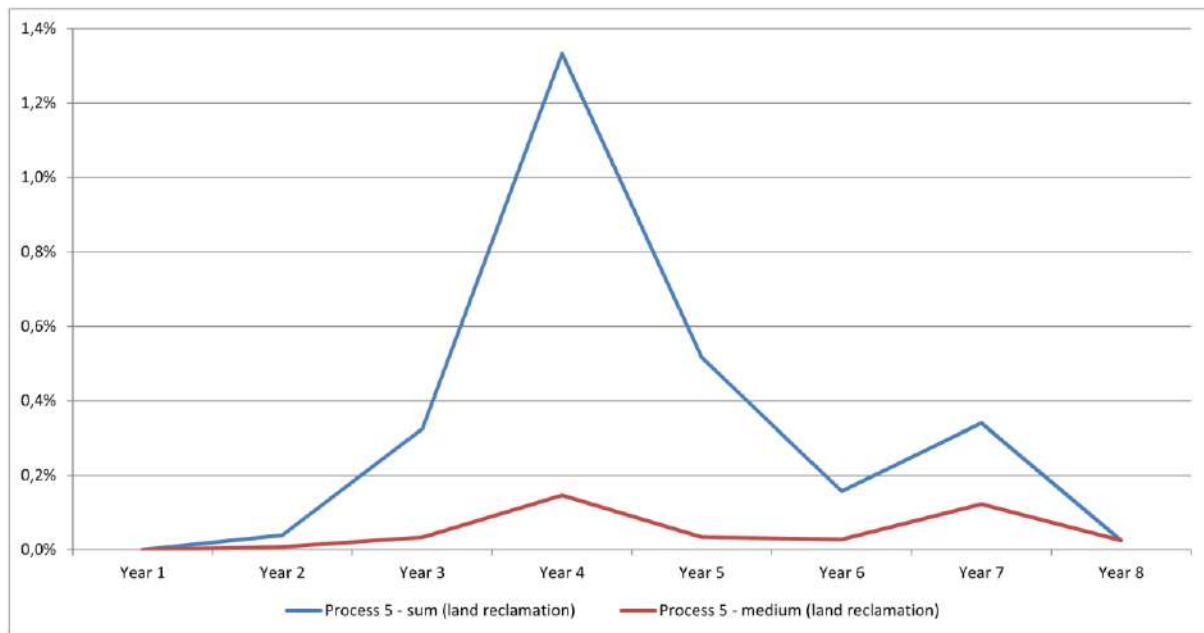


Figure 7. Process 5 – Land reclamation. Source: An own study.

The decisive factor influencing the amount of expenditures on the Process 5 (land reclamation) is the area requiring clearance and reclamation. SRK S.A. spends 2,75% of costs on this process and similarly to the previous cases, the highest values occur in the fourth and fifth year of its processes (Figure 7). Usually, the reclamation process begins in the last years of liquidation, after the completion of Processes 4 and 6. As in the case of Process 3, the mean value is difficult to estimate. For branches carrying out reclamation it is 0,05%. For branches liquidating a part of a mining plant located in the main area of another active mine, reclamation is usually not carried out and no costs are incurred in this regard.

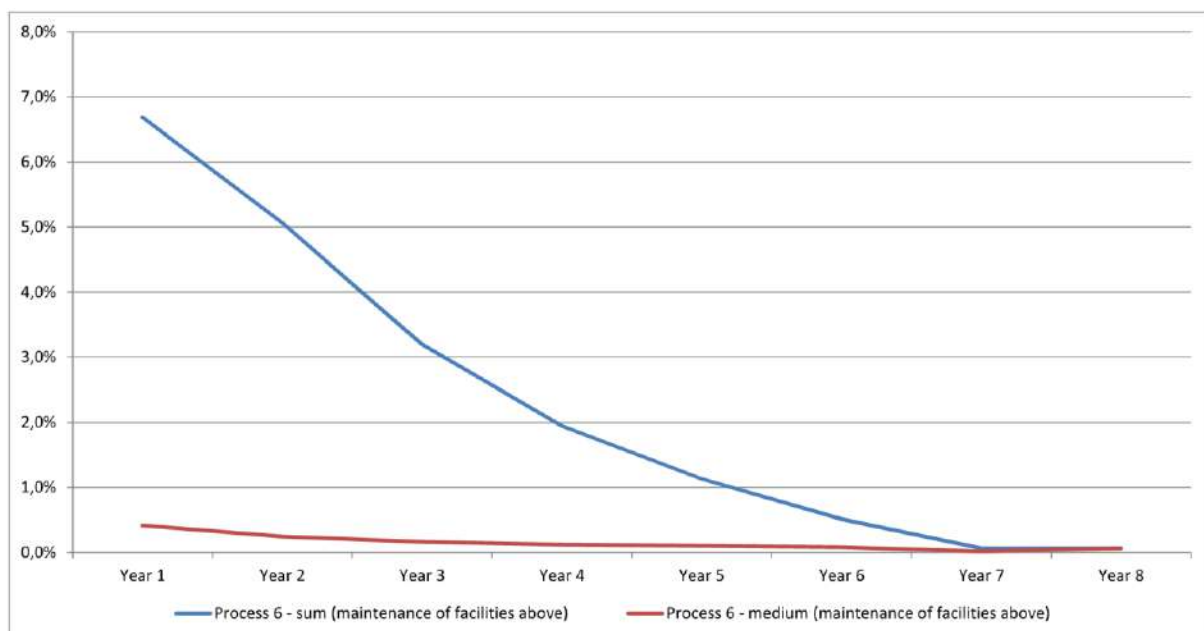


Figure 8. Process 6 – Maintaining the facilities for liquidation in sequence ensuring safe liquidation of the mining plant. Source: An own study.

Process 6 – maintaining the facilities for liquidation in sequence ensuring safe liquidation of the mining plant (Figure 8) is the second largest of the amount of financial outlays for implementation. Similarly to Process 4, it grows proportionally to the size of the liquidated branch and decreases on an annual basis with the decreasing number of maintained facilities. This task ends before the beginning of the reclamation process and consumes 18,65% of the total liquidation cost (1,1% on average per a branch). The duration of the maintenance of facilities, their amount, structure and cubature have an influence on outlays. The largest components are expenditures on the maintenance of the tops of liquidated shafts – about 40% of this process, the maintenance of surface facilities – about 27% of this process and the maintenance of power networks – about 14% of this process. SRK S.A. has a potential impact only on the possibility of intensifying the liquidation processes and optimization can be carried out in this case. However, the length of technological processes and the associated minimum liquidation time may prevent such activities.

Process 7 – carrying out security works and measures to prevent hazards in connection with the liquidated mining plant (Figure 9) is the most capital – intensive process. SRK S.A. allocates about 35,49% of the total costs to this process (0,61% on average per a branch). Experts pointed out that the largest impact on this costs is the broadly understood size of the mining plant, that is the amount and area of facilities that require protection and supervision. The intensification of liquidation would limit the expenditures on this process. The largest components of this process are the costs of the maintenance of shafts and excavation gates – about 40% of costs and the supervision of the works performed – about 20% of costs. On an annual basis, the cost is gradually decreasing according to the decrease in the number of objects. On the other hand, in the case of the mean value it increases with the passage of time. According to the calculations about the time lapse of this value, it eliminates small branches and in the following years the average value is calculated from large branches with higher liquidation costs. The group of branches liquidated for 6, 7 and 8 years includes all large and very large branches.

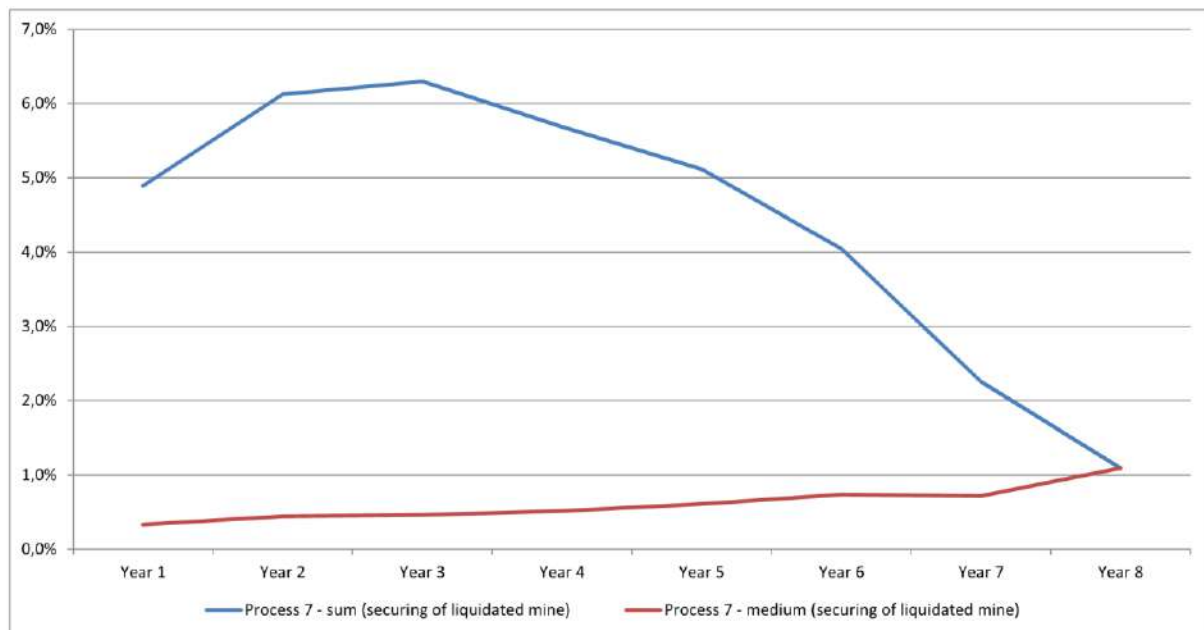


Figure 9. Process 7 – Carrying out security works and measures to prevent hazards in connection with the liquidated mining plant. Source: An own study.

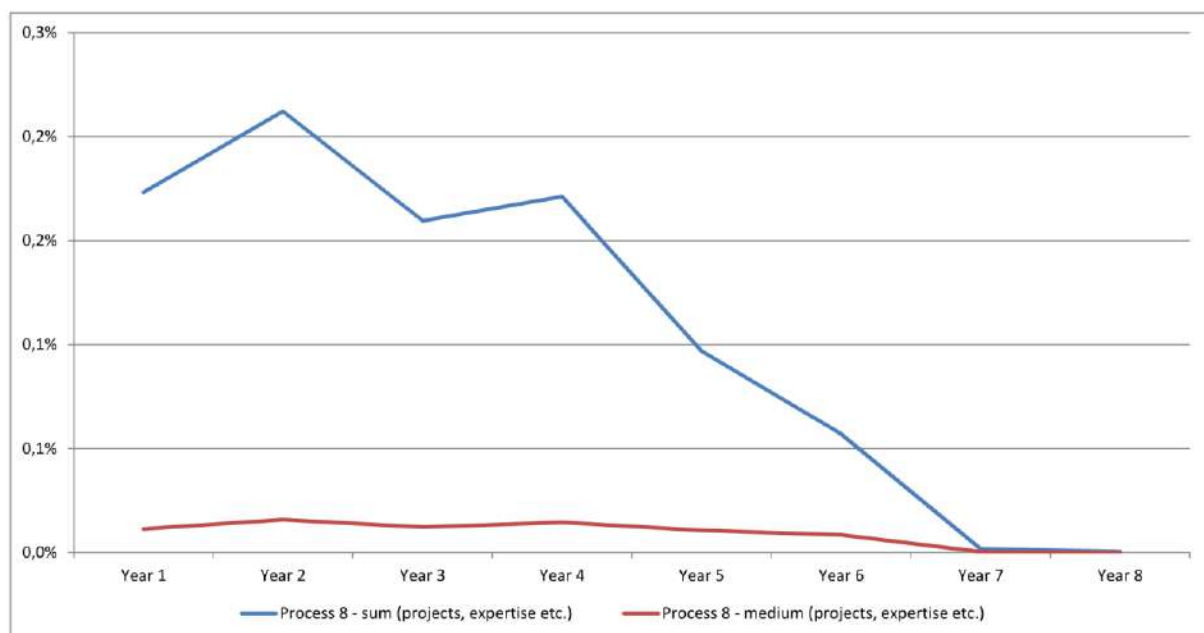


Figure 10. Process 8 – Development of the required projects, documentation, opinions, expertise and analyses related to the closure of the mine. Source: An own study.

0,86% of the total costs are spent on Process 8 and it is 0,01% on average per a branch (Figure 10). External entities are commissioned to carry out projects, expert opinions or analysis required by the regulations, which is the part of this task. Due to the thematic diversity of executive orders, it is not possible to identify the most important cost component. The statistical analysis shows that the costs increase with the size of the branch. The sum value and the average value tend to decrease with the matter of time. The number of commissioned experts opinions results from separate regulations, so the rationalization and optimization of costs may only rely on the price negotiations of individual orders.

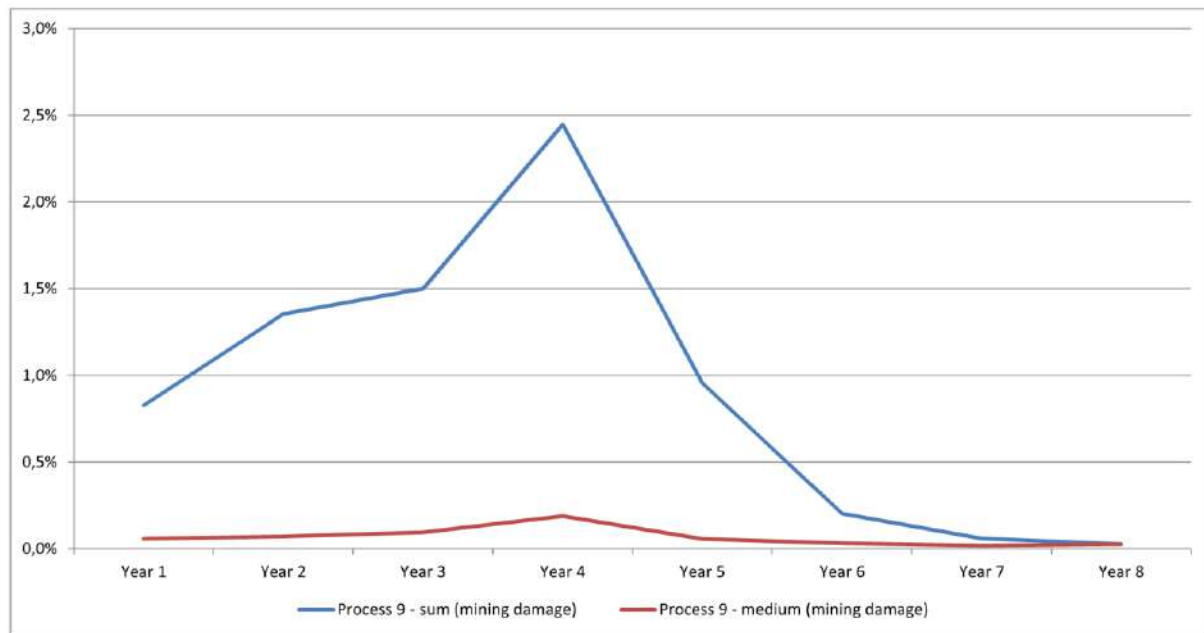


Figure 11. Process 9 – Repair of damage caused by mining plant operations. Source: An own study.

Due to the legal consequences of previous mining activities, the Management Board has no major influence on the costs incurred in Process 9 – repair of damage caused by mining plant operations. Pro – effective activities can only rely on rational and timely payment of compensation. According to the experts' opinions, the amount of the cost is related to the projected area of influence on exploitation conducted in the period of 5 years preceding the end of production (Figure 11). 7,66% of the total expenditures are allocated to the payment of mining damages and it is 0,07% on average per a branch. The average value is also calculated only for the branches that incur costs in this matter. Some branches do not bear any costs because when liquidating a part of mining plant it is usually taken over without the deposit and SRK S.A. is not a legal successor to the previous mining operations. When analysing the annual system, the increase in the total costs in the fourth year can be noticed. The increase in costs results from the simultaneous acquisition of several mines with mining areas and a temporary increase in the number of claims for damages. When analysing the individual branches, the cost of this process is more or less constant over the entire period of the branch existence.

After Process 7 and 6, Process 10 – general management of the tasks performed during the mine closure is the next most capital intensive process. 15,91% of the total expenditures are allocated to this process and it is 0,19% on average per a branch. The cost of this process increases with the size of the branch. The largest components of this process are salaries – about 38%, employee claims – about 27% and taxes and fees – about 19%. On an annual basis, the amount of the total and average cost decreases over time, while the analysis of branches shows that the cost is virtually unchanged throughout the existence of the branch. A potential place for savings could be outsourcing more operations while reducing employment.

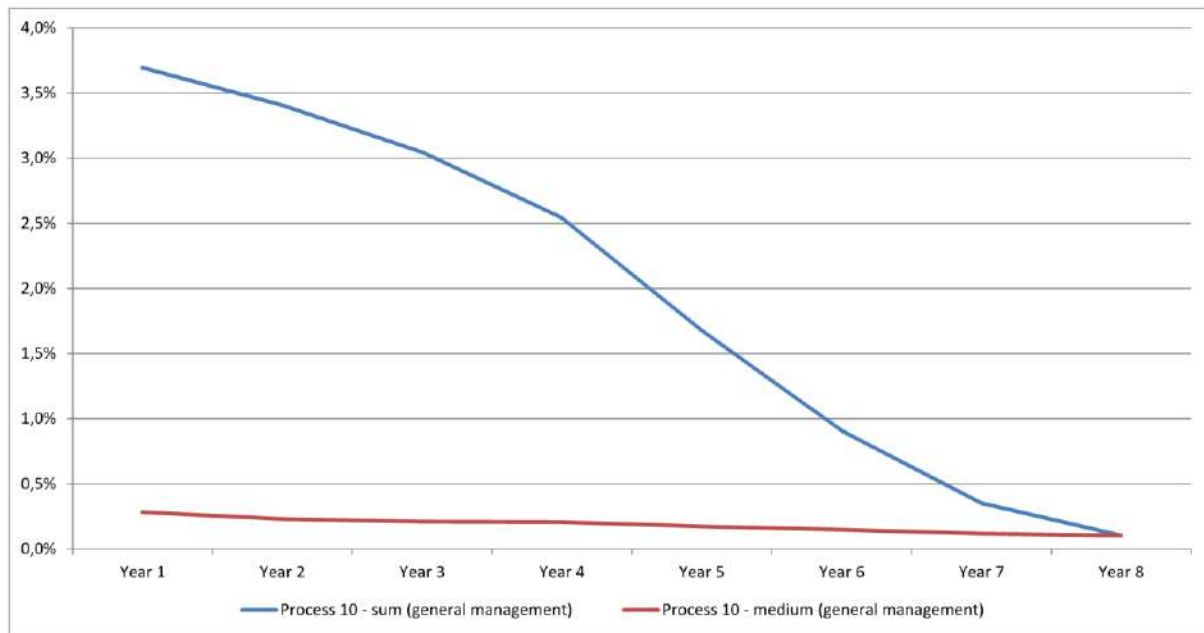


Figure 12. Process 10 – General management of the tasks performed during the mine closure. Source: An own study.

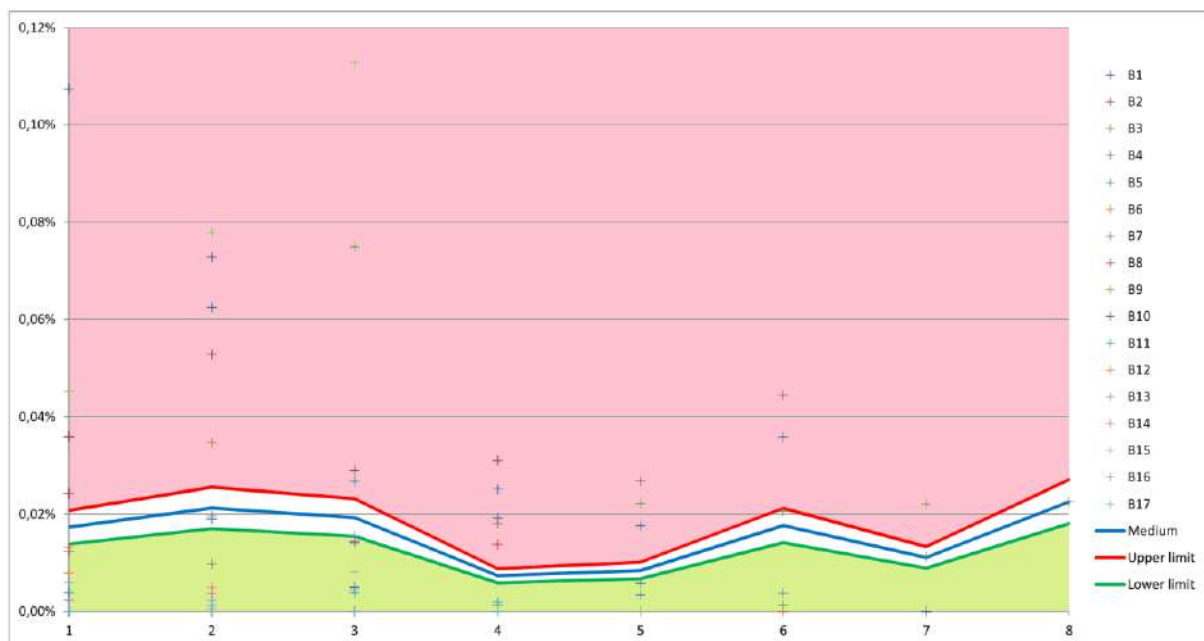


Figure 13. The idea of assessment method of cost structure on an annual basis on the example of Process 1. Source: An own study.

Tools that assess the amount and structure of capital expenditures for individual tasks are useful for proper supervision of the cost of restructured mines. The interviews with the Management Board and Directors of Branches carried out during the research explained most of the technical doubts and performed liquidation processes that can be considered as properly carried out and treated as comparative example for the development of a method for assessing the cost of mining plants liquidation. Figure 13 presents the idea of assessment method of cost structure on an annual basis on the example of Process 1 in all analysed liquidation examples. The proposed method signals that the analysed value of the mine liquidation cost is leaving the

zone of acceptable values. Most of the costs differ from the average value, therefore the zone of acceptable values has been determined (Figure 13 – the field between the green and red lines). The zone of acceptable values is the average value of the processes that have been carried out so far, in division into individual processes and subsequent years of the procedure. The zone is defined by the user who determines the size of the coefficient of variation for each of the component processes and for the total cost. The mean value reduced and increased by the standard deviation calculated for this value of the coefficient of variation determines the lower and upper limits of the acceptable zone (Figure 13). The publication assumes that the acceptable deviation will be at the level of 15%, which corresponds to a high compliance population. When the entered costs exceed the upper limit of the acceptable value, the field turns into red and the digits turn into brown. When the costs is below the lower limit of the acceptable zone, the field and the digits turn into green. Additionally, the yellow colour indicates that no costs are incurred in a given process. Signalling of leaving the acceptable zone is only information for the designer as it may result from the specific nature of liquidated branch. In order to find the values the most distant from the optimal value (the average resulting from the experience of SRK S.A.), the user may increase the value of the coefficient of variation and the software will immediately eliminate the signalling of deviations that are less different from the average value. The analysis of branches is carried out in groups corresponding to the period of their existence so as to increase the compliance of the calculations with reality.

The method was verified in two stages. In the first stage, the correctness of the method was tested, on the basis of four hypothetical branches called B18, B19, B20 and B21. Branch B18 is a branch with estimated liquidation costs equal to the average value. Branch B19 is a branch with the highset component costs for all analysed 17 mining plants that have been liquidated since 2015, without any division into reference groups. Branch B20 is a branch with costs equal to the average costs for the group of branches liquidated for 4 years (this is the largest group of six examples). The last of the hypothetical branches is Branch 21 and its liquidation costs were assumed as random values. In practice, the costs of liquidated branch for 2 years were entered three times in the data table, resulting the branch liquidated for 6 years. The cost structure of this branch is very unusual.

Table 5.

An analysis of liquidation costs of Branch B18

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	SUM
Process 1	0,02%	0,02%	0,02%	0,01%	0,01%	0,03%	0,02%	0,02%	0,15%
Process 2	0,00%	0,06%	0,04%	0,20%	0,06%	0,08%	0,00%	0,06%	0,52%
Process 3	0,00%	0,00%	0,03%	0,17%	0,39%	0,58%	0,14%	0,00%	1,32%
Process 4	0,01%	0,03%	0,05%	0,17%	0,18%	0,14%	0,00%	0,07%	0,66%
Process 5	0,00%	0,00%	0,02%	0,13%	0,07%	0,04%	0,17%	0,03%	0,47%
Process 6	0,40%	0,30%	0,20%	0,18%	0,16%	0,13%	0,03%	0,07%	1,47%
Process 7	0,29%	0,37%	0,40%	0,57%	0,67%	1,02%	1,13%	1,10%	5,56%
Process 8	0,01%	0,01%	0,01%	0,02%	0,01%	0,01%	0,00%	0,00%	0,08%
Process 9	0,05%	0,09%	0,10%	0,28%	0,09%	0,05%	0,03%	0,03%	0,71%
Process 10	0,22%	0,20%	0,19%	0,26%	0,23%	0,23%	0,18%	0,11%	1,62%
SUM	1,00%	1,10%	1,07%	2,00%	1,87%	2,31%	1,71%	1,48%	12,54%

Source: An own study.

According to expectations, in the case of Branch B18 the method showed that both the lower and upper limits of the acceptable zone were exceeded (Table 5). Due to the total liquidation cost which is 12,54%, this branch should be classified as a large branch. The amount of the total costs was influenced by the long duration of the process and the method of calculating the average. The average was calculated only for the branches incurring costs in each of the component processes (the average without zero). For this reason, most exceeded the upper limit. The lack of exceedances in the eighth year of liquidation results from the method of estimating the average value, which is the weighted average of one liquidation example over 8 years and the average for the group liquidated over 7 years. The calculated average value is a model for calculations which cannot signal any deviations.

The case of Branch B19 with the highest costs incurred by SRK S.A. so far caused the signalling that the upper limit of acceptable values was exceeded in almost all processes and years, except from the eighth year of liquidation (Table 6). It results from the similar factors as in the case of Branch B18 (long liquidation time and the method of calculating the average). Such a reaction was expected, as the cost of liquidating such a branch equal to 28,23% is approaching to the amount of approximately 2 billion PLN.

Table 6.

An analysis of liquidation costs of Branch B19

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	SUM
Process 1	0,11%	0,08%	0,11%	0,03%	0,03%	0,04%	0,02%	0,02%	0,45%
Process 2	0,02%	0,34%	0,13%	0,95%	0,44%	0,16%	0,00%	0,06%	2,11%
Process 3	0,00%	0,00%	0,48%	0,88%	1,37%	1,85%	0,20%	0,00%	4,78%
Process 4	0,05%	0,20%	0,24%	0,58%	0,43%	0,18%	0,01%	0,07%	1,75%
Process 5	0,00%	0,04%	0,30%	0,52%	0,49%	0,08%	0,32%	0,03%	1,77%
Process 6	0,97%	0,72%	0,60%	0,45%	0,22%	0,15%	0,06%	0,07%	3,24%
Process 7	0,90%	1,33%	1,25%	1,06%	1,13%	1,04%	1,10%	1,10%	8,91%
Process 8	0,03%	0,04%	0,03%	0,06%	0,04%	0,03%	0,00%	0,00%	0,22%
Process 9	0,20%	0,42%	0,44%	1,04%	0,19%	0,10%	0,03%	0,03%	2,46%
Process 10	0,68%	0,36%	0,39%	0,35%	0,27%	0,25%	0,15%	0,11%	2,55%
SUM	2,95%	3,52%	3,98%	5,93%	4,60%	3,88%	1,90%	1,48%	28,23%

Source: An own study.

The cost analysis of Branch B20 also resulted in the expected reaction of the method to the case of the reference object. The software only coloured yellow fields with zero values, signalling no costs in Processes 3 and 5 and remaining fields were without the method's response (Table 7). Due to the amount of the liquidation cost (3,25%), this branch can be classified as small branches.

Table 7.*An analysis of liquidation costs of Branch B20*

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	SUM
Process 1	0,01%	0,02%	0,02%	0,00%	0,00%	0,00%	0,00%	0,00%	0,06%
Process 2	0,00%	0,09%	0,04%	0,24%	0,00%	0,00%	0,00%	0,00%	0,37%
Process 3	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Process 4	0,01%	0,02%	0,03%	0,07%	0,00%	0,00%	0,00%	0,00%	0,13%
Process 5	0,00%	0,01%	0,05%	0,14%	0,00%	0,00%	0,00%	0,00%	0,19%
Process 6	0,27%	0,36%	0,18%	0,05%	0,00%	0,00%	0,00%	0,00%	0,85%
Process 7	0,15%	0,21%	0,19%	0,14%	0,00%	0,00%	0,00%	0,00%	0,70%
Process 8	0,01%	0,01%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,02%
Process 9	0,05%	0,15%	0,10%	0,21%	0,00%	0,00%	0,00%	0,00%	0,51%
Process 10	0,11%	0,11%	0,09%	0,08%	0,00%	0,00%	0,00%	0,00%	0,40%
SUM	0,62%	0,98%	0,70%	0,94%	0,00%	0,00%	0,00%	0,00%	3,25%

Source: An own study.

Last but not the least analysed hypothetical Branch B21 was the most difficult case for the cost assessment method (Table 8). Due to the liquidation costs (5,63%) this branch is classified to a medium- sized branches and is characterised by an unstable and chaotic cost structure. In this case, the method also worked properly and signalling the deviations from the average value is consistent with the opinion of experts.

Table 8.*An analysis of liquidation costs of Branch B21*

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	SUM
Process 1	0,01%	0,00%	0,01%	0,00%	0,01%	0,00%	0,00%	0,00%	0,05%
Process 2	0,00%	0,10%	0,00%	0,10%	0,00%	0,10%	0,00%	0,00%	0,30%
Process 3	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Process 4	0,00%	0,03%	0,00%	0,03%	0,00%	0,03%	0,00%	0,00%	0,10%
Process 5	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Process 6	0,33%	0,09%	0,33%	0,09%	0,33%	0,09%	0,00%	0,00%	1,25%
Process 7	0,19%	0,20%	0,19%	0,20%	0,19%	0,20%	0,00%	0,00%	1,14%
Process 8	0,02%	0,00%	0,02%	0,00%	0,02%	0,00%	0,00%	0,00%	0,06%
Process 9	0,13%	0,11%	0,13%	0,11%	0,13%	0,11%	0,00%	0,00%	0,70%
Process 10	0,40%	0,27%	0,40%	0,27%	0,40%	0,27%	0,00%	0,00%	2,03%
SUM	1,07%	0,80%	1,07%	0,80%	1,07%	0,80%	0,00%	0,00%	5,63%

Source: An own study.

In the second stage of the verification, that hypothetical examples were presented to the Directors of the Branches of SRK S.A. so as to evaluate. The experts agreed with the conclusions of the method and approved the correctness of its operation. At this stage, suggestions for further research in this area appeared and indicated areas and research problems the need to be solved were pointed out.

5. Conclusions

The proposed method of assessing the estimated costs of liquidated mining plants on an annual basis can be used as a reference point for cost estimation with the possible takeover of further branches. After some modifications of the structure of component processes (developed by Spółka Restrukturyzacji Kopalń S.A.) the proposed method may be applied by another mine enterprise.

The presented tool may be one of the components of increasing the effectiveness of mining plants liquidation. The procedure may help the Management Board to rationalize and minimize the costs incurred.

The described methodology is based on a statistical analysis of the cost of liquidation process divided into subsequent years of liquidation processes. Further research will require the connection between the structure of incurred costs with the size of the branch in a matter of time. In the group of liquidated branches for 4 years there are small, medium and very small branches which may lead to incorrect results. The total cost of the branch with the highest liquidation cost is 18 times higher than the total cost of the branch with the lowest liquidation cost.

The unresolved scientific problem is the interaction between the main processes and the structure of the amount of costs of liquidation processes. We have only the unsystematic knowledge of practitioners.

In the case of liquidation for 2, 3 and 8 years, there is only one case of the branch and becomes the benchmark. When analysing above cases, the calculation of the weighted average value gave good results for 2 and 3 years of liquidation. The period of 8 years gave slightly worse but satisfactory results. The proposed method requires further research. Nevertheless, can be a very useful auxiliary tool in initial design works and ongoing engineering works.

References

1. Bijańska, J., Wodarski, K. (2020). Model of process management system in enterprises of the hard coal mining industry. *Management Systems in Production Engineering, Vol. 28, Iss. 2*, pp. 112-120.
2. Bijańska, J., Wodarski, K. (2018). Process management in a mining enterprise – basic areas and research problems. *Scientific Papers of Silesian University of Technology, series: Organization and Management, vol. 120*, pp. 35-50.
3. Brzychczy, E., Napieraj, A., Sukiennik, M. (2018). Modelling of processes with use of process mining techniques. *Scientific Papers of Silesian University of Technology, series: Organization and Management, vol. 116*, pp. 23-36.

4. Duda, A. (2018). Identification of environmental events associated with mine closures in selected countries of the European Union. *Przegląd Górniczy*, nr 3, pp. 7-15.
5. Dźwigoł, H. (2007). *Model restrukturyzacji organizacyjnej przedsiębiorstwa górnictwa węgla kamiennego*. Warszawa: Difin.
6. Fernandez de la Buelga, L., Chmiela, A. (1995). The Spanish Energy Sector: Regulatory Changes and Prospects. *Scientific Papers of Silesian University of Technology*, 1307, series: Mining, vol. 225. Gliwice, pp. 59-72.
7. Grmela, A., Harat, A., Adamczyk, Z. (2017). Proces likwidacji kopalń jako problem środowiskowy, ekonomiczny i prawny. *Ecological Engineering*, vol. 18, 4, pp. 39-45.
8. Harat, A., Grzesik, B., Adamczyk, Z. (2017). Ocena oddziaływania na środowisko i jej zastosowanie w procesie inwestycyjnym likwidacji kopalni. *Budownictwo*, nr 23, pp. 110-115.
9. Jonek-Kowalska, I. (2013). Analiza i ocena kosztów w cyklu istnienia wyrobiska wybierkowego – wnioski dla rachunkowości zarządczej. *Scientific Papers of Silesian University of Technology*, series: Organization and Management, vol. 66, pp. 195-206.
10. Korski, J., Korski, W. (2015). Underground mine as a system of processes. *Mining – Informatics, Automation and Electrical Engineering*, 2(522), pp. 19-27.
11. Marek, J. (2006). Conditions and course of the liquidation process of hard coal mines. *Studia Ekonomiczne, Akademia Ekonomiczna w Katowicach* 37/2006, Zarządzanie strategiczne w przedsiębiorstwie, pp. 269-283, (2006).
12. Paszcza, H. (2010). Restructuring processes in the Polish hard coal mining industry in terms of the implemented changes and changes in the resource base. *Górnictwo i Inżynieria*, nr 3, pp. 62-82.
13. Przybyła, H., Chmiela, A. (2007). *Organizacja i ekonomika w projektowaniu wybierania węgla*. Gliwice: Wydawnictwo Politechniki Śląskiej.
14. Przybyła, H., Chmiela, A. (2002). *Technika i organizacja w robotach przygotowawczych*. Gliwice: Wydawnictwo Politechniki Śląskiej.
15. Riesgo Fernandez, P., Chmiela, A., Stanienda, K. (2003). The situation of coal mining in Spain after joining the European Union. *Scientific Papers of Silesian University of Technology* 1600, series: Mining, vol. 258. Gliwice, pp. 291-301.
16. Riesgo Fernandez, P., Przybyła, H., Chmiela, A., Kołodziejczyk, P., Wesółowski, M. (2001a). Economic policy towards coal mining in Spain. Cz. 1. *Wiadomości Górnicze*, nr 3, pp. 118-123.
17. Riesgo Fernandez, P., Przybyła, H., Chmiela, A., Kołodziejczyk, P., Wesółowski, M. (2001b). Economic policy towards coal mining in Spain. Cz. 2. *Wiadomości Górnicze*, nr 4, pp. 136-143.
18. Riesgo Fernandez, P., Przybyła, H., Chmiela, A., Kołodziejczyk, P., Wesółowski, M. (2000). Coal restructuring program in Spain. *Scientific Papers of Silesian University of Technology* 1480, series: Mining, vol. 246. Gliwice, pp. 453-465.

19. Riesgo Fernandez, P., Wesołowski, M., Chmiela, A. (1997). Financing of mining investment projects in Spain with intensive capital expenditure. *Scientific Papers of Silesian University of Technology 1378, series: Mining, vol. 236*. Gliwice, pp. 249-258.
20. Rother, M., Shook, J. (2009). *Naucz się widzieć, eliminacja marnotrawstwa poprzez mapowanie strumienia wartości*. Lean Enterprise Institute.
21. Smoliło, J., Chmiela, A. (2021). A liquidation of the mine in SRK S.A. in a processive approach. *Scientific Papers of Silesian University of Technology, series: Organization and Management*.
22. Smoliło, J., Chmiela, A. (2021). The mine liquidation processes in SRK S.A. in a cost approach. *Scientific Papers of Silesian University of Technology, series: Organization and Management*.
23. Turek, M. (2013). *Analiza i ocena kosztów w górnictwie węgla kamiennego w Polsce*. Warszawa: Difin.
24. Turek, M. (2013). *System zarządzania kosztami w kopalni węgla kamiennego w cyklu istnienia wyrobiska wybierkowego*. Warszawa: Difin.
25. Turek, M., Jonek-Kowalska, I. (2013). Contemporary cost accounting as an inspiration for the cost accounting in the life cycle of a mining excavation. *Scientific Papers of Silesian University of Technology, series: Organization and Management, vol. 66*, pp. 113-184.
26. Wójcik, J. (2018). Former mining areas of Wałbrzych Basin 20 years after mine closures. *Przegląd Geograficzny, nr 2*, pp. 267-290.

THE MINE LIQUIDATION PROCESSES IN SRK S.A. IN A COST APPROACH

Janusz SMOLIŁO¹, Andrzej CHMIELA^{2*}

¹ Spółka Restrukturyzacji Kopalń S.A., Bytom; jsmolilo@srk.com.pl, ORCID: 0000-0003-4987-2881

² Spółka Restrukturyzacji Kopalń S.A., Bytom; achmiela@srk.com.pl, ORCID: 0000-0002-0833-0923

* Correspondence author

Purpose: The cost of the subsidy of liquidated mine is about 250 million PLN. Because of such financial outlays it is relevant to lead the processes of rationalization and minimization of the costs incurred what requires a complex scientific approach.

Design/methodology/approach: A statistical analysis of the course of the mine liquidation process in SRK S.A. was conducted. During the research panel survey and direct interviews were conducted with the Management Board of SRK S.A. and Directors of Branches.

Findings: The presented method of signaling deviations of mining plant liquidation costs from the mean value is a useful tool while implementing a process approach in the issue of the liquidation of the mine.

Research limitations/implications: The assessment method of the proposed mine liquidation process described in the publication is based on the analysis of total costs of liquidation. Further research will require the analysis of costs incurred in subsequent years of the liquidation processes.

Practical implications: The method can be used during the initial estimation of the costs of mining plant liquidation as a benchmark for detailed cost estimation of liquidated mines.

Social implications: The assessment method of the cost estimation of mining plant liquidation can be used as a reference point for detailed analysis and multi-criteria costs estimation of following liquidated mining plants. The cost accounting system is typical for SRK S.A. but thanks to some modifications the methodology can also be applied by another entity conducting the liquidation of mines.

Originality/value: The presented cost assessment procedure may help The Management Board of SRK S.A. to monitor incurred costs (rationalization and minimization of the costs). The tool can be useful in effective liquidation of mining plants which is especially important in a situation where the scientific literature in this area is extremely scarce.

Keywords: process management, restructuring of mining enterprises, liquidation of a hard coal mine.

Category of the paper: Research paper.

1. Introduction

After 1989 changes of political system affected the Polish economy. The economy had to be changed very quickly from centrally controlled to free market. In the hard coal mining industry those changes have a big influence on their processes. During the political system transformation the hard coal mining was completely unadjusted to the rules of the market competition with the huge overproduction, the excess of employment and the huge amount of non-productive assets.

Since the beginning of the 1990s the Polish hard coal mining industry has been implementing restructuring activities aimed at adapting the industry to the needs and conditions of the market economy. The most rational way of reducing costs in this industry is to liquidate non-profit mines which have not got coal resources any more or which give unprofitable exploitation in particularly unfavorable mining and geological conditions.

The mine liquidation process started in 1994 and is still carrying out by Spółka Restrukturyzacji Kopalń S.A. established in 2000. The liquidation and securing of mining excavation sites or the liquidation of buildings from mining plants are carried out by 8 Branches of SRK S.A. (www.srk.com.pl). The Property Management Department deals with the management of industrial property after liquidated mines and The Housing Resource Administration is responsible for the management of non-industrial assets (apartments, garages, commercial premises, etc.) As a part of the securing of neighboring mines against flooding, the Company is also responsible for pumping water from sites of previously closed mines.

Until the end of 2023 on the basis of European Union approval, the Polish government obtained permission to finance the liquidation from the state budget. The value of the subsidy will amount to approximately 5 billion PLN. Because of such financial outlays it is relevant to lead the processes of rationalization and minimization of the costs incurred what requires a complex scientific approach. Such research has not been conducted so far.

2. Research problem

The existence of the mine is not only the period of extraction but also the period of its liquidation. Reducing the capital intensity of liquidated hard coal mines is a problem that affects both Mining Communities and the state budget. A lack of instruments and tools which support the cost management is one of the reason limiting the improvement of liquidation efficiency. In the hard coal mining industry, no comprehensive solutions tailored to the specifics of the industry have been developed so far. Solutions which have been developed concern mainly on

selected issues related to the efficiency of mining process or preparatory works. (Jonek-Kowalska, 2013; Przybyła, Chmiela, 2002, 2007; Turek, 2013; Turek, Jonek-Kowalska, 2013).

The total cost of liquidation of 17 mines in SRK S.A. since 2015 has amounted to approximately 5 billion PLN at the end of 2020. The average cost of liquidated branch is around 250 to 300 million PLN. In the case of liquidation of mines, no scientific research has been conducted so far to improve efficiency and effectiveness of its processes. The available literature concerns only on general issues related to that problem (Grajewski, 2012; Riesgo et al., 1997, 2000, 2001, 2003).

The process management in SRK S.A. requires further research in this area. The presented publication tries to propose a cost management support tool and identify research areas and problems that require further analysis. The method and conclusions presented will be the basis for further research aiming at improving the effectiveness and efficiency of the processes which are carrying out in the company dealing with liquidation of mines (Dźwigoł, 2007; Grajewski, 2012; Skrzypek, Hofman, 2010).

3. Research methods

An introduction of the process management system in SRK S.A. requires having knowledge about the current state of liquidation processes and ability to propose a tool for assessing the course of these processes. An additional aim of this research was to identify further areas and research problems that need to be solved. The aim was achieved in three stages (Table 1). The research plan was carried out on the basis of actual data collected which were concerned on existing processes of mines liquidation. The processes of mines liquidation and the liquidation plan for 17 mines or their parts were analyzed in a period from 2015 to 2023. In the group which was researched there were 6 liquidated mines or their parts and 11 mines or their parts which are currently liquidated in 8 Branches of SRK S.A. (www.srk.com.pl).

Table 1.
Methods and results of their use in individual research stages

Research stage	Research Methods	Results of the use of research methods
I	- Study of literature - Analysis - Synthesis - Direct interview	- An analysis of the current state of the process management in SRK S.A. - Development of the methodology of the assessment of the liquidation process
II	- Face-to-face interview - Panel studies - Analysis - Synthesis	- A statistical analysis of the researched liquidation process - Proposition of a tool for assessing the course of liquidation process - Indication of research areas and problems
III	- Analysis - Synthesis	- Verification of the results - Indication of further areas and research problems

Source: An own study.

In the first stage, the available literature on the management processes was analyzed and compared with personal experience of the mine liquidation. The possibility of adapting the process management concept to the specificity of SRK S.A. was analyzed. The results of the analysis made it possible to prepare data used in the second stage.

In the second stage, a statistical analysis of the researched liquidation process in SRK S.A. was carried out. During the research a face-to-face interview with The Management Board and Directors of Branches was conducted so as to explain deviations of actual values from their mean values. During this stage questions about the character of the process, technical problems while their implementation, the correctness of their course or suggestions for possible changes in a liquidation practice were asked. The process courses according to the Figure 1. Based on interviews with experts a methodology of general evaluation of the course of mines liquidation in SRK S.A. was prepared. This methodology is verified in the third stage of research. The research identify areas and problems that need to be solved.

In the third stage, the correctness of the proposed methodology of mines liquidation processes evaluation was checked. The correctness of the process assessment tool was carried out on the basis of hypothetical new Branches of SRK S.A. This stage also revealed further unresolved areas and research problems.

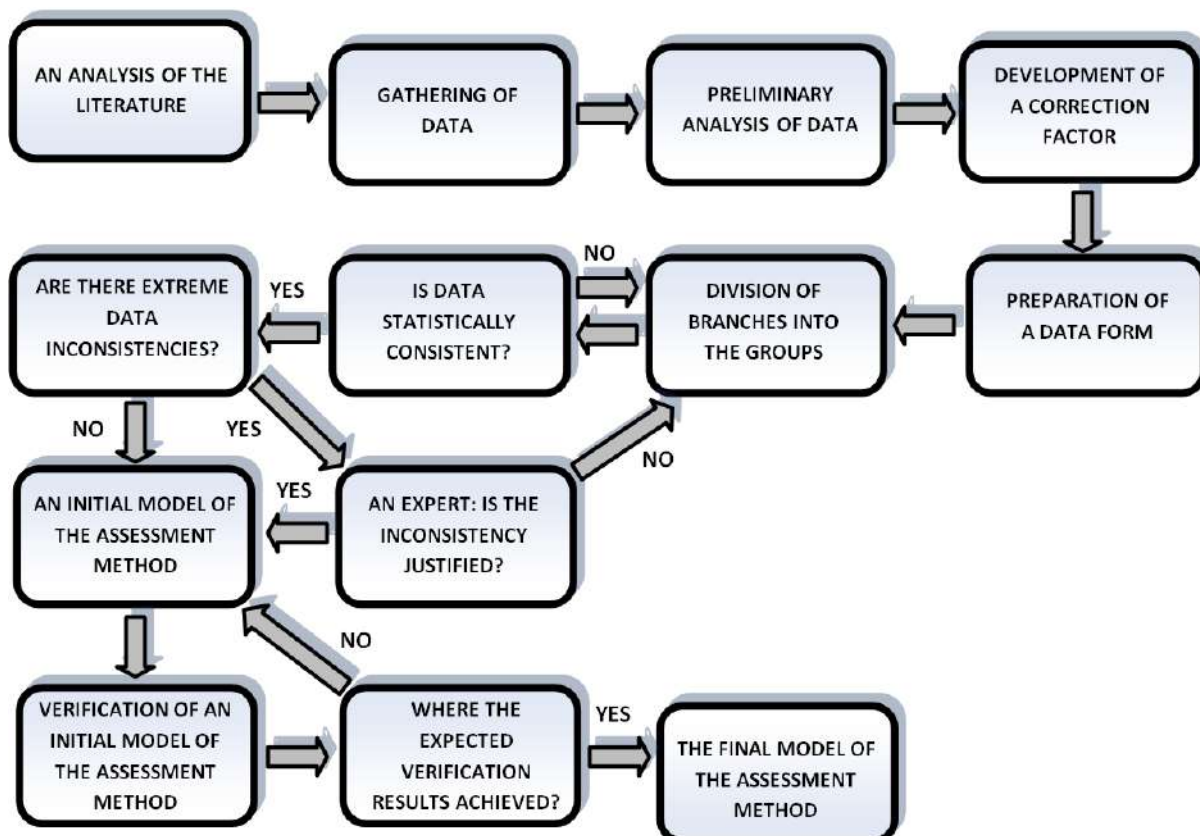


Figure 1. A map of the process of the research method. Source: An own study.

4. Findings

The authors use the term “liquidation process”. This concept is related to the phenomenon of the cyclicity. In the case of the mine liquidation we can distinguish some constantly occurring activities with a cycle length from 2 to 8 years therefore the mine liquidation operations can be treated as a long-term processes. In SRK S.A. the physical liquidation of mine is carried out with a division of 10 component processes. These processes are called “schedules”. However, due to the possibility of misinterpretation of this word, the authors will use the term “process” in this publication. The mine liquidation processes in SRK S.A. are presented in the Table 2. Moreover, a map of the mine liquidation processes in SRK S.A. in a cost approach is presented in Figure 2.

Table 2.

The mine liquidation processes in SRK S.A.

1.	Liquidation and securing of excavation gates
2.	Liquidation and securing of shafts and pits
3.	Protection of neighboring mines against water, gas and fire hazards
4.	Liquidation of the mine's infrastructure
5.	Land reclamation
6.	Maintaining the facilities for liquidation in sequence ensuring safe liquidation of the mining plant
7.	Carrying out security works and measures to prevent hazards in connection with the liquidated mining plant
8.	Development of the required projects, documentation, opinions, expertise and analyses related to the closure of the mine
9.	Repair of damage caused by mining plant operations
10.	General management of the tasks performed during the mine closure

Source: Data from SRK S.A.

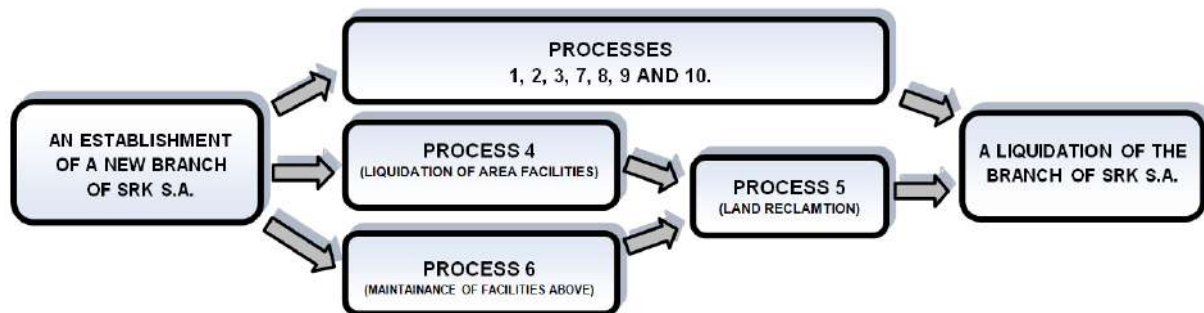


Figure 2. A map of the mine liquidation processes in SRK S.A. in a cost approach Source: Smoliło, Chmiela, 2021.

So as to create the process management system in SRK S.A. it is necessary to develop tools which support the management of process liquidation costs and identify in a qualitative and quantitative way additional areas and research problems that need to be solved. The aim was achieved in three stages (Table 1). The research plan was carried out on the basis of actual data concerning the existing mine liquidation processes. The research was conducted according to updated liquidation programs.

SRK S.A. has 8 Branches that deal with mine liquidation (www.srk.com.pl). For the research purposes the branches was divided into the storage mines. In this way a group of 11 branches was obtained. In order to increase the credibility of the research results, also 6 previously liquidated branches were analyzed. Summing up, 17 cases of mine plant liquidation were analyzed. In the research the authors ranked the liquidated branches in order of decreasing total cost. Due to the incomparability of costs in different years caused by inflation and changes in the cost of obtaining labor the coefficient of correction was used. The analysis took into account the liquidation cost estimated at the end of 2020. The branches were divided into their size resulting from the total cost of their liquidation. At this time, SRK S.A. carries out the liquidation according to the updated liquidation programs which should end before 2024. Nevertheless, it needs to be taken into account that because of COVID-19 the liquidation processes may be extended. Table 3 presents the division of liquidated Branches of SRK S.A. subjected to statistical analysis. In order not to reveal sensitive data the costs are calculated as a percentage value of total liquidation costs.

Table 3.

Liquidated Branches of SRK S.A. subjected to statistical analysis

Branch	B1	B2	B3	B4	B5	B6	B7	B8	B9
Liquidation cost	16,16%	12,75%	10,27%	9,98%	8,94%	6,93%	6,19%	5,88%	5,43%
Branch	B10	B11	B12	B13	B14	B15	B16	B17	
Liquidation cost	4,30%	3,00%	2,78%	2,24%	1,88%	1,62%	1,34%	0,32%	

Source: An own study.

In SRK S.A. a statistical mine is liquidated for less than 5 years, the average cost of liquidated branch is 5,88% of total cost of liquidation and each year of liquidation of the branch increases the total costs by 1,2% of this value. Every liquidated mine is different so there is no surprise that data is diverse. The average cost of liquidation of a small branch is 13,8% of the average cost of liquidation of a large branch. It is similar in the case of liquidation time where the minimum time of liquidation is 2 years and the maximum time is 8 years. The differentiation is even greater during the calculation of large, medium and small branches. In this case the cost of the largest branch liquidation is even 40 times bigger than the cost of the smallest branch liquidation.

During the statistical analysis of such diverse research group the problem of significant differentiation in the amount of cost incurred was encountered. It was analyzed by the coefficient of compliance according to the formula:

$$V = \frac{s}{\bar{x}} * 100\% \quad (1)$$

where:

V – compliance coefficient,

s – standard deviation,

\bar{x} – arithmetic average.

Taking into account all branches the coefficient of differentiation was so high that further statistical analysis of mining liquidation as whole had to be resigned. Not only the size of the average coefficient of variation of the cost of liquidation process was calculated but also the coefficient of variation of total liquidation costs. The results are presented in Table 4. It has been found that the average coefficient of variation of the cost of liquidation process is not indicative and will be provided only for comparative purposes. Its variability results from different models of liquidation and changeable costs incurred in a various component processes. As an example the increase in costs for the construction of the pumping station will be “compensated” by the reduction of costs of shafts and workings liquidation. To state whether the analyzed group is statistically uniform the coefficient of variation of total liquidation costs was compared. For all the liquidated branches this coefficient amounted to 75,92% which proves enormous variability of the results.

Table 4.

The size of the coefficient of variation in the grouping of liquidated branches

1.	An analysis of Branches of SRK S.A. as a one group			
Branches included in the group			All	
I	The average coefficient of variation of the cost of liquidation process		119,41	
II	The coefficient of variation of total liquidation costs		75,92	
2.	A division according to the size of the branch (three groups)			
	Large	Medium	Small	
Branches	1, 2, 3, 4, 5, 9	6, 7, 8, 10, 11, 14, 16	12, 13, 15, 17	
I	73,15%	114,22%	63,96%	
II	34,19%	52,36%	61,00%	
average			49,18%	
3.	A division according to the amount of the liquidation cost (four groups)			
	Large	Medium larger	Medium smaller	Small
Branches	1, 2, 3, 4	5, 6, 7	8, 9, 10, 11	12, 13, 14, 15, 16, 17
I	72,31%	61,18%	91,12%	59,9%
II	23,29%	19,4%	27,62%	49,66%
average				29,99%

Source: An own study.

Another attempt to improve costs compliance was to propose the division of the liquidated mines due to their physical size. The division into large, medium and small mines was made. In large and small groups we could find mines that are liquidated as a whole and in medium groups we could find mines that are partly liquidated. Much better cost compliance was achieved (49,18%) especially in the case of large branches (34,19%). However, worse results were achieved in the case of small branches (61%) and that determined the search for an alternative division into groups. Ultimately the division of branches was made according to the total cost of liquidated branch. Table 5 presents the principles of the proposed statistical division into groups that are analyzed.

Table 5.*A division of branches according to the amount of the liquidation cost*

Group	Group characteristic	Cost range	Amount of Branches	A share of the total cost
A	All	0 to 100%	17	100 %
L	Large	9% (inclusive) to 100%	4	49,2 %
ML	Medium larger	6% (inclusive) to 9%	3	22,1 %
MS	Medium smaller	3% (inclusive) to 6%	4	18,7 %
S	Small	0 do 3%	6	10,2 %

Source: An own study.

The results of the division into 4 groups were more satisfactory (29.99%) especially in the group of medium larger branches (19,4%). In that group the high cost compliance was achieved. Nevertheless taken into consideration must be the fact that lower cost compliance appears in the group of small branches. Table 6 presents the statistical data of liquidation of analyzed group.

Table 6.*Statistical characteristic of analyzed group*

Branches	A	L	ML	MS	S
Average time of liquidation - [years]	4,9	6,5	6,0	4,3	3,7
Minimum liquidation time - [years]	2	5	5	4	2
Maximum liquidation time - [years]	8	8	7	5	5
Average cost of liquidated branch	5,88%	12,29%	7,35%	4,65%	1,70%
Average annual cost of liquidation	1,2%	1,9%	1,2	1,1%	0,5%

Source: An own study.

In the entire process of mine liquidation only 11,1% of total cost is allocated to the physical liquidation of underground workings and surface facilities (the sum of processes 1, 2 and 4) which is the fourth largest cost of liquidation. As a result, almost 89% costs incurred are spent on activities related to handling of liquidation. The largest group of costs (35,5%) are costs incurred to secure the liquidated mine (Process 7). The second largest group of costs are costs while maintenance of facilities dedicated to liquidation (Process 6). That group consumes almost 19% of financial outlays. The third group are costs of general management (Process 10) which accounts for approximately 16% of total costs.

Table 7 presents the percentage share of the cost of liquidation process in the total cost with a division into groups. With around 5 billion PLN of subsidy even a small percentage correction of the cost of liquidation processes has a big influence on budget savings. In each of the presented component process of liquidation some savings can be found. Only the mining damage process (Process 9) is independent of the Management Board and in that case the cost rationalization can be only found in the correctness and timeliness of compensation payments.

Table 7.*Percentage share of the cost of liquidation process in the total cost*

The process of liquidation	A	L	ML	MS	S
Process 1 (liquidation of excavations)	1,32%	0,79%	0,13%	0,31%	0,08%
Process 2 (liquidation of shafts and pits)	4,61%	1,45%	0,31%	2,01%	0,84%
Process 3 (securing of neighboring mines)	7,59%	4,93%	2,64%	0,01%	0,00%
Process 4 (liquidation of area facilities)	5,16%	2,59%	1,20%	0,81%	0,57%
Process 5 (land reclamation)	2,75%	0,98%	0,38%	1,39%	0,00%
Process 6 (maintenance of facilities above)	18,65%	6,66%	4,03%	3,99%	3,97%
Process 7 (securing of liquidated mine)	35,49%	21,20%	8,56%	4,30%	1,42%
Process 8 (projects, expertise etc.)	0,86%	0,40%	0,22%	0,15%	0,10%
Process 9 (mining damage)	7,66%	3,17%	0,75%	3,15%	0,58%
Process 10 (general management)	15,91%	6,98%	3,84%	2,48%	2,60%
Sum 1, 2 and 4 (liquidation)	11,10%	4,83%	1,64%	3,14%	1,49%

Source: An own study.

In the liquidation cost analysis of such diverse “population” of liquidated mines certain regularities can be found. The increase of costs is mostly related to the “scale” of the project. Usually higher liquidation costs are connected with the size of the branch so they depend on the number of liquidated facilities and this is the result of other costs. Table 8 shows the average percentage share of the cost of liquidation process of the branch in the total cost.

Table 8.*Average percentage share of the cost of liquidation process in the total cost*

The process of liquidation	A	L	ML	MS	S
Process 1 (liquidation of excavations)	0,08%	0,20%	0,04%	0,08%	0,01%
Process 2 (liquidation of shafts and pits)	0,27%	0,36%	0,10%	0,50%	0,14%
Process 3 (securing of neighboring mines)	0,45%	1,23%	0,88%	0,00%	0,00%
Process 4 (liquidation of area facilities)	0,30%	0,65%	0,40%	0,20%	0,09%
Process 5 (land reclamation)	0,16%	0,25%	0,13%	0,35%	0,00%
Process 6 (maintenance of facilities above)	1,10%	1,66%	1,34%	1,00%	0,66%
Process 7 (securing of liquidated mine)	2,09%	5,30%	2,85%	1,07%	0,24%
Process 8 (projects, expertise etc.)	0,05%	0,10%	0,07%	0,04%	0,02%
Process 9 (mining damage)	0,45%	0,79%	0,25%	0,79%	0,10%
Process 10 (general management)	0,94%	1,75%	1,28%	0,62%	0,43%

Source: An own study.

Each of those processes conducted in SRK S.A. is very complex and depend on many different factors. In the analysis presented below the authors tried to indicate only the most important factors that have influence on the cost of individual liquidation processes. The authors point out that estimation of liquidation costs cannot be based only on the factors mentioned and it must always be a comprehensive and multi – criteria process.

SRK S.A. spends about 1,32% of the total costs on Process 1 connected with the liquidation of excavations. The mean value for the statistical branch is 0,08%. According to the opinions of the experts this cost depends mainly on the number of independent sidings that can be insulated with the help of dams and natural hazards. In the event of methane hazard the increase in cost of liquidation is due to the need of installation of explosion- proof plugs. An additional cost in this process can be the cost of recovering the equipment of liquidated excavation. Work aimed at recovery of equipment should be supported by a cost effectiveness analysis.

The increase in the cost of liquidation of medium smaller branches results from the fact that this group included separate parts of mines which had been small independent mines with lots of working and shafts before.

The liquidation of shafts and pits (Process 2) absorbs 4,61% of the total liquidation costs. The mean value of the branch is 0,27% of this cost. The cost of this process results from the amount of shafts, their volume (length and diameter) and the number of available levels and hazards. In the case of large branches the increase in costs is connected with the liquidation of entire mine. The deviation of amount of costs in the process in medium smaller branches follows similarly to Process 1. It is caused by the nature of liquidated branches.

SRK S.A. allocates 7,59% of liquidation costs for securing of neighboring mines. In that case it is hard to mention the mean value. In the majority of cases the securing of neighboring mines is conducted or not. It is related to the target model of liquidated mine. The cost of securing the neighboring mines depends on the geology of its deposit and the most important decisive factor for the necessity to conduct this process is the possibility of flooding neighboring active mine. An open research problem is the difference between the total cost of liquidation of the mine and the cost of liquidated mine leaving the pumping station.

According to Table 8 the liquidation of area facilities (Process 4) runs in accordance with the size of the branch and consumes 5,16% of total cost of liquidation. In this case some approximation can be taken. If all branches have the same aim, they will have the same objects with the significant difference that small branches have small objects and low cost of liquidation and large branches have huge objects and high cost of liquidation. According to the experts opinion, the cost of this process results from the amount of objects, their structure and volume.

SRK S.A. allocates 2,75% of costs for land reclamation (Process 5). In that case, as in Process 3, the mean value is not reliable. In some of the branches land reclamation is not carried out because of the fact that in most cases a part of the mine is usually liquidated that is situated in the area of active mine. The most important cost factor in this process is the area of reclamation.

The cost related to the maintenance of facilities above (Process 6) as in Process 4 grows with the size of liquidated branch. SRK S.A. allocates 18,65% of total cost liquidation and 1,1% on average for a branch. The size of this cost is related to the amount of objects, their structure and volume held until their physical liquidation and also to the period of waiting for liquidation. Every delay of liquidation causes an increase in outlays. Taking this aspect into account savings should be sought.

The securing of liquidated mine (Process 7) is similar to Process 4 and 6. The cost increases within the size of the branch. In the case of mine liquidation it is the most capital intensive process. SRK S.A. allocates around 35,49% of total costs. Experts claim that the greatest impact in this process has the size of a mine which is associated with the amount of objects that requires securing and the size of the area that need to be protected. Minimizing the period of liquidation would significantly reduce the costs incurred in this process.

In Process 8 external entities are commissioned to carry out projects, expert opinions or analysis which are required by regulations. SRK S.A. allocates 0,86% of total costs. Data analysis shows that the cost increases with the size of the branch. The variety performed in this process is so huge that it is impossible to identify the dominant factor. The best way to reflect the reality is to refer to the widely understood size of the branch. Rationalization of this process cannot result from the amount of commissioned work because these result from separate regulations. Rationalization should result from economical spending of money for individual orders.

As it was mentioned before, it is a little influence on the costs incurred in Process 9 connected with mining damage. The necessity of payments results from legal consequences of previous mining activities. It can be assumed that the value of the cost connected with the area of influence of conducted exploitation in the period of 5 years preceding the end of production. SRK S.A. allocates 7,66% of total outlays. Some of the analyzed branches do not bear costs in this process because they were taken over without mining areas and SRK S.A. in that cases is not a legal successor.

Process 10 referring to the costs of general management is the third according to the size of outlays incurred. SRK S.A. allocates 15,91% of outlays for liquidation processes. The cost of this process increases with the size of the branch. In this case the dominant factors influencing the amount of expenditure are salaries, employee claims, taxes and fees.

The statistical analysis made it possible to propose an assessment method of the amount of the estimated cost of possible liquidation of mines independently from the company responsible for liquidation. This method signals to the designer obtained cost deviations of mine liquidation as a whole or in division to particular processes. Due to the significant diversity of analyzed branches it will depend on the user how far the estimated costs may be from the base value. To better illustrate the assessment in this publication the acceptable deviation on the level of 20% was assumed. The compliance rate of this value shows that results are very consistent. The mean value which was calculated for each group of branches that was reduced and increased by the standard deviation was calculated for the value of the consistency factor giving the upper and lower of the acceptable cost range. Signaling exceeding the upper limit in red and the lower limit in green may indicate mistake which were made in estimating of liquidation cost. In that case, the correctness of the process of estimated cost liquidation should be analyzed. Due to the huge diversity of liquidated mining plants signaling of deviation from the mean value is not the same as finding mistakes. The differences may result from the specific nature of the liquidated plant. Additionally, the authors proposed signaling on yellow the fact of not incurring costs in a given process. It is both information and a question directed to the designer whether this process should actually be skipped.

Table 9.

A list of the costs of liquidated branches analyzed with the deviation of the average value (a comparison method)

Group	Large				Medium larger			Medium smaller				Small					
Branch	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17
Σ costs	16,16	12,75	10,27	9,98	8,94	6,93	6,19	5,88	5,43	4,30	3,00	2,78	2,24	1,88	1,62	1,34	0,32
Percentage share of the liquidated cost of analyzed branch according to the total cost																	
Process 1	0,28	0,22	0,19	<u>0,10</u>	0,05	0,06	0,02	0,04	0,24	0,03	0,01	0,01	0,01	0,02	0,01	0,04	0,00
Process 2	0,28	0,36	<u>0,06</u>	0,76	0,08	0,15	0,09	1,29	0,49	0,03	0,20	0,18	0,21	0,10	0,12	0,21	0,03
Process 3	4,40	<u>0,53</u>	0,00	0,00	1,12	1,52	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00
Process 4	<u>0,31</u>	1,12	0,40	0,76	0,38	0,42	0,39	0,12	0,41	0,03	0,26	0,11	0,08	0,03	0,18	0,16	0,01
Process 5	0,02	<u>0,10</u>	0,05	0,81	0,38	0,00	0,00	0,86	0,30	0,00	0,23	0,00	0,00	0,00	0,00	0,00	0,00
Process 6	1,24	1,32	<u>1,16</u>	2,94	0,47	1,82	1,74	1,94	1,22	0,17	0,66	0,96	1,28	0,42	0,80	0,27	0,24
Process 7	6,93	5,44	6,52	<u>2,31</u>	4,87	1,64	2,05	0,43	1,31	1,77	0,79	0,29	0,25	0,38	0,07	0,43	0,00
Process 8	0,12	0,18	<u>0,03</u>	0,07	0,07	0,08	0,06	0,03	0,03	0,03	0,06	0,01	0,03	0,02	0,02	0,01	0,01
Process 9	0,85	<u>1,28</u>	0,41	0,63	0,08	0,09	0,58	0,74	0,64	1,65	0,13	0,28	0,07	0,23	0,00	0,00	0,00
Process 10	<u>1,73</u>	2,19	1,45	1,61	1,44	1,14	1,25	0,44	0,79	0,59	0,66	0,93	0,33	0,67	0,42	0,22	0,03
Percentage share of the liquidated cost of analyzed branch according to the cost of the process																	
Branch	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17
Process 1	21,0	16,8	14,4	<u>7,8</u>	3,5	4,7	1,5	2,9	18,1	2,2	0,6	1,0	0,6	1,2	0,6	2,9	0,0
Process 2	6,0	7,8	<u>1,2</u>	16,4	1,7	3,2	1,9	28,0	10,6	0,7	4,4	4,0	4,5	2,1	2,6	4,5	0,6
Process 3	58,0	<u>7,0</u>	0,0	0,0	14,8	20,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0
Process 4	<u>6,0</u>	21,7	7,8	14,7	7,4	8,1	7,6	2,3	7,9	0,5	5,1	2,2	1,5	0,7	3,5	3,0	0,1
Process 5	0,9	<u>3,8</u>	1,8	29,3	13,8	0,0	0,0	31,4	10,9	0,0	8,2	0,0	0,0	0,0	0,0	0,0	0,0
Process 6	6,7	7,1	<u>6,2</u>	15,8	2,5	9,7	9,3	10,4	6,5	0,9	3,5	5,1	6,8	2,2	4,3	1,5	1,3
Process 7	19,5	15,3	18,4	<u>6,5</u>	13,7	4,6	5,8	1,2	3,7	5,0	2,2	0,8	0,7	1,1	0,2	1,2	0,0
Process 8	13,8	21,1	<u>3,3</u>	7,8	8,0	9,8	7,4	3,1	4,0	3,1	6,7	1,4	3,2	2,3	2,5	1,4	1,1
Process 9	11,1	<u>16,8</u>	<u>5,3</u>	8,2	1,1	1,2	7,6	9,6	8,3	21,5	1,7	3,7	0,9	3,1	0,0	0,0	0,0
Process 10	<u>10,9</u>	13,8	9,1	10,1	9,1	7,2	7,9	2,7	5,0	3,7	4,2	5,9	2,1	4,2	2,6	1,4	0,2

Source: an own study.

Table 9 presents a list of the costs of liquidated branches analyzed with the deviation of the average value. A huge discrepancy in the obtained data may be alarming. The coefficient of convergence calculated for the entire “population” of liquidated mining plants exceeds 70% which proved that analyzed data is very inconsistent. During the statistical analysis people who are in charge of liquidation of analyzed branches were interviewed. Interviews allow to explain most of the deviations of the actual values from their mean values. We can assume the correctness and compliance with “the mining art” of conducted liquidation process. Tabular data are monetary values converted into a percentage value in relation to the total cost of liquidation and in relation to the total cost of individual processes. The same results were obtained in the statistical analysis of the monetary value as well as when converting cost of the mine liquidation process on the mean and maximum value of the entire process. Due to the volume of the publication these analysis were not included. The compliance of conversions may prove the correctness of the method used.

In near future there is no further branches that are going to be taken so as to liquidate therefore in order to verify the proposed methodology the authors proposed a theoretical acquisition of four hypothetical branches. The estimated liquidation costs were taken from the group of large branches. Due to the higher parameter values that group is the best to illustrate the correctness of procedure methodology. One of the hypothetical branches called Alpha which characterizes by maximum costs of liquidation of individual processes. A branch named Beta is a branch characterized by the average costs in the group of large branches and the branch called Gamma is associated with minimum values for the group of large branches. The last one is a branch called Delta where the cost values were assumed as random values of liquidation process costs from the group of large branches (in Table 9 underlined numbers are put in the form of letter “S”). The analysis of verification of the hypothetical cost liquidation of new Branches of SRK S.A. presents Table 10.

Although the liquidation costs come from the group of large branches only the cost of two of them (Alpha and Beta) put them in this group. The branch called Gamma was qualified to the group of medium larger branches and the branch called Delta to the group of medium smaller branches. The cost analysis was conducted in accordance with the affiliation to the reference group. For the liquidation process costs of branches Alpha and Beta this method worked as expected. In the case of the branch Alpha all the fields turned red what indicates that the upper limit of the acceptable value has been exceeded. The total cost of liquidation of this branch amounted to 20,90% of all costs incurred for liquidation that is about 1 billion PLN. Data of the branch Beta was mean values and did not cause a reaction as expected (the fields were uncolored). In the case of the branch Gamma the total cost of liquidation was in the zone of acceptable values, however processes 1, 9 and 10 exceeded the upper limit for the group of medium larger branches. Processes 2, 3, 4 and 8 signaled the possibility of an underestimation.

The total cost of liquidation such as Processes 1 and 9 of the branch Delta in the group of medium smaller branches signaled that the upper limit of the acceptable area was exceeded while Processes 2, 4, 5 and 8 were below the lower limit of this area. One field turned into yellow which signaled that no costs were incurred in this process which was consistent with the assumptions. It was assumed that the liquidation will be carried out without leaving the pumping station. Similar results were obtained when analyzing the costs of liquidation process and the total cost of liquidation.

Table 10.

Verification of the hypothetical cost liquidation of new Branches of SRK S.A.

A new branch	Alpha	Beta	Gamma	Delta
Total cost of liquidation	20,90%	12,29%	7,61%	5,85%
Group	L	L	ML	MS
Percentage share of the cost of liquidation of a new Branch according to the total cost				
Process 1 (liquidation of excavations)	0,28%	0,20%	0,10%	0,10%
Process 2 (liquidation of shafts and pits)	0,76%	0,36%	0,06%	0,06%
Process 3 (securing of neighboring mines)	4,40%	1,23%	0,53%	0,00%
Process 4 (liquidation of area facilities)	1,12%	0,65%	0,31%	0,31%
Process 5 (land reclamation)	0,81%	0,25%	0,10%	0,02%
Process 6 (maintenance of facilities above)	2,94%	1,66%	1,16%	1,16%
Process 7 (securing of liquidated mine)	6,93%	5,30%	2,31%	2,31%
Process 8 (projects, expertise etc.)	0,18%	0,10%	0,03%	0,03%
Process 9 (mining damage)	1,28%	0,79%	1,28%	0,41%
Process 10 (general management)	2,19%	1,75%	1,73%	1,45%
Percentage share of the cost of liquidation of a new branch according to the cost of the process				
A new branch	Alpha	Beta	Gamma	Delta
Process 1 (liquidation of excavations)	21,00%	15,00%	7,77%	7,77%
Process 2 (liquidation of shafts and pits)	16,42%	7,86%	1,25%	1,25%
Process 3 (securing of neighboring mines)	58,05%	16,25%	6,97%	0,00%
Process 4 (liquidation of area facilities)	21,69%	12,52%	5,97%	5,97%
Process 5 (land reclamation)	29,27%	8,93%	3,78%	0,86%
Process 6 (maintenance of facilities above)	15,78%	8,93%	6,22%	6,22%
Process 7 (securing of liquidated mine)	19,53%	14,94%	6,50%	6,50%
Process 8 (projects, expertise etc.)	21,09%	11,49%	3,26%	3,26%
Process 9 (mining damage)	16,77%	10,35%	16,77%	5,33%
Process 10 (general management)	13,78%	10,98%	10,88%	9,13%

Source: An own study.

5. Conclusions

The method of signaling of cost liquidation deviations of a new branch of SRK S.A. from the average value presented by the authors is a useful tool when trying to implement a process approach in the issue of mine liquidation in terms of rationalization and minimization of costs incurred. Especially it is important in a situation of insufficient research on this field.

The assessment method of the size of the estimated cost of possible mine liquidation presented by the authors is simple, understandable and easy to use in engineering and design projects.

The method can be used in initial estimation of costs of liquidated mining plants as a reference point for detailed analysis. This aspect requires more detailed research.

The assessment method of liquidation process proposed by the authors gives the same results when converted into the total cost of liquidation, the total cost of the process, the average cost of branch liquidation as well as converted into the maximum value of these costs. This compliance may prove the correctness of the method that was applied. The biggest disadvantage of this method is significant cost diversification in a particular group of branches. The diversification index indicates an enormous differentiation of the results which results from the huge variety of liquidated mines. During further research there will be need to propose an alternative method of classification of new group of branches so as to gain greater consistency of results in particular groups.

The assessment method of liquidation process described in this publication is based on analysis of the total cost of liquidation. The analysis of cost incurred in the process of liquidation for the next few years will require further research.

Another scientific problem that is not solved is the interaction between main processes and their interdependence.

References

1. Dźwigoł, H. (2007). *Model restrukturyzacji organizacyjnej przedsiębiorstwa górnictwa węgla kamiennego*. Warszawa: Difin.
2. Grajewski, P. (2012). *Procesowe zarządzanie organizacją*. Warszawa: PWE.
3. Jonek-Kowalska, I. (2013). Analiza i ocena kosztów w cyklu istnienia wyrobiska wybierkowego – wnioski dla rachunkowości zarządczej. *Scientific Papers of Silesian University of Technology, series: Organization and Management*, vol. 66, pp. 195-206.
4. Korski, J., Korski, W. (2015). Underground mine as a system of processes. *Mining – Informatics, Automation and Electrical Engineering*, 2(522), pp. 19-27.
5. Marek, J. (2006). Conditions and course of the liquidation process of hard coal mines. *Studia Ekonomiczne, Zarządzanie strategiczne w przedsiębiorstwie*, nr 37. Akademia Ekonomiczna w Katowicach, pp. 269-283.
6. Paszcza, H. (2010). Restructuring processes in the Polish hard coal mining industry in terms of the implemented changes and changes in the resource base. *Górnictwo i Inżynieria*, nr 3, pp. 62-82.

7. Przybyła, H., Chmiela, A. (2007). *Organizacja i ekonomika w projektowaniu wybierania węgla*. Gliwice: Wydawnictwo Politechniki Śląskiej.
8. Przybyła, H., Chmiela, A. (2002). *Technika i organizacja w robotach przygotowawczych*. Gliwice: Wydawnictwo Politechniki Śląskiej.
9. Riesgo Fernandez, P., Chmiela, A., Stanienda, K. (2003). The situation of coal mining in Spain after joining the European Union. *Scientific Papers of Silesian University of Technology, 1600, series: Mining, vol. 258*. Gliwice, pp. 291-301.
10. Riesgo Fernandez, P., Przybyła, H., Chmiela, A., Kołodziejczyk, P., Wesołowski, M. (2001a). Economic policy towards coal mining in Spain. Cz. 1. *Wiadomości Górnicze, nr 3*, pp. 118-123.
11. Riesgo Fernandez, P., Przybyła, H., Chmiela, A., Kołodziejczyk, P., Wesołowski, M. (2001b). Economic policy towards coal mining in Spain. Cz. 2.: *Wiadomości Górnicze, nr 4*, pp. 136-143.
12. Riesgo Fernandez, P., Przybyła, H., Chmiela, A., Kołodziejczyk, P., Wesołowski, M. (2000). Coal restructuring program in Spain. *Scientific Papers of Silesian University of Technology, 1480, series: Mining, vol. 246*. Gliwice, pp. 453-465.
13. Riesgo Fernandez, P., Wesołowski, M., Chmiela, A. (1997). Financing of mining investment projects in Spain with intensive capital expenditure. *Scientific Papers of Silesian University of Technology, 1378, series: Mining, vol. 236*, Gliwice, pp. 249-258.
14. Skrzypek, E., Hofman, M. (2010). *Zarządzanie procesami w przedsiębiorstwie*. Warszawa: Oficyna Wolters Kluwer business.
15. Smoliło, J., Chmiela, A. (2021). A liquidation of the mine in SRK S.A. in a processive approach. *Scientific Papers of Silesian University of Technology, series: Organization and Management*.
16. Turek, M. (2013). *Analiza i ocena kosztów w górnictwie węgla kamiennego w Polsce*. Warszawa: Difin.
17. Turek, M. (2013). *System zarządzania kosztami w kopalni węgla kamiennego w cyklu istnienia wyrobiska wybierkowego*. Warszawa: Difin.
18. Turek, M., Jonek-Kowalska, I. (2013). Contemporary cost accounting as an inspiration for the cost accounting in the life cycle of a mining excavation. *Scientific Papers of Silesian University of Technology, series: Organization and Management, vol. 66*, pp. 113-184.

COMPARISON OF JACKKNIFE AND BOOTSTRAP METHODS IN ESTIMATING CONFIDENCE INTERVALS

Łukasz SROKA

University of Economics, Katowice; lukasz.sroka@edu.uekat.pl, ORCID: 0000-0001-5721-2475

Purpose: The development of technology has allowed creating and using the new, more complex computational tools in static and econometrics in recent years. Since then, resampling methods has become more popular techniques in estimating statistics from small samples. The aim of the article is to present and to compare the bootstrap and the jackknife methods in estimation of interested statistics with explaining and illustrating the usefulness and limitation in the context of using in econometric.

Design/methodology/approach: To compare and present the methods, data of the length of bicycle paths divided into 371 polish counties from 2019 was received from Local Data Bank. From the data three samples were randomly selected and used as bootstrap and jackknife samples. Using the bootstrap and the jackknife simulations confidential intervals of the searching statistics with standard error were calculated. Results obtained for the methods were compared and described.

Research limitations/implications: An analysis of these methods will allow improving the efficiency and reducing the error in estimating confidence intervals for searching statistics.

Findings: As presented in the article, both the methods can be used to estimate mean, however, slightly better results are provided by the bootstrap. Furthermore, confidence intervals for confidence level at 95% created by these methods cover the population mean for each sample randomly selected from the population. To estimate standard deviation the better option is to choose the bootstrap method. Although, both confidence intervals for confidence at level 95% cover the population standard deviation, the bootstrap methods perform more accurate results with a smaller standard deviation.

Originality/value: It was proven that the bootstrap method is slightly better in estimation confidence intervals based on the skewed data in comparison with the jackknife method.

Keywords: jackknife, bootstrap, confidential intervals, resampling, simulations.

Category of the paper: research paper.

1. Introduction

The development of the technologies made it possible to use new, more powerful statistic tools in ways previously inconceivable. The new methods allow scientists do more realistic and accurate analysis. The bootstrap and the jackknife methods are parts of the technological revolution in statistics. These two methods can help to identify quantify uncertainty by calculating standard errors, confidence intervals and performing significance tests. The main advantage of the bootstrap and jackknife is that they require fewer assumptions than traditional methods and generated more accurate results (Hasenberg et al., 2003).

The bootstrap and the jackknife have been the object of statistic research since they were introduced. The results of the research were presented in the subject literature by B. Efron and C. Stein (1981), Beran and Ducharme (1991), Efron and Tibshirani (1993) or McIntosh (2016).

The aim of the article is to present and compare the bootstrap and the jackknife methods in estimation of interested statistics with explaining and illustrating the usefulness and limitation in the context of using econometric. The discussion in this article provides a mathematically detailed theory of the bootstrap and the jackknife with comparison these two methods using real data set.

The article is divided into two main parts – theoretical and empirical. The first theoretical part contains presentation of the bootstrap and the jackknife methods with their differences. The second empirical part presents comparison of the results of the usage of these two methods in estimation two statistics: mean and standard deviation from the samples of the populations. The conclusions of the empirical part are presented at the end of the article.

2. The bootstrap and the jackknife as simulation methods

2.1. The bootstrap method

The bootstrap as a method of simulation was presented in 1979 by B. Efron. It is widely use in estimating of the confidence intervals, approximation of estimator distributions or tests of the statistics. Using this simulation allows, among other things for obtaining the evaluation of the estimators variance or creating confidence intervals for population parameters. It also can be us to develop new statistics tests and estimation procedures. (Kończak, 2012, p. 108). The main advantage of the method is possibilities of statistical inference without knowing of the whole population. The bootstrap method prepares its estimates, only a sample from the observed population (Dunaj, 2017, p. 6).

The bootstrap distribution is obtained by estimation of independent samples created by sampling with replacement from the original dataset. Let F denote the distribution of an individual observation E . Let $G_n(u, F)$ denote the distribution of the estimator $\check{\theta}$ (Hansen, 2021). That is:

$$G_n(u, F) = Pr(\check{\theta} \leq u \mid F) \quad (1)$$

The G_n distribution is written as a function of n and F since they influence on the distribution of $\check{\theta}$. If the F distribution is known, determination of the distribution G_n is not the issue. In the real data there are two main obstacles which do not allow us to determine the F distribution:

- The calculation of $G_n(u, F)$ is impossible, except some exceptions such as a normal regression model.
- The distribution of the individual observations from F population is not known (Hansen, 2001).

The bootstrap simulation is able to omit one of the obstacles by using empirical distribution function (EDF) F_n to estimate F . EDF is the simplest nonparametric estimator of the joint distribution of the observations. When F is replaced by F_n in $G_n(u, F)$ it is possible to receive the bootstrap estimator of the distribution of $\check{\theta}$:

$$G_n^*(u) = G_n(u, F_n) \quad (2)$$

$G_n^*(u)$ is estimated by simulation. The simulation from F_n is sampling with replacement from the original data. Applying the estimation formula for T_n it is possible to receive draws from the distribution $G_n^*(u)$. By making a large number of the draws any feature of G_n^* can be estimated (Hansen, 2021, pp. 263-270).

The procedure of bootstrap is as follows:

1. Resample – creating new samples, called bootstrap samples by sampling with replacement from the original random sample. Each sample has the same size as the original random sample.
2. Calculating a bootstrap distribution – calculation the statistics for each obtained sample. The distribution of these samples is called the bootstrap distribution.
3. Using the bootstrap distribution – the received distribution from the bootstrap samples gives information about shape, center and spread of the samples distribution of the statistics (Hasenberg et al., 2003).

Let estimate the parameter θ from population. To receive the estimation of the parameter estimator $\check{\theta}$ can be used. It is important to obtain an estimator of variance for the estimator as well. From the randomly selected n -element sample, bootstrap samples are drawn by N fold sampling with replacement. The subsequent bootstrap samples are labelled as presented below (Kończak, 2012, pp. 110-111):

$(\dot{x}_1^{(1)}, \dot{x}_2^{(1)}, \dots, \dot{x}_n^{(1)})$ – the first bootstrap sample,

$(\dot{x}_1^{(2)}, \dot{x}_2^{(2)}, \dots, \dot{x}_n^{(2)})$ – the second bootstrap sample,

...

$(\dot{x}_1^{(N)}, \dot{x}_2^{(N)}, \dots, \dot{x}_n^{(1N)})$ – the N bootstrap sample.

For each bootstrap sample the value of $\check{\theta}^{(i)}$ statistic ($i = 1, 2, \dots, N$) is obtained by using the same formula as for $\check{\theta}$ statistic. The value of the statistic is determined on the basis of the particular bootstrap sample. In the next step, the value of bootstrap estimator is calculated as following:

$$\check{\theta}_B = \frac{1}{N} \sum_{i=1}^N \check{\theta}^{(i)} \quad (3)$$

And the variation of the estimation is calculated as presented below (Efron, Tibshirani, 1993):

$$\check{V}_1(\check{\theta}) = \frac{1}{N-1} \sum_{i=1}^N (\check{\theta}^{(i)} - \check{\theta}_B)^2 \quad (4)$$

The bootstrap method allows determining the confidence intervals for unknown value of parameter θ . The confidence intervals for the unknown parameter can be designated by limit theorem:

$$(\check{\theta} - t^{*(1-\frac{\alpha}{2})} D(\check{\theta}); \check{\theta} - t^{*(\alpha/2)} D(\check{\theta})) \quad (5)$$

Where $t^{*(1-\frac{\alpha}{2})}$ and $t^{*(\alpha/2)}$ are the percentiles of the empirical distribution for order $1 - \frac{\alpha}{2}$ and $\frac{\alpha}{2}$ of statistic $t^* = \frac{\check{\theta}^* - \check{\theta}}{D(\check{\theta}^*)}$.

In this statistic $D(\check{\theta})$ is the standard deviation of $\check{\theta}$ estimator and $\check{D}(\check{\theta}^*)$ is the estimation of the estimator.

2.2. The jackknife method

The jackknife as a method was described in 1949 by M.H. Quenouille. At the beginning, the method was used as a procedure for correcting bias. In 1956 J. Turkey adapted the jackknife to construct a confidence limit for a large class of estimator. The method is similar to the bootstrap, however the main difference is that the jackknife estimator of a parameter is found by systematically leaving out each observation from a dataset and calculating the estimate and then finding the average of these calculations (McIntosh, 2016).

Let Y_1, \dots, Y_n denote a sample of independent and identically distributed random variables, $\check{\theta}$ denotes an estimator of the parameter θ based on a sample of n . Let $\check{\theta}^{(-i)}$ be the corresponding estimator based on the sample size $(g-1)h$, where the i -th group of size h has been excluded (Miller, 1974).

$$\check{\theta}_i = g\check{\theta} - (g-1)\check{\theta}^{(-i)} \quad (6)$$

where $i = (1, 2, \dots, g)$. The estimator:

$$\check{\theta} = \frac{1}{g} \sum_{i=1}^g \check{\theta}_i = g\check{\theta} - (g-1) \frac{1}{g} \sum_{i=1}^g \check{\theta}^{(-i)} \quad (7)$$

excludes the order $1/n$ term from a bias of the form

$$E(\tilde{\theta}) = \theta + a_{1/n} + O\left(\frac{1}{n^2}\right) \quad (8)$$

Turkey (1958) presented g values as widely used, approximately, independent and identically distributed random variables. The statistic:

$$\frac{\sqrt{g(\tilde{\theta} - \theta)}}{\left(\frac{1}{1-g} \sum_{i=1}^g (\tilde{\theta}_i - \tilde{\theta})^2\right)^{1/2}} \quad (9)$$

has an approximate t distribution with $g-1$ degrees of freedom and constitutes a pivotal statistic for proper interval estimation.

In this article, the jackknife method with excluding one observation from the data set is described, however, in literature occurs the other method with removing more than only one observation (Kamiński, 2010).

The procedure of jackknife with excluding one observation is simpler than bootstrap procedure:

Excluding – from the data set one observation is omitted sequentially. The new data set with the excluded observation is called a jackknife sample.

Calculating the statistic – the interested statistic is calculated from each jackknife sample.

Finding average value – of all statistics from the second step the average value is calculated. The value is the jackknife estimation of the interested statistic.

The jackknife samples can be described as presented below:

$(\dot{x}_2^{(1)}, \dot{x}_3^{(1)}, \dots, \dot{x}_n^{(1)})$ – the first jackknife sample,

$(\dot{x}_1^{(2)}, \dot{x}_3^{(2)}, \dots, \dot{x}_n^{(2)})$ – the second jackknife sample,

...

$(\dot{x}_1^{(N)}, \dot{x}_2^{(N)}, \dots, \dot{x}_{n-1}^{(1N)})$ – the N jackknife sample.

An example of using jackknife method in estimating median and variance is described as the following: let $\tilde{\theta}$ denotes any estimator of a vector-valued parameter θ which is a function of a random sample size n . Let $V(\tilde{\theta}) = \text{var}(\tilde{\theta})$ be a variation of θ and $\tilde{\theta}_{(-i)}$ denotes the leave-one-out estimators which are computed using the formula for $\tilde{\theta}$ except the deleted observation i . Turkey's jackknife estimator for $V_{\tilde{\theta}}$ is described as a scale of the sample variance of the leave-one-out estimators and presented below (Hansen, 2001):

$$V(\tilde{\theta}) = \frac{N-1}{N} \sum_{i=1}^N (\tilde{\theta}^{(-i)} - \bar{\theta})^2 \quad (10)$$

where $\bar{\theta}$ is the sample mean of the leave-one-out estimator:

$$\bar{\theta} = \frac{1}{N} \sum_{i=1}^N \tilde{\theta}^{(-i)} \quad (11)$$

In the jackknife method the confidence intervals are determined in the same way as in the bootstrap method.

2.3. Differences between the bootstrap and the jackknife

There are a few differences between the bootstrap and the jackknife methods. The jackknife is an older method which is less computationally expensive, while the bootstrap is more computationally expensive but gives more precision with estimation of the parameters. In addition, bootstrap is conceptually simpler and produces less standard error than the jackknife. One of the advantages of the jackknife is that the method performs the same results every time, while bootstrap gives different results in every run. Therefore there are some conditions where each of the methods can be used. The jackknife is better for estimation of the confidence interval for pairwise agreement measures and it is more suitable for small data, however bootstrap achieves better results for data with skewed distribution (Nguyenova, 2020).

3. Results

To prepare the comparison between the bootstrap and the jackknife in estimation of the interested statistics (mean and standard deviation) and determination of the confidence intervals real data of length of bicycle paths from polish counties were obtained. From the population three samples were randomly selected. The first sample contains 25% observations from the population, the second 50% and the third 75%. In addition, 5000 bootstrap samples were created from each of the selected samples to prepare bootstrap estimations. The results of these two methods were described and compared to select the best method to estimate interested statistics.

As presented in the previous part of the article to prepare the bootstrap and the jackknife simulations a sample data from the population is needed. Because one of the aims of the article is comparing results of estimation of these two methods real data of length of bicycle paths from polish counties were obtained. The data contains information about the length of bicycle paths divided into 371 polish counties in 2019. The set was received from Local Data Bank. During analysis one outlier was detected and removed from the analysis. The outlying concern county of the capital city of Warsaw was removed. The county is an anomaly in the data – over two times higher than the next highest value.

Figure 1 presents the distribution of the bicycle paths lengths while the table 1 statistics for the data.

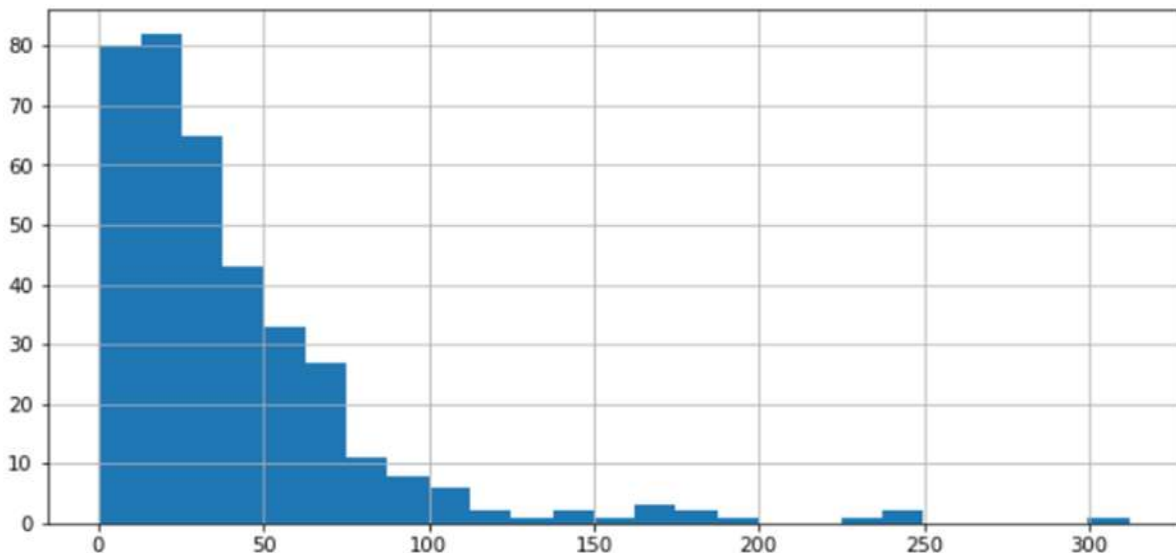


Figure 1. Distribution of the population of the bicycle paths lengths Source: Author's own elaboration based on: Local Data Bank.

Table 1.

Statistics of the population of the bicycle paths lengths

Statistic	Result (in meters)
Mean	40,15
Standard deviation	40,14
Min	0,20
Max	312,10
Percentile 0,25	15,00
Percentile 0,50	29,60
Percentile 0,75	312,10

Source: own calculations based on Local Data Bank.

As presented in figure 1 and table 1 the population of the length of the bicycle path has the right-hand distribution with the mean equal to 40,15 meters and the standard deviation of 40,14 meters. The population contains a lot of outliers which is very common in real data sets. The huge difference between min and max values is related to the fact that not all polish counties have an extensive network of bicycle paths.

Table 2 presents the statistics of the three randomly selected samples from the population. As described in the methodology, the samples are used to create the bootstrap and the jackknife simulations and are necessary to estimate the interested statistics. Each of the samples has a different number of observations. The first has 25% observations of the total population ($n = 93$), the second has 50% observations of the total population ($n = 186$), and the third has 75% observations of the total population ($n = 279$).

Table 2.*The statistics for the samples of the bicycle paths lengths sample size*

Statistic	Result for 25% sample n = 93	Result for 50% sample n = 186	Result for 75% sample n = 279
Mean	46,23	43,38	38,12
Standard deviation	49,23	42,10	36,70
Min	2,20	0,20	0,20
Max	248,50	312,10	312,10
Percentile 0,25	12,90	17,23	14,85
Percentile 0,50	33,30	32,45	29,40
Percentile 0,75	56,30	55,38	53,20

Source: own calculations based on Local Data Bank.

Below, the tables from 3 to 8 contain the results obtained using the bootstrap and the jackknife methods. The point estimations of mean and standard deviation are presented in tables 3, 5 and 7. Also standard error of the estimators was included in these tables. Confidence intervals for confidence level 95% were described in the tables 4, 6 and 8.

Table 3.*The results for 25% sample of the population for the bootstrap and the jackknife simulations*

Statistic	Bootstrap		Jackknife	
	Estimation	Standard error of the estimation	Estimation	Standard error of the estimation
Mean	44,98	5,68	44,96	5,78
Standard deviation	54,43	9,06	56,54	9,56

Source: own calculations based on Local Data Bank.

Table 4.*The confidential intervals for 25% sample of the population n for the bootstrap and the jackknife simulations*

Statistic	Bootstrap		Jackknife	
	2,5%	97,5%	2,5%	97,5%
Mean	34,35	56,86	33,64	56,28
Standard deviation	35,86	71,04	37,80	75,28

Source: own study based on Local Data Bank.

The results provided by the two methods are very similar, however, the jackknife makes slightly better estimation for the population mean, and the bootstrap estimates the population standard deviation closer to population result. Additionally, a lower level of standard error for the both estimations occurs in the bootstrap. It can be assumed that the means and standard deviations calculated based on bootstrap samples have a lower variance, therefore, the estimations are more stable. Both the methods cover population mean and standard deviation by their confidence intervals for confidence level equal to 95%.

Table 5.

The confidential intervals for 50% sample of the population for the bootstrap and the jackknife simulations

Statistic	Bootstrap		Jackknife	
	Estimation	Standard error of the estimation	Estimation	Standard error of the estimation
Mean	43,37	3,09	43,38	3,09
Standard deviation	41,40	5,95	42,55	6,24

Source: own study based on Local Data Bank.

Table 6.

The confidential intervals for 25% sample of the population for the bootstrap and the jackknife simulations

Statistic	Bootstrap		Jackknife	
	2,5%	97,5%	2,5%	97,5%
Mean	37,67	49,75	37,33	49,42
Standard deviation	30,21	53,07	30,32	54,79

Source: own study based on Local Data Bank.

Also for the second sample both methods estimate mean almost the same. In addition, standard error of the estimation is the same for the bootstrap and the jackknife methods. The main difference occurs in estimation of standard deviation. The methods overestimated population standard deviation, however, results provided by bootstrap are closer to the real standard deviation than the jackknife propose. Confidence intervals created by the two methods cover the population mean and standard deviation at the 95% level of confidence.

Table 7.

The results for 75% sample of the population for the bootstrap and the jackknife simulations

Statistic	Bootstrap		Jackknife	
	Estimation	Standard error of the estimation	Estimation	Standard error of the estimation
Mean	38,16	2,20	38,12	2,20
Standard deviation	36,30	4,46	37,10	4,77

Source: own study based on Local Data Bank.

Table 8.

The confidential intervals for 75% sample of the population for the bootstrap and the jackknife simulations

Statistic	Bootstrap		Jackknife	
	2,5%	97,5%	2,5%	97,5%
Mean	33,99	42,60	33,81	42,42
Standard deviation	28,23	45,56	27,65	46,36

Source: own study based on Local Data Bank.

The same as for the previous results estimation of population mean provided by the bootstrap and the jackknife are very similar with standard error at the same level. As for estimation of standard deviation both of the methods underestimated the population standard deviation, however, the jackknife estimation is closer to the population statistic. In both cases

confidence intervals at 95% level of confidence cover the population standard deviation, the same as population mean.

4. Conclusions

In this article the bootstrap and the jackknife methods were discussed. Both the methods are very useful tools in statistics analyses. The main advantage of these techniques is the possibility of using them when the underlying distribution for the population is not known and the traditional formulas are difficult or impossible to apply. The paper focuses on describing both methods and comparing them in estimating selected statistics.

The theoretical part of the article presents the consideration about the two methods. The procedure of creating the bootstrap and the jackknife simulations were described. Also the use of these methods to estimate interested statistics with the standard error was presented. In the empirical part of the paper the bootstrap and the jackknife methods were the tools to estimate mean and standard deviation of the length of the bicycle paths.

As presented in the article, both the methods can be used to estimate mean, however, slightly better results are provided by the bootstrap. Furthermore, confidence intervals for confidence level at 95% created by these methods cover the population mean for each sample randomly selected from the population.

To estimate standard deviation the better option is to choose the bootstrap method. Although, both confidence intervals for confidence at level 95% cover the population standard deviation, the bootstrap methods perform more accurate results with a smaller standard deviation.

It has been proven that both methods are suitable for estimating the mean and standard deviation with the use of samples with different numbers of observations. Nevertheless, the solutions that will allow for the reduction of standard errors and the narrowing of the confidence intervals of the interested statistics should still be sought.

References

1. Beran, R., and Ducharme, G.R. (1991). *Asymptotic Theory for Bootstrap Methods in Statistics*. Montreal: Les Publications CRM.
2. Dunaj, J. (2017). *Bootstrap i jego zastosowania do analizy wrażliwości estymatora wartości zagrożonej*, <https://ftims.pg.edu.pl/katedra-analizy-nieliniowej-i-statystyki/prace-dyplomowe>.

3. Efron, B., Stein, C. (1981). *The jackknife in estimate of variance. The analyst of statistics Vol. 9, Iss. 3*, pp. 586-596.
4. Efron, B., Tibshirani, J.R. (1993). *An Introduction to the Bootstrap*. New York: Chapman and Hall.
5. Hansen, E.B. (2001). *Econometrics*. Wisconsin: University of Wisconsin, Department of Economics, pp. 253-270.
6. Hasenberg, T., Monaghan, S., Moore, S.D., Clipson, A., Epstein, R. (2003). *Bootstrap Methods and Permutation tests*. New York: W.H. Freeman and Company, pp. 11-13.
7. Kamiński, A. (2010). *Wykorzystanie algorytmów Bootstrap i Jackknife w estymacji parametrów regresji*, <http://docplayer.pl/36440257-Wykorzystanie-algorytmow-bootstrap-i-jackknife-w-estymacji-parametrow-regresji.html>.
8. Kończak, G. (2012) *Wprowadzenie do symulacji komputerowych*. Katowice: Wydawnictwo Uniwersytetu Ekonomicznego.
9. McIntosh, A. (2016). *The Jackknife Estimation Method*, <https://arxiv.org/abs/1606.00497>.
10. Miller, G.R. (1974). *The Jackknife – A Review*. *Biometrika*, Vol. 61, Iss. 1, pp. 1-15.
11. Nguyenova, L. (2020). *Bootstrapping vs. jackknife*, <https://medium.com/@lymielynn/bootstrapping-vs-jackknife-d5172965207b>.

REASONS AND DIRECTIONS FOR MARKET REORIENTATION OF RESEARCH INSTITUTES IN POLAND

Lilianna STAŃCZAK

KOMAG Institute of Mining Technology; lstanczak@komag.eu, ORCID: 0000-0002-5154-7693

Purpose: Regulations related to the activities of research institutes, the regulations specifying the criteria and procedure for awarding a scientific category to research institutes and the principles of financing science, as well as the economic policy of the European Union in terms of increasing innovation and reforming the R&D sphere force the need to restructure marketing in the research sector. The aim of this article is to present solutions used by research institutes in marketing communication, leading to the development of cooperation with various market participants.

Design/methodology/approach: This is a review article. For this purpose, a review of Polish and foreign literature was carried out to synthetically show the solutions currently used by research institutes. Additionally, to show the challenges facing the institutes, a few words were devoted to new technologies.

Findings: Offers of research institutes are specific and require the use of special solutions in marketing, and the new economic conditions, in which the research institutes currently operate, force them to introduce innovative solutions and implement new directions in the field of marketing activities. Research institutes should react and intensify marketing activities to strengthen their image and maintain the current one, as well as to acquire new markets for the offered products, including R&D projects results.

Originality/value: The review of available literature enables to draw conclusions of a general character which can be a sort of guidelines for the management of the research institutes. The efficiency state-of-the-art marketing tools differs as regards innovative solutions, so it seems to be useful to analyze different possibilities in this scope. As the Author of this article has been involved in marketing activities of the KOMAG Institute for several years, it is interesting to be acquainted with her first hand professional experience.

Keywords: marketing of research institutes, commercialization, dissemination of research results.

Category of the paper: Literature review.

1. Introduction

Research institutes as the state organizational entities were established to realize R&D projects aimed at implementation and use of the research results in practice (Niemczyk, 2014).

Under the current Research Institutes Act (Act on Research Institutes), research and development organizations were transformed into research institutes. The most important changes, introduced in the Research Institutes Act relate to the functioning of research institutes. Increasing the efficiency of research organizations in testing and implementation of the results by a comprehensive evaluation of their scientific and research and development activities every 4 years, which will allow selecting the most valuable organizations of the scientific and innovative activities, conducted at the highest level, is the main objective of the adopted solutions.

Regulations related to the activity of research institutes, provisions defining the criteria and procedure for awarding a scientific category to scientific organizations and the principles of financing the science, as well as the economic policy of the European Union in terms of increasing innovation and reforming the R&D sphere, require restructuring the marketing activities in the research sector. The aim of the article is to present solutions, used by the research institutes in marketing communication, leading to a development of cooperation with various market participants. Marketing communication (https://mfiles.pl/pl/index.php/Komunikacja_marketingowa) is the process of sending signals and information to the marketing environment through various sources, as well as the process of their collection by the company. Marketing communication is aimed at providing the most important information about the company activities and the market offer prepared by it. Its purpose is also to induce the feedback of recipients to the information sent by it. Any information coming from the market environment is important for the company to introduce changes to its offer, adapting it to the needs and requirements of current, but also future customers or business partners. In turn, sending appropriate stimuli to the market environment allows to change behaviour of customers, thus shaping the demand for the company's products. The activities, described above, should be realized in parallel and then, from the marketing communication point of view, some kind of a dialogue between the company and the recipients about products or services can be created. Marketing communication includes a flow of information among market entities using various communication channels to implement the marketing strategy adopted by the company.

The article reviews the literature in terms of identifying marketing goals of research institutes and specific marketing tools, effective as regards a research institute functionality, including the principles of parametric evaluation of scientific organizations. The literature analysis begins with an identification of barriers to innovation in the R&D sector. Then, the models of marketing activities, used by research institutes to disseminate innovative solutions and commercialization of R&D projects are described. At the end of the article, some directions of marketing activities and the current marketing trends are presented.

2. Literature review

An identification of barriers to innovation in the Polish economy was one of the goals of the studies conducted in the years 2014–2016. Studies of the Warsaw Management University showed that one of the key factors constructing these barriers is a low level of cooperation between business and science, which in turn results from structural problems being a matter of the state policy and the inability to communicate between representatives of business and science (Mikosik, 2018).

The problem of innovation is analyzed by Kaźmierczak (2011), who believes that the lack of effective links between business and the R&D sectors is the main barrier to the improvement of the innovation level. The reluctance of entrepreneurs to take a risk as regards an implementation of innovations is also an important barrier. The changes on the global market and a pressure on a commercialization of R&D results, increase competitiveness and force the implementation of marketing methods of managing, also in the case of research and development organizations. These organizations, treated as specific enterprises, offer research results on a commercial basis (Sojkin, 2014). The phenomenon of knowledge commercialization is currently observed in research institutes. The change in regulations, concerning scientific entities, forced them to develop new strategies based on a commercialization of research results and speeding up innovation processes to implement them in the industry. The commercialization subject of research and development work can be any product or service, generated at a scientific organization in the result of research: an innovation, an invention, a new technology or method (Flisiuk and Gołąbek, 2015), Figure 1.



Figure 1. Product categories of research institutes (Slotorsz and Cichoń, 2014).

Maślanka (2019) notes that the offer of research institutes is specific and requires an application of specific marketing solutions, and new economic conditions in which research institutes operate to stimulate an introduction of new solutions and use of new marketing trends. To apply the marketing concept in research institutes, their restructuring is required in the following three basic areas:

1. Market reorientation of a research institute.
2. Product restructuring in the scope of realized research and development projects.
3. Change in the sales of R&D products and services with use of marketing mix tools.

Sojkin (2014), in the case of a research institution, describes a group of market participants, who form a network of connections to create a value for customers as stakeholders. These include: present and future customers, national and international associations and industry corporations, local and central authorities, technology parks, research and scientific centres, universities, financial institutions and media. An adaptation of the product to individual parameters required by customers is the basic problem.

An introduction of marketing orientation, the use of which in R&D organizations contributes to building science-business relations, resulting in the transfer of knowledge to the economy (Slotorsz and Cichoń, 2014), is one of the elements influencing an increase of effectiveness in commercialization of the R&D project results. An adequate implementation of marketing orientation, on one hand, helps a research institute to disseminate information about its research and implementation projects, and on the other hand, to make potential entrepreneurs aware of the profits resulting from an implementation of specific R&D results. Walasik (2018) describes the methods of implementing the marketing orientation in a research and development organization in the result of using the defined hybrid and dedicated models, depending on the instrumentation model, as a part of the 4P marketing-mix concept, the use of which translates into an increase of the success rate as regards a commercialization of R&D results. A set of 5 hybrid models within a marketing-oriented research organization is described. They are as follows: the innovation model, the niche model, the sub-supply model, the comprehensive model and the market model. Each of the five models was verified in terms of the possibility of its use depending on three key input parameters: the type of solution, the nature of the solution and the commercialization mechanism. For each combination, containing the type of the solution (5 options), the nature of the solution (3 options) and the commercialization mechanism (4 options), dependency matrices were created, the analysis of which determined the selection of adequate hybrid models. The developed hybrid models were verified on several dozen examples of commercialized R&D results and are used in relation to the results of scientific research, development work, research and implementation projects, etc. developed at a research institute.

In another project, Walasik (2014) presents good practices in the field developed and implemented at the Institute for Sustainable Technologies – National Research Institute (ITeE – PIB), examples of using the dissemination system as an essential component of the process of managing innovative technological products. The dissemination includes all the activities aimed at attracting relevant people, enterprises or institutions to the results of R&D work, presenting the possibilities of their use and the benefits of their application in the economy. The dissemination requires identifying the target market, formulating the right message for a given market segment, selecting the most effective ways to reach the groups of potential

recipients identified in the segmentation process, or an effective implementation of the intended marketing activities. Their product portfolio consists of innovative technological solutions that require an innovation not only in terms of technique and technology, but also an efficient and effective marketing model using state-of-the-art sales techniques on strictly defined target markets.

The key success factors for the process of developing a new product or improving an existing one and introducing it to the market, referred to in the literature as NPD (new product development), are as follows: technology (added value of technology, cost reduction achieved due to the use of technology), marketing (meeting the needs of customers, production time, profit, market share), NPD management and the commercialization process, i.e. the stage of introducing a new product to the market (profit increased by possible additional investments made in the result of the product commercialization). Among them, the most important is NPD management, which consists of four main processes:

- creating and implementing the product that meets the market demand,
- adjusting the business model to the structures and rules of the market, taking into account target segments,
- adjusting marketing activities to the rules and principles of competing on a given market,
- activities strengthening the market position of entities.

Figure 2 shows the system of disseminating the innovative solutions dedicated to a research and development organization, consisting of five main elements, i.e. market analysis, segmentation process, development of marketing strategy, organization of dissemination activities, follow-up phase.

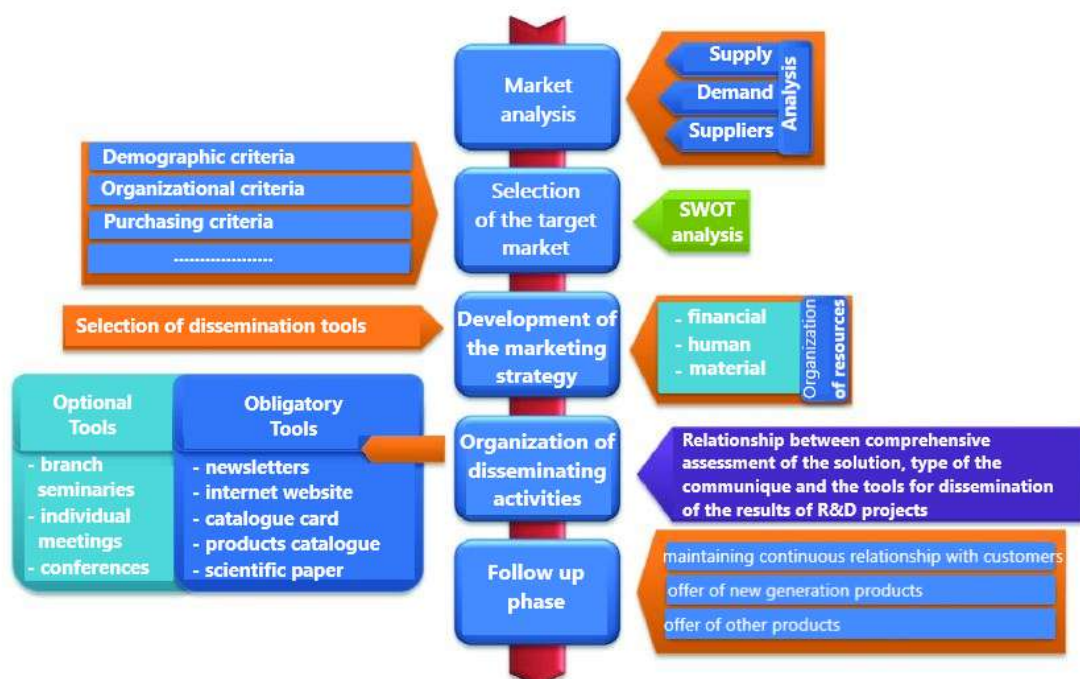


Figure 2. System stages of disseminating the results of R&D work in the economy (Walasik, 2014).

The paper (Niemczyk, 2014) shows that multi-channel reaching the specific groups of business customers with appropriate information, which is the essence of marketing communication, including the following activities:

- communicating all the company's values to the market environment through marketing activities,
- a communication inside the company,
- shaping the company's identity, i.e. distinguishing features,
- a partner-oriented reaction to information coming from the environment.

Such an approach is the result of conscious management of products developed bearing the commercialization in mind.

According to Sojkin (2014), a today's product requires not only innovation in the field of technique and technology, but also an efficient and effective model of market communication or sales techniques in strictly defined segments, and above all, an innovation in planning its full life cycle (innovative and market). Adjusting marketing activities to the rules and principles of competition (focus on developing a competitive position), which in today's economy is one of the basic conditions enabling functioning of each economic entity and determining its competitive position. A development and implementation of the marketing strategy, based on the market segmentation and understanding the needs and requirements of consumers is an important element in this process. It is advisable to undertake both: image-building activities, which are primarily aimed at strengthening the brand of a research institute in the national and international area, promoting new products at national and international conferences and symposia, and by publishing scientific articles, as well as undertaking individual marketing activities. The last area of NPD management – carrying out activities strengthening the market position of a research and development organization – is possible by monitoring the level of customer satisfaction. It is also important to inform customers about the work on creating new generations of a given type of product. The system of tools for dissemination shows Figure 3.

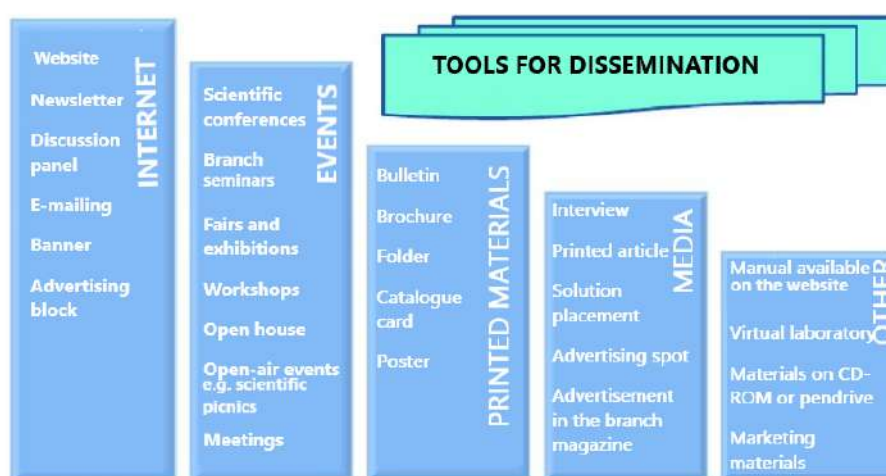


Figure 3. Main tools for dissemination of R&D results (Walasik, 2014).

The purpose of dissemination is:

- Building a positive image of the research organization.
- Reaching individual target groups with a clear and understandable message about the product.

In addition, present market challenges, related to global trends and local changes in the behaviour of market participants, force marketing activity consisting in use of a constantly developing range of marketing tools for the market participants to search for new strategic solutions on the supply and demand side (Sojkin, 2014).

A preparation of a set of market values that constitute clearly and precisely defined goals of the organization activity on the market, based on the knowledge and experience in various areas of activity is a start of the way leading to a creation of the aforementioned resources. They will be used for a preparation of the company's strategy (including the marketing strategy), which will allow for their implementation adequately to the needs and expectations of customers and the shaped market mechanism. The scale of implementation and ultimately an achievement of the values is not easy in the light of previously indicated globalization processes, a dynamic development of information technology as well as changeability and complexity of market conditions, relations between market stakeholders/participants and repeating crises on micro and macro scales. Hence the enormous challenges, faced by the participants of each product market, in particular the service market, who want to effectively and efficiently implement the marketing strategy, and especially the requirements and expectations in this regard, are addressed to market participants of scientific and research organizations. As a consequence, market values related to the implemented innovation and re-innovation processes, require a non-standard approach due to a desire of satisfying new, often unknown customer's needs, which must be very precisely described, their utilitarianism must be indicated and explained in a comprehensive manner (misunderstandings around CO₂, GMO or nanotechnology); and often it is required to intensively educate a target market participant to create new dimensions of needs as well as forms and techniques of their access and use. This usually needs a different approach to the marketing of a scientific-research institution, which usually adopted the traditional 4P or 4C toolkit as a starting point and focused mainly on recognizing the shaped infrastructure of the target market, using effective and efficient marketing instruments and creating new market/marketing relationships among stakeholders of innovative processes. The current canons of the market operating mechanism, in the vast majority of markets, mainly due to changes in the infrastructure on the supply side as well as the tools and forms of communication of its participants, and above all, revolutionary changes in the needs and expectations of consumers/customers/buyers, force a change in the approach to defining the marketing instruments of scientific and research organizations.

Public relations are treated by PR practitioners as a separate field, as opposed to marketing specialists who consider it a tool helping to achieve marketing goals (including publicity). An influence on such a perception of public relations is attributed to its location in the mix

marketing by the marketing "prophet" Philip Kotler. Despite this, Kotler in the 1990s stated that PR is a separate field of science, but still many academics believe that it has a marketing function.

Marketing public relations are defined as "the process of planning, implementing and evaluating programmes that encourage purchase and contribute to a customer's satisfaction by credible communicating information and perceptions, identifying companies and their products with the needs and interests of buyers" (Harris, 1998). Relations between marketing and public relations are shown in Figure 4.

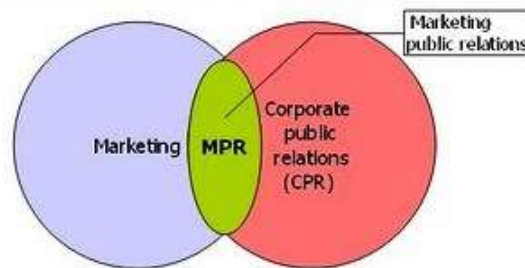


Figure 4. Relations between marketing and public relations (Szymańska, 2004).

The main tasks of marketing public relations (MPR) are the following ones (Olędzki and Tworzydło, 2008):

- building awareness of the existence of products or services,
- sales stimulation,
- building relationships and facilitating dialogue between consumers and brands,
- image creation,
- providing information on products and services,
- CSR activities.

Marketing constantly follows new trends which, in the light of theoretical knowledge, are often not well described or categorized yet. Recalling the most characteristic trends of recent years, some trends of current marketing such as content marketing, digital marketing, social media marketing, buzz marketing - closely related to the development of new internet marketing technology and tools can be mentioned. An integration should take place not only at the level of the promotion mix tools themselves, but also the mix marketing as well as at the strategic level (such as the vision, mission, main strategic assumptions of the company). Therefore, it is necessary to study marketing communication in terms of the operation of the entire organization, which leads to an adoption of the concept of integrated marketing communication (Pluta-Olearnik, 2018).

The concept of Integrated Marketing Communication (IMC) combines a variety of marketing tools to ensure transparency, consistency and maximize the communication impact (Figure 5). This, in principle, two-sided, controlled flow of information between the organization and its contractors allows for the creation of a coherent context of the transmitted messages, which affects the image and effective positioning of the brand. The selection of

appropriate IMC tools depends not only on the target audience, but also varies in different phases of the product or service life cycle (Jarosławska-Sobór and Dulewski, 2014).

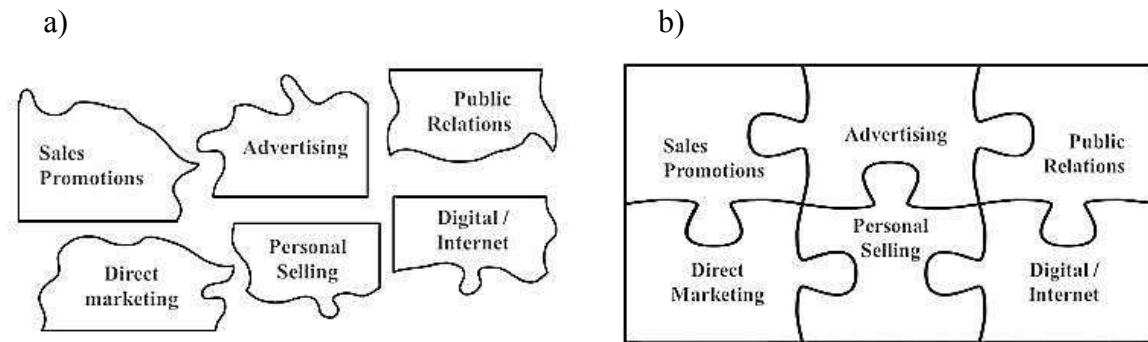


Figure 5. a) Typically disintegrated approach to the marketing communication; b) Integrated approach to the marketing communication (Key and Czaplewski, 2017).

According to Niemczyk (2014), the task of integrated marketing communication is to establish and maintain partner relations with various market participants. It must reflect the culture and style of the company by conveying the characteristics and values that have been adopted as specific to the company. Integrated marketing communication requires an implementation of the activities such as:

- the market surveillance and getting information needed to prepare an offer,
- a preparation and an implementation of a promotional plan (defining the promotion target, addressees, budget, executors, evaluation of the promotion),
- a selection of forms and means with use of synergy effects,
- a preparation of promotional messages in the way of:
 - minimizing the gap between the promise contained in the message and the value obtained in the product,
 - enabling an implementation of the communication and sales effect,
 - maintaining the consistency of the message due to the content, source and time,
- linking promotional activities with other elements of mix marketing,
- a coordination of all the activities by the person responsible for the company's marketing communication.

At the Institute of Logistics and Warehousing, e-marketing, which is a part of integrated marketing communication, is mainly carried out through websites, internet portals, social media, and e-mail newsletters. On the other hand, analytical and research tools in the marketing of scientific and research organizations, such as Google Analytics, SeoStat, Salesmanago, an advertising equivalent and a series of reports, are used to test the effectiveness and efficiency of marketing communication.

A skilful use and a combination of brand communication strategy and advertising activities increase the chances of reaching the customers/recipients.

360 Degree Marketing is another type of integrated marketing and it is nothing more than integrated activities based on a holistic advertising strategy. Its assumptions say that all the promotion channels are consistent and they must also be integrated with one another to effectively affect the recipient. The nomenclature is not accidental, it speaks of the entirety and unity of the carried out activities. Monitoring and evaluation of the undertaken activities are extremely important elements of such a strategy. This type of marketing is only effective, when the progressivity of the channels, not only in general, but also individually is analysed systematically. 360 Degree Marketing also means a comprehensive understanding of the brand, an awareness of its goals and mission, and then selecting the right tools and target group to achieve these goals (<https://virtualpeople.pl/blog/10-Marketing-360-czym-wlasciwie-jest>).

A recent study by Robinson (2017) shows how young people are involved in multi-task activities in media, so campaigns need to convey a coherent narrative across different media. To achieve this, a higher level of cooperation is needed among all the agencies involved in marketing campaigns for the company.

Jarosławska-Sobór et al. (2019) present the issues of Marketing Automation (MA) and the possibilities of using its tools in the operational activities of research and scientific organizations. MA is one of the most important trends in current marketing, which is a real challenge, when it comes to using it to build a competitive advantage. MA is a state-of-the-art, advanced technological solution aimed at streamlining marketing processes and a wider use of market and customer data. In everyday practice, it means all the activities in the field of automation of communication processes with potential and current customers. It has been assumed that MA is a technology that allows to automate and measure marketing tasks and workflow so as to be able to increase operational efficiency and accelerate revenue growth. Properly formulated content is delivered to potential customers and business partners via a pop-up banners, e-mails or social media redirection at the most appropriate moment. By using the tracking system on the website, the campaigns targeted at the potential business partners can be addressed. MA enables to run campaigns in all the channels at the same time, assuming that they are online channels. The article presents a case study of the GIG (Central Mining Institute), which started its implementation work by designing a completely new website. Its architecture is to provide users with comprehensive information about the offer. The preparation of a special JavaScript code and its implementation in the structure of the www.gig.eu website allowed the Institute's marketing departments to better understand the needs of potential customers and match them with the appropriate commercial offers. Registration forms that enable transferring the key data, such as an e-mail address, marketing consent and interest in a specific field of science, have been prepared. After signing up via the form, the customer goes to the contact manager and becomes a monitored contact. On this basis, the history of the activity of each customer, browsing the Institute's website, is created.

The Integrated Marketing is another type of marketing activity, which is nothing more than a collection of all the possible Internet advertising activities as shown in Figure 6. All the activities and channels, used in this type of marketing mainly have two purposes (<https://poradnikprzedsiębiorcy.pl/-marketing-zintegrowany-wszystko-co-nalezy-o-nim-wiedziec/>):

- increasing traffic on the landing pages,
- brand promotion and branding.

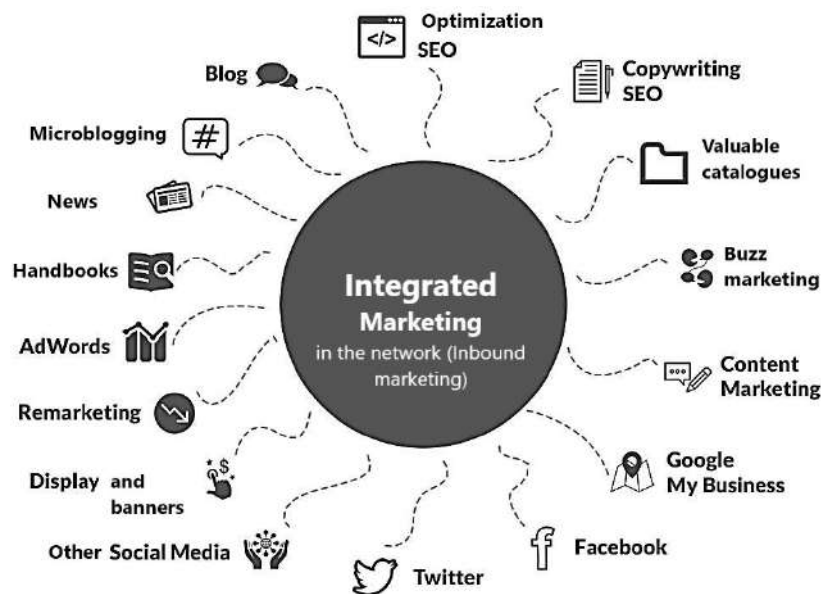


Figure 6. Marketing activities creating the integrated marketing (<https://marketingmind.pl/co-to-jest-marketing-zintegrowany/>).

Social Media are very important for the integrated marketing on the web, as they attract customers and attract their interest. The contents in social media should engage the audience and convey important and attractive information. Marketing integrated on the web, due to a synchronization of several means of communication, increases the chances of popularizing the content, which in turn allows to achieve a better sales effect. This type of marketing tries to surround the customer on all sides and put him at the centre of the activities. Integrated marketing on the web consists in coordinating actions that are to increase the final effect. It combines the possibilities offered by websites, Search Engine Optimization (SEO), social media, blogs, Search Engine Marketing SEM (sponsored links) or e-mail marketing. Consumers look for information about products on the Internet, that is why SEM is so important as regards helping customers to find the right page and make them become interested in its content. Positioning in search engines and the content must interest customers.

Marketing on social networks, better known as Social Media Marketing, has become an integral part of the business of the 21st century organizations. However, the literature in this area remains fragmented and focuses on single issues (Jurado et al. 2018).

Keller (2016) argues that the future of advertising and marketing communication will be determined by an increasingly diverse set of new digital options added to traditional media and communication options already available to marketers. By leveraging the unique strengths of different communication options and by combining and sequencing them strategically, marketers have the ability to drive sales and build brands in the ways that were never possible before. But such an approach will require new concepts, new tools and a new mindset.

Virtual reality is one of the new tools, described by Krasnov (2018) in his work that can be used by marketers. It is one of the technologies that can make a big difference in our lives in the next few years, so it is very important that we understand what it really is and what it can do now and in the future. Lack of content is the problem which the virtual reality can face. Since the number of users is still small, few people create content for the devices. There are already many platforms for content, but there are no unified standards yet. Virtual reality can create a new marketing platform that has yet to be discovered by many companies. VR allows creating more interesting content for receivers and gives them a more realistic experience than regular films or apps. Technology tricks the mind into thinking that you are somewhere else. Devices for receiving virtual reality can use both computers and mobile devices. Virtual reality is used by research institutes to support the process of servicing the mining machines and training the machine users at work stations (Winkler et al., 2010, 2013).

Virtual reality can be used to promote products and services in a completely unique way or to promote events. In the case of an institute for which the problem is to present its products (at least due to their dimensions) at fairs, the easiest way to benefit from virtual reality is to create good-quality content that can be presented at many events, as well as commissioning the production and renting a virtual reality headset with instructors for the fair. In the era of live streaming and 5G network, people will increasingly use Internet communication instead of travelling, and virtual reality will give the opportunity to be around the world staying at office or at home. Ads for those who use a VR headset are an effective way to get the message across. The persons using the VR headset are fully immersed in the content which they can see through the VR headset. The people, who have tried the VR solutions know that when using the VR goggles, it is almost impossible to do other tasks apart from focusing on the content as the view is blocked and the audio content must be listened to. This means that the user is less likely to be distracted during listening the broadcasted content, compared to the modern world, where distractions are everywhere. Virtual reality advertising continues to be marginally used, and YouTube is one of the few platforms that have made it possible. Virtual reality has the potential to really change the game, when it comes to marketing. While social media and digital marketing gain popularity, some companies try to come up with new ways to attract an audience, and virtual reality is one of the best ways to do so. Using VR, as a part of the marketing portfolio, is not an easy task as it requires a lot of effort, time and money. However, virtual reality has overcome the hype phase and it is in line with the Gartner hype cycle for new technologies (Figure 7). It is well on its way to becoming a mainstream product.

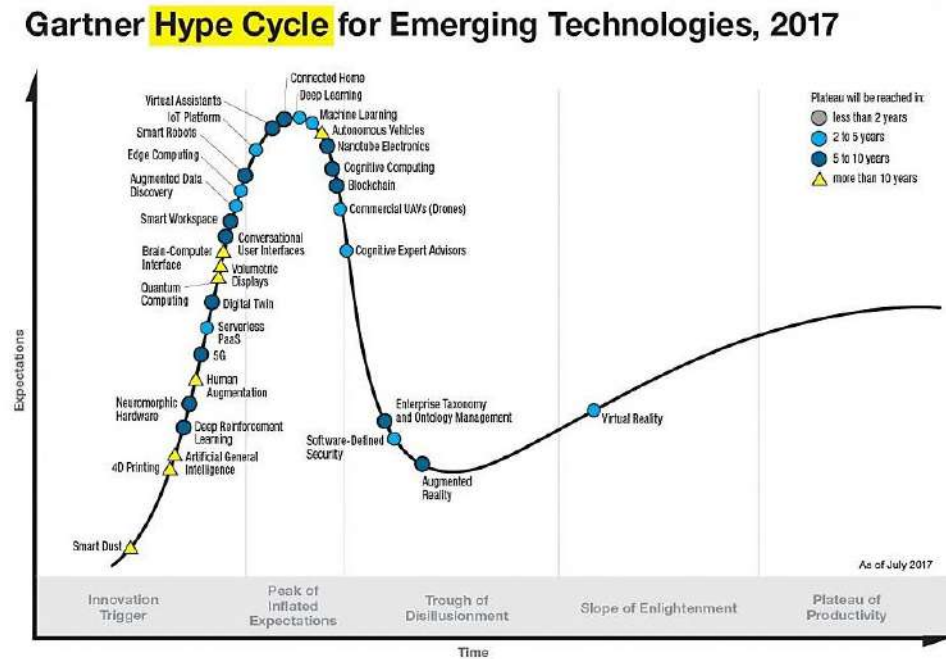


Figure 7. Gartner advertising cycle concerning emerging technologies (<https://www.gartner.com/smarterwithgartner/top-trends-in-the-gartner-hype-cycle-for-emerging-technologies-2017/>).

According to the specialists from [gartner.com](https://www.gartner.com), it should take from 2 to 5 years before virtual reality reaches the so-called "productivity plateau". The term "productivity plateau" means that an adoption to the mainstream is beginning to develop.

3. Conclusions

Offers of research institutes are specific and require the use of special solutions in marketing, and the new economic conditions, in which the research institutes currently operate, force them to introduce innovative solutions and implement new directions in the field of marketing activities. Research institutes should react and intensify marketing activities to strengthen their image and maintain the current one, as well as to acquire new markets for the offered products, including R&D projects results.

The marketing tools, which will work well for the sales of certain products or services, will not necessarily be applicable to other products. One of the ways is to get interested in the entrepreneur's innovation from the very beginning and to consider submitting a joint project within a scientific and industrial consortium. This solution guarantees that after the successful completion of the project, the developed innovation will be directly implemented by the industrial partner. The European Union, the main founder of research projects, places emphasis on cooperation between science and business, so in EU competitions, often the participation of a research organization and enterprise is

the condition for establishing a consortium. One example of such a solution, used in a research institute is described by Malec and Stańczak, 2020.

The activities of research institutes are also financed by subsidies and their own revenues. In the light of the introduced regulations regarding institutes, which are aimed at increasing the effectiveness of research and implementation activities of the research organizations by a comprehensive evaluation of scientific, research and development activities once every 4 years as well as a selection of appropriate tools seems to be extremely important to compete on domestic and international markets. It seems necessary to create a model of integrated marketing using the state-of-the-art technologies. The use of virtual reality in marketing activities seems to be an obligation, especially in a pandemic situation and impossibility of using traditional marketing tools.

References

1. *Co to jest marketing zintegrowany*. Available online <https://marketingmind.pl/co-to-jest-marketing-zintegrowany/>, 29.11.2020.
2. Flisiuk, B., & Gołąbek, A. (2015). Możliwości komercjalizacji wyników badań naukowych w instytutach badawczych-modele, procedury, bariery oraz dobre praktyki. *Zeszyty Naukowe. Organizacja i Zarządzanie/Politechnika Śląska*, 77, 63-73.
3. Harris, T.L. (1998). *Value-added public relations: the secret weapon of integrated marketing*. NTC Business Books.
4. Jarosławska-Sobór, S., & Dulewski, M. (2018). Wykorzystanie zintegrowanej komunikacji marketingowej we wprowadzaniu na rynek nowej marki. Case study Eko Patrolu Głównego Instytutu Górnictwa. *Marketing Instytucji Naukowych i Badawczych*, 4(30), 57-74.
5. Jarosławska-Sobór, S., Dulewski, M., & Wasilewski, F. (2019). Marketing Automation w jednostce badawczej-realna wartość czy mrzonka skuteczności. *Marketing Instytucji Naukowych i Badawczych*, 4(34), 21-42.
6. Jurado, D.B., Morales, D.S., Analuisa, F.L., & Hernández, S.V. (2018). Marketing estratégico en redes sociales de las organizaciones. Un abordaje 360°. *Revista Científica Ciencia y tecnología*, 18(17).
7. Kaźmierczak J., (2011). Inżynieria innowacji: techniczny wymiar wdrażania innowacyjnych rozwiązań w gospodarce. In: R. Kosala (ed.), *Komputerowo zintegrowane zarządzanie, t. 1* (pp. 463-472). Opole: Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją.
8. Keller, K.L. (2016). Unlocking the power of integrated marketing communications: How integrated is your IMC program? *Journal of Advertising*, 45(3), 286-301.

9. Key, T.M., & Czaplewski, A.J. (2017). Upstream social marketing strategy: An integrated marketing communications approach. *Business Horizons*, 60(3), 325-333.
10. *Komunikacja marketingowa*. Available online https://mfiles.pl/pl/index.php/Komunikacja_marketingowa, 4.12.2020.
11. Krasnov, M. (2018). *Using Virtual Reality and 360-degree Photos and Videos in Marketing*.
12. Malec, M., & Stańczak, L. (2020). A Generation of Innovative Technical Ideas and Solutions as an Important Component of the KOMAG Strategy. *Multidisciplinary Aspects of Production Engineering*, 3(1), 248-262.
13. *Marketing 360 czym właściwie jest*. Available online <https://virtualpeople.pl/blog/10-Marketing-360-czym-wlasciwie-jest>, 5.12.2020.
14. *Marketing zintegrowany*. Available online <https://poradnikprzedsiębiorcy.pl/-marketing-zintegrowany-wszystko-co-nalezy-o-nim-wiedziec>, 29.11.2020.
15. Maślanka, M.E. (2019). Uwarunkowania i kierunki działań marketingowych w polskich instytutach badawczych. *Marketing Instytucji Naukowych i Badawczych*, 1(31), 1-20.
16. Mikosik, P. (2018). Problemy współpracy nauki i biznesu. *Marketing Instytucji Naukowych i Badawczych*, 2(28), 99-120.
17. Niemczyk, A. (2014). Rozwój współpracy instytutu badawczego z przedsiębiorstwami w kontekście komunikacji marketingowej. *Marketing i Rynek*, 3(CD), 331-354.
18. Olędzki, J., & Tworzydło, D. (Eds.) (2008). *Public relations: znaczenie społeczne i kierunki rozwoju*. PWN.
19. Pluta-Olearnik, M. (2018). Zintegrowana komunikacja marketingowa – koncepcje, praktyka, nowe wyzwania. *Marketing Instytucji Naukowych i Badawczych*, 2(28), 121-138.
20. Robinson, H.R. (2017). Towards an enhanced understanding of the behavioural phenomenon of multiple media use. *Journal of Marketing Management*, 33(9-10), 699-718.
21. Slotorsz, A., & Cichoń, W. (2014). Marketing instytutów badawczych w świetle obecnych uwarunkowań organizacyjno-prawnych. *Marketing i Rynek*, 3(CD), 409-429.
22. Sojkin, B. (2014). Informacyjne uwarunkowania marketingu instytucji naukowo-badawczej. *Marketing i Rynek*, 3(CD), 393-405.
23. Szymańska A. (2004). *Public relations w systemie zintegrowanej komunikacji marketingowej*, 367-377.
24. *Top trends in the Gartner Hype Cycle for emerging technologies 2017*. Available online <https://www.gartner.com/smarterwithgartner/top-trends-in-the-gartner-hype-cycle-for-emerging-technologies-2017/>, 9.12.2020.
25. Ustawa o instytutach badawczych – Dziennik Ustaw z 2010 r., nr 96, poz. 618
26. Walasik, M. (2014). System działań upowszechniania innowacyjnych rozwiązań technologicznych zaimplementowany w instytucie naukowo-badawczym. *Marketing i Rynek*, 3(CD), 433-452.

27. Walasik, M. (2018). Orientacja marketingowa jednostek naukowo-badawczych jako wsparcie procesu komercjalizacji wyników B+R. *Marketing Instytucji Naukowych i Badawczych*, 4(30), 75-89.
28. Winkler, T., Michalak, D., Jaszczyk, Ł., & Rozmus, M. (2010). *Use of Augmented Reality technology in life of technical means*.
29. Winkler, T., Tokarczyk, J., & Michalak, D. (2013). Virtual working environment. *Handbook of loss prevention engineering*, 1, 393-421.

OUTSOURCING AS A MANAGEMENT CONCEPT IN THE LEGAL PLANE

Anna SVITANA

University of Wrocław, Faculty of Law, Administration and Economics, Wrocław; svitana.aa@gmail.com

Purpose: The purpose of the article is to analyze the legal regulation on outsourcing. Outsourcing is a contemporary phenomenon, which is on the development stage and there are no precise legal regulations in this area. Therefore, it is important to carry out research, clarify and systematize the provisions relating to such an extensive and complex form of activity of economic entities.

Design/methodology/approach: In this case, the subject of application is the analysis of judicial decisions, doctrine and legal practice.

Findings: The need for legal regulation in the field of outsourcing is very real. In particular, it is essential to make an introduction of the outsourcing definition in a separate act and point out the provisions specifying the outsourcing of services. Eventually, the limits of the outsourcing concept established by the legislator have to be specified, along with the appropriate interpretation and use of art. 23¹ of the Labor Code.

Originality/value: The current state of the legal regulation in the field of outsourcing was analyzed. The relationship, similarities and differences between outsourcing and taking over a workplace under Art. 23¹ of the Labor Code were presented.

Keywords: outsourcing, outsourcing agreements, legal qualification of outsourcing, takeover of the workplace.

Category of the paper: Research paper.

1. Introduction

The economic development of the modern economy is characterized by a variety of forms of economic activity, a fast pace of modernization and a very high level of competition. Intensively developing technologies and management techniques contribute to even higher level of production and services. At the same time, such conditions for the functioning of the economy pose new challenges, forcing economic entities to undertake activities in order to optimize their activities in order to achieve the highest possible efficiency, effectiveness and productivity.

The Polish Constitution of 1997 declares the freedom of economic activity, which is one of the basic and necessary principles of the Polish economic system. The scope and significance of the principle of freedom of economic activity for the functioning of entrepreneurs in the social market economy system, also defined by the constitution, is essential. According to Art. 20 of the Polish Constitution "A social market economy based on the freedom of economic activity, private property and solidarity, dialogue and cooperation of social partners is the basis of the economic system of the Republic of Poland". In Article 22 of the Constitution, the legislator specifies the scope of freedom of economic activity in the following wording: "Limitation of the freedom of economic activity is allowed only by statute and only due to important public interest" (Constitution of the Republic of Poland, 1997). The Act of March 6, 2018 Entrepreneurs' Law in Art. 2 indicates that "Taking up, performing and terminating business activity is free for everyone on equal rights" (Act, 2018).

One of the modern tools of the modern market economy is outsourcing (Zimniewicz, 2000). On the one hand, outsourcing is perceived as a management technique that helps to increase the efficiency of enterprises by reducing operating costs and, as a result, gain a competitive position on the market. On the other hand, outsourcing is an instrument of a strategic nature, which is perceived as a tool of organizational restructuring and changes, enabling the creation of very unusual organizational structures of enterprises (Trocki, 2001).

2. Outsourcing as a management strategy

According to the doctrine, outsourcing is a modern model of enterprise management, which involves the use of external services, which relieves the current operations of the enterprise and allows employees to focus on the most important tasks, i.e. the activity for which such an enterprise was established (Zimniewicz, (2000). Outsourcing may be a part of a new strategy, the manifestation of which is outsourcing (to an external partner) tasks not directly related to the core business of the company. It is a long-term contract of supporting departments to an external service provider (Trotsky, 2001). Thanks to this, the company can focus its resources and financial resources on those areas which constitute the basis of its activities, in which it achieves a competitive advantage. As part of outsourcing, the economic entity realizes "the possibility of using independent, external entities as suppliers of specific goods and services instead of the need to develop these spheres of activity within the enterprise" (Perechuda, 2000).

An important issue is to consider the business functions of an economic entity to effectively plan and outsource services. Due to the different roles of the company's organizational units, they can be divided into five groups (Marciniak, 2010):

1. Basic departments – directly performing the main functions of the enterprise (production cells in a production company, service or customer service).
2. Strategic departments – supporting organizational management functions in key areas: strategic planning, staffing of managerial staff, information flow and its processing, finance and controlling, shaping the organizational structure.
3. Coordinating departments – e.g. production, procurement, employment policy.
4. Staff departments – performing advisory functions in the field of, for example, legal services, public relations, recruitment and employee evaluation.
5. Auxiliary departments – performing purely service functions in the field of, for example: accounting, transport, data processing, environmental protection, health and safety.

Taking the above analysis into account, I propose the following definition of outsourcing. Outsourcing is a long-term contract obligating a specialized external company to perform the specific functions, which are necessary to provide the operational efficiency of the organization, which allows the organization to focus on its core activities.

Outsourcing can also be used as a form of business reorganization. It is closely related to the tendency of creating the so-called "slim" organizational structures and is the basic way for enterprises to depart from complex and often ineffective structures of economic activity.

3. Benefits and risks related to outsourcing

As a result of introducing outsourcing as part of its operations, the company may obtain the following potential benefits (Niedźwiedzińska, 2002):

- cost reduction – there is no need to incur costs related to creating and maintaining a job, social security, employee training,
- higher qualifications and experience of specialists from a specialized company,
- providing high-quality services,
- maintaining the desired number of jobs,
- easy access to the latest information technologies and achievements in the field of management and organization, the risk of technology aging is borne by the outsourcing company,
- development and focus on the company's core activities,
- increasing the company's efficiency by getting rid of routine and time-consuming tasks,
- greater stability – no dependence on illness, vacation or childcare,

The use of outsourcing also entails problems caused by failure to achieve the expected benefits. The main problems include failure to achieve the expected cost reduction, deterioration of the quality of functions previously performed independently, failure to develop a cooperation relationship with the service provider, disputes between the client and the service provider – regarding the quality of services and the amount of remuneration, and missing opportunities to achieve a better focus on customer needs and greater operational flexibility to meet these needs (Gay, and Essinger, 2002).

Despite the undoubted advantages of implementing outsourcing, there are also some risks that may cause losses, such as an increase in operating costs instead of the expected savings. The causes of this problem may lie in defective recording and settlement of costs, which causes their overvaluation, transaction costs related to the preparation and shaping of contracts and their control, especially in the provision of comprehensive services, and incorrect calculation of fixed costs, e.g. this applies to employees who have become redundant, and they cannot be otherwise engaged or released (Wesołowski, 2003). Another problem may be unfair attitude or the lack of high competences of the contractor of outsourcing orders, which may lead to insufficient quality of products and services. There is also a risk of becoming dependent on the client if a complex task is commissioned to a company with a monopolistic position. There are also security and confidentiality risks, although the outsourcing service provider has access to information that is often considered confidential. The risk is also an increase in costs that may occur as a result of the changing economic situation, as outsourcing contracts are often concluded for a period of several years. During this time, there may be changes in technology, customer expectations or legal changes, and no contracts are able to predict what the impact will be on doing business. Poorly planned outsourcing may also lead to the loss of many talented employees (Juchno and Kaszubski, 2001).

4. Regulations of Art. 23¹ of the Labor Code

The concept of employee outsourcing is often equated with the transfer of a workplace or part of it to a new employer, made in accordance with Art. 23¹ of the Labor Code. An important issue is to analyze and establish the relationship, similarities and differences between outsourcing and taking over a workplace under Art. 23¹ of the Labor Code. According to this article of the Labor Code, in the event of transfer of the workplace or part of it to another employer, it becomes, by operation of law, a party to the existing employment relationships. For obligations arising from the employment relationship, arising before the transfer of part of the workplace to another employer, the previous and new employer are jointly and severally liable. The transfer of the workplace or its part to another employer may not constitute a reason, which justifies the termination of the employment relationship by the employer. It should be

noted that within 2 months of the transfer of the workplace or its part to another employer, the employee may terminate the employment relationship without notice, with seven days' notice. The transferring employer and the employer taking over the workplace or part thereof are bound by the obligation to consult with trade unions and inform employees about the legal, economic and social reasons and consequences of such takeover of the workplace or part thereof (Act, 1974).

The provisions of the Labor Code do not contain the term "taking over the workplace". In this matter, particular attention should be paid to what are the premises for the Art. 23¹ of the Labor Code, and when they occur. Therefore, in this situation, we refer to judicial decisions. The Supreme Court in its judgment of June 7, 1994 indicated that the takeover of the workplace – within the meaning of Art. 23¹ of the Labor Code – should be understood broadly as all activities and events that result in a transfer to another person of the workplace in the objectively, completely or in the part. In other words, the takeover of the workplace always takes place when the assets related to the employment of employees are transferred to another person. The event causing the takeover of the workplace may be a legal act, both bilateral and unilateral, as well as another event, e.g. inheritance (reference number I PZP 20/94).

In the judgment of December 10, 2004, the Supreme Court stated that the transfer of a significant part of the employer's tasks to an external entity, without which the workplaces operated by both these employers could not function, leads to the transformation of employers within the meaning of Art. 23¹ of the Labor Code. It is unjustified to limit the normative impact of Art. 23¹ of the Labor Code only in cases where the transfer of a part of the workplace to a new employer is accompanied only by the transfer of separate material components that may create an independent employment institution (file reference number I PK 103/04). The transfer of the workplace or its part does not have to involve the acquisition of the enterprise or its part and does not depend on the type of legal act on the basis of which it takes place. The assessment that a part of the workplace has been transferred to a new employer depends on the determination that he actually took over some of the tasks or tasks constituting the employment institution (see the judgment of the Supreme Court of September 15, 2006, file reference number I PK 75/06). Agreements concluded between economic entities not aimed at the actual takeover of employees, referred to in art. 23¹ of the Labor Code, do not cause the workplace to "transfer" to another employer if under the concluded agreement, there was no actual transfer of employees to a new employer. So, the important issue is to determine whether the transfer of the workplace or part of it actually took place and was not an apparent action. Also, the Supreme Court in its judgment of 27 January 2016 I PK 21/15 indicated that the concept of the so-called outsourcing of HR and payroll services does not allow for determining the transfer of employees to a new employer within the meaning of Art. 23¹ of the Labor Code. The mere fact that remuneration is paid for work by another entity that maintains appropriate HR and payroll documentation in this respect is not a premise of taking over employees under Art. 23¹ of the Labor Code. The assessment of whether a part of the workplace (economic unit)

has transferred to a new employer requires determining whether the transferred part of the workplace (economic unit) has retained its identity, and in particular, depending on whether the activity of the economic unit is mainly based on human work or on assets; it is necessary to establish whether the new service provider took over the part of the employees or the property (material equipment) of the acquired entity which was decisive for its behavior (judgment of the Supreme Court of 26 February 2015, III PK 101/14).

The case law of the Supreme Court also shows that for the scope of automatic legal impact of Art. 23¹ of the Labor Code it is irrelevant whether the new employer performs an identical or only activity similar to the tasks performed by the current employer (Supreme Court judgment of 3 June 1998, I PKN 159/98). Moreover, the Supreme Court has repeatedly stressed that the normative impact of Art. 23¹ of the Labor Code takes place by operation of law, which means that the parties to a civil law contract may not modify the legal automatism in terms of the immutability of employment relationships of the acquired employees performing employee duties in the acquired part of the workplace (judgment of the Supreme Court of February 1, 2000, I PKN 508/99).

The provision of art. 23¹ of the Labor Code has a protective nature for employees of the acquired workplace and mainly regulates employee guarantees aimed at protecting the existing employment relationship and the obligations of the employer who takes over the workplace. This provision is also mandatory. This means that it will be applicable in any case of taking over the workplace. The parties to the employment contract cannot exclude its application – whether by concluding a separate agreement or an agreement excluding the application of Art. 23¹ of the Labor Code, or by concluding an annex to the employment contract (Walczak, 2009).

On the basis of the analysis of legal provisions and court case law, we can distinguish the basic conditions for taking over a workplace or part thereof pursuant to Art. 23¹ of the Labor Code:

1. all activities and events that result in a transfer to another person of the workplace in the meaning of the object, in whole or in part, in situations where:
 - a. assets related to the employment of employees are transferred, and/or
 - b. transferred essential spheres of tasks or competences, without which the established workplaces cannot be performed in the meaning of the subject,
2. actual takeover of the control of the workplace by a new entity, which becomes the employer,
3. maintaining the identity of the acquired unit,
4. the existence of employment relationships with employees employed to perform employee duties in the taken over part of the workplace. Such employment relationships are strictly and automatically protected by the application of Art. 23¹ of the Labor Code.

The Supreme Court stated that the takeover of the workplace may occur as a result of various legal events and actions (e.g. conclusion and termination of a lease agreement – (Resolution of the Supreme Court of June 7, 1994, I PZP 20/94), as well as e.g. as a result of death of an employer who is a natural person (Resolution of the Supreme Court of February 22, 1994, I PZP 1/94), as well as a result of the operation of legal provisions (resolution of the Supreme Court of June 16, 1993, I PZP 10/93). it may be the result of a joint action of the taking over and the taken over ("new" and "old" employer), but also against the will of one or even both of them under the Act (Supreme Court of 29 August 1995, I PRN 38/95).

In connection with the above, whether the conditions contained in Art. 23¹ § 1 of the Labor Code, it is not the contracts and agreements concluded between the parties that decide, but the factual circumstances identifying the normative concept of transfer of the workplace. Performing legal acts in a manner inconsistent with the standards of employee protection under Art. 23¹ of the Labor Code should be considered as an action conflicting with the law referred to in art. 58 § 1 of the Civil Code, and thus invalid. The assigned effect of invalidity means that the employer has not changed (judgment of the Provincial Administrative Court in Gliwice of 04/10/2017, I SA/Gl 231/17) (Walczak, 2009).

5. Outsourcing legal qualification

The services necessary to maintain and perform the proper functioning by the enterprise do not necessary have to be provided by employees or co-workers, as evidenced by the common practice of outsourcing. Services necessary to run the business of an economic entity, performed somewhat outside of it by another economic entity – are provided on the ground of civil law contracts between these economic entities (Dąbrowska, and Szydlik, 2013).

For the legal qualification of outsourcing, the form of cooperation and the type of legal relationships between business entities are important.

The main issue will be to define the links between entities in economic trading and the goals and procedure of building partnership relations. By applying the criterion of the method of establishing a legal relationship under outsourcing, we can distinguish the following forms of outsourcing:

1. The organization entrusts the performance of specific functions to the service provider, specifying the effects and expectations that the client intends to achieve. In this case, outsourcing will be the initial entrusting to another entity of the activity or its part, not yet performed by the regulated entity. Yes, for example, we are talking about creating a new enterprise, starting a business or introducing new directions of activities (production, services). In such a situation, there are usually contractual links with the use of the services of the contractor (both related to the entity within the group and

external to the entity) in order to permanently perform activities that would be performed by the regulated entity, now or in the future. Purchase and sale agreements, e.g. contracts for the purchase of standard products, equipment, materials or software, will not be treated as outsourcing.

2. Handing over to external service providers, on the basis of contracts (contracts), recurring internal tasks of the organization carried out by it and transferring them to other economic entities for implementation, i.e. transfer of activities (or its part) to another entity. In this case, outsourcing becomes a tool for the restructuring of enterprises and an element of transactions carried out in connection with the separation of functions related to their implementation of employees, machines, devices, equipment, technologies and other resources as well as decision-making competences regarding their use.

The concept of outsourcing is not explicitly defined in the law. The outsourcing mechanism is not marked with any specific legal structure. We also draw on the regulations in this area from the judicature of the courts. Yes, the Supreme Court in the judgment of 27 January 2016, file ref. Act I PK 21/15 indicated that the essence of outsourcing consists in separating from the organizational structure of a parent enterprise certain functions performed by this enterprise and transferring them to other economic entities for implementation. The subject of the order is primarily activities not related to key competences of complementary and auxiliary nature. Namely, activities that are irreplaceable elements, decisive for competitive advantage and which constitute the core of the company's core business should not be excluded from the outside. When assessing whether we are dealing with an outsourcing agreement, we need to consider the judgment of the Supreme Court of 27 January 2016, ref. No. act I PK 21/15, in which the Supreme Court indicated that the basic feature distinguishing employee outsourcing from employing own employees or providing work by temporary employees is the lack of direct and permanent subordination (both legal and actual) of contractors to the entity (insourcer) at which such services or work are performed. In the case of assigning an employee by an outsourcer to work in another entity, this employee may be subject only to indirect and short-term supervision in the new workplace.

Based on the analysis of doctrine, jurisprudence and practice, we can distinguish the basic premises of outsourcing as a management strategy in the legal plane:

1. determining the functions necessary for the effective operation of the enterprise as the subject of the order that do not relate to key competences, but are complementary and auxiliary,
2. transferring the subject of the order to other economic entities,
3. lack of direct and permanent subordination (both legal and actual) of contractors to the entity where such services or work are performed,
4. cooperation on the basis of civil law contracts between the economic entity ordering the performance of specific functions and the entity accepting the performance of the ordered tasks.

6. The essence of outsourcing agreements

When separating specific functions or areas of activities from the organization's structure and transferring them to external outsourcing partners for execution, it is necessary to establish cooperation with a company that handles the outsourced functions on mutually beneficial terms. At the same time, it is necessary to take into account the fact that outsourcing consists of building a strategic partnership for a long-term perspective.

When specifying the sources of law regarding the conclusion of contracts, it is necessary to indicate the regulation of the Act of 23 April 1964 – Civil Code (Journal of Laws No. 16, item 93, as amended) and other acts, but not limited to the law positive. Customs, both local and international, play a significant role, considering that they are known or should be known to the parties. This is especially true of professionals who are assumed to know the established habits in business transactions. Moreover, agreements are influenced by international regulations. Apart from the provisions of legal acts, as well as the views of the doctrine, court judgments play an important role (Wojtowicz, 2010).

Due to the lack of legal regulations regarding the outsourcing agreement, the indication of its characteristics is based on the views of the doctrine, jurisprudence and legal practice. A common solution is the conclusion of outsourcing contracts, the subject of which are auxiliary services related to the internal needs of the company (cleaning, accounting services, HR services, OHS, IT, etc.), which allows the entrepreneur to focus on the core subject of activity. However, there are no clear criteria which characteristics should be met by this area of the company's proper activity, which will be entrusted to an external company under an outsourcing agreement. However, an incorrect situation should be considered when an external company, on the ground of an outsourcing agreement will provide exactly the same services that the entrepreneur will also provide in person or through other external companies – then the external company will not be transferred to specific functions, separated from the entrepreneur's organizational structure (Owl, 2019).

On February 25, 2019, the EBA (European Banking Authority) published guidelines on outsourcing, addressed to financial institutions. According to these guidelines, outsourcing is defined as the relationship between a financial institution and an external service provider, on the basis of which the provider carries out activities that would otherwise be performed by the institution itself. The institution specifies a catalog of activities outsourced to the service provider (Kaniewski, Węgrzyn, 2019). The Financial Supervision Authority (UKNF), taking into account the EBA guidelines, expressed its position on this matter, where, inter alia, it's indicated that the outsourcing agreement should contain a closed catalog of processes, services and activities, the performance of which will be entrusted with a clear indication of the decision-making entity competent for all stages of their implementation. The annexes to the outsourcing agreement may contain graphic presentations of individual processes subject to

entrustment, along with an indication of individual activities / steps in the process and the determination of the decision-making entity (Position of the KNF Office, 2019).

It is important to properly formulate the provisions of the employee outsourcing agreement, which is safer to conclude in writing, although it is not a formal requirement. Such an agreement will be an important evidence during a possible inspection of the Tax Office, Social Insurance Institution or PIP for the employment of employees with an employer other, than for whom they provide work. It should be borne in mind that the greater the influence of the current employer on the shaping of the employment relationship of employees with the new employer (e.g. recording working time, granting leaves, deciding on the amount of remuneration), the greater doubts may arise on the part of the supervisory authorities in determining who is the actual employer. When using employee outsourcing in the correct way, it is therefore necessary to actually separate from your enterprise a department or departments that perform auxiliary functions, not related to the company's main activity and use an external company in this area, i.e. not to interfere in the relationship between the outsourced employees and their new employer (Socha, 2018).

7. Summary

"Takeover of a workplace or its part" and "outsourcing" are separate legal institutions. As indicated in the previous chapters, each of these institutions has its own features and are used to perform separate tasks in the course of trade. The issues of transferring the workplace or its part mainly related to organizational changes of business entities, and the regulation of art. 23¹ § 1 of the Labor Code it will take place in every situation with regard to the succession of rights and obligations arising from employment relationships.

The main goal of outsourcing, in its most general terms, is to increase the effectiveness and efficiency of your business. The main strategic goal is to focus the company on its key activity, which determines its competitive position and development prospects. As a result, there is an increase in the freedom of selection of partners and the conditions for cooperation with them (IT Outsourcing/Definition and purpose of outsourcing, 2002-2020). Outsourcing of services may lead to the transfer of the workplace or its part to a new employer, made in accordance with Art. 23¹ of the Labor Code. However, the circumstances for taking over the workplace or part of it may also occur in other situations, for example, when companies are split or merged according to the provisions of the Code of Commercial Companies (Act, 2000). On the other hand, outsourcing of services will not always be associated with the need to take over the workplace. Such a newly established company may entrust the designated functions to external entities from the very beginning. Also, the Supreme Court in its judgment of 13 April 2010, I PK 210/09 on employee outsourcing, expressed the view that entrusting the performance of

auxiliary tasks by the employer to an external entity providing services in this area (outsourcing) may not constitute a transfer of a part of the workplace to another employer (Article 23¹ § 1 of the Labor Code), if it is not supported by a comprehensive assessment of such circumstances as the type of establishments, acquisition of assets and intangible assets, acquisition of the majority of employees, acquisition of customers, and in particular the degree of similarity of activities carried out before and after taking over the tasks.

Taking into account the analyzed circumstances, it should be noted that outsourcing is not only a powerful management strategy, but also a multilateral legal, economic and social structure. Despite the risk and often complicated procedures it entails, outsourcing has been present in the global economic turnover for many years. Thanks to the advantages and benefits, outsourcing services are provided on a large scale. Unlike the other trends in management, the concept of entrusting activities to an external entity has stood the test of time. It is important to adjust the legal regulations to the needs of the practice. The considerations presented above show that there are still many issues to consider, analyze and implement at the level of legal regulations, and there is a need to adapt the regulations to the realities of economic transactions. Most of the current regulations are based on judicial decisions and standards set by international organizations. The differences are mainly due to the practice in a given country and experience in international trade.

References

1. Act of June 26, 1974, the Labor Code. Journal of Laws, 1998, No. 21, item 94, as amended.
2. Act of March 6, 2018, Entrepreneurs' Law, Journal of Laws No. 2018, item 646.
3. Act of September 15, 2000, Code of Commercial Companies, Journal Of Laws 2000 No. 94, item 1037.
4. Constitution of the Republic of Poland of 02.04.1997, Journal of Laws No. 78, item 483.
5. Dąbrowska, A., Szydlik, A. (2013). *Element of outsourcing in the classification of disposal transactions assets*. Retrieved from <http://www.codozasady.pl/element-outsourcingu-w-klasyfikacji-transakcji-zbycia-skladnikow-majatku/>, 28.10.2020.
6. Gay, C., Essinger, J. (2002). *Strategic outsourcing – concept, models, implementations*. Krakow: EAS.
7. https://www.knf.gov.pl/knf/pl/komponenty/img/Stanowisko_UKNF_ws_outsourcingu_67075.pdf, 10.10.2020.
8. *IT outsourcing. IT orders portal*. Available online <http://outsourcingit.pl/definicja>, 26.11.2020.
9. Juchno, R., Kaszubski, R. (2001). Outsourcing in banking activities. *Głosa*, No. 6, p. 5.

10. Kaniewski, P., Węgrzyn, Ł. (2019). *The EBA has spoken: new guidelines for outsourcing*. Retrieved from <https://ssw.solutions/pl/eba-przemowila-nowe>, 15.09.2020.
11. Marciniak, J. (2010). *Outsourcing – the concept and basics of using this solution*. Retrieved from <https://sip.lex.pl/komentarze-i-publikacje/komentarze-praktyczne/outsourcing-pojecie-i-podstawy-stosowania-tego-469831068>, 11.08.2020.
12. Niedźwiedzińska, H. (2002). Outsourcing as a modern tool of e-economy. *Acta University of Lodz. Oeconomica foil*, 157, pp. 191-198.
13. Perechuda, K. (ed.) (2000). *Business management of the future*. Warsaw: PWE.
14. Resolution of the Supreme Court of 7 June 1994, I PZP 20/94. Retrieved from www.sn.pl, 08.11.2020.
15. Socha, J. (2018). *Employee outsourcing – when can it be challenged?* Retrieved from <https://poradnikprzedsiębiorcy.pl/-outsourcing-pracowniczy-kiedy-moze-zostac-zakwestionowany>, 23.09.2020.
16. Sowa, A. (2019). *Employee outsourcing – the most important clauses in contracts*. <https://iuridica.com.pl/outsourcing-pracowniczy-najistotniejsze-klauzule>, 12.10.2020.
17. The judgment of the Supreme Court of 26 February 2015, III PK 101/14. Retrieved from www.sn.pl, 19.11.2020.
18. The judgment of the Supreme Court of 27 January 2016. I PK 21/15. Retrieved from www.sn.pl, 15.11.2020.
19. The judgment of the Supreme Court of 29 August 1995, I PRN 38/95. Retrieved from the LEX website, 12.11.2020.
20. The judgment of the Supreme Court of 9 December 2004, I PK 103/04. Retrieved from www.sn.pl, 10.11.2020.
21. Trocki, M. (2001). *Outsourcing. Business restructuring method*. Warsaw: PWE.
22. Walczak, A. (2009). *Takeover of the workplace and its employees*. Downloaded from <https://e-prawnik.pl/artykuly/przejecie-zakladu-pracy.html>, 19.09.2020.
23. Wesołowski, S. (2003). The status and prospects of outsourcing. *Materials Management and Logistics*, No. 4, pp. 10-11.
24. Wojtowicz, E. (2010). *Concluding contracts between entrepreneurs*. Retrieved from <https://sip.lex.pl/komentarze-i-publikacje/monografie/zawieranie-umow-miedzy-przedsiębiorcami-369211509>, 14.08.2020.
25. Zimniewicz, K. (2000). *Contemporary concepts and methods of management*. Warsaw: PWE.

INNOVATIVE COMPANY PROFILE: AGE, SIZE AND SOURCES OF FINANCING

Katarzyna SZUPER

Maria Curie-Skłodowska University in Lublin, Poland; katarzyna.szuper@live.umcs.edu.pl,
ORCID: 0000-0003-4191-336X, PhD Student

Purpose: The purpose of this work is to presents the features of an innovative company, especially age, size and sources of financing. In addition, the paper shows the impact of these features on the company's innovation and the relationship between age, size and the available financing methods.

Design/methodology/approach: Due to the cognitive nature of the article, the aim of the work will be achieved using the method of analyzing the literature on the subject. Literature studies include Polish and foreign publications.

Findings: Innovations are the basis for the functioning of enterprises in competitive markets. Innovative enterprises are able to adapt to environmental conditions and quickly respond to the needs of consumers. The presented research confirms the positive relationship between the increasing size of the company and the growing level of innovation. In the case of the relationship between the development stage and innovation, it is indicated that younger companies are more inclined to implement innovations than mature ones. It is worth emphasizing that the degree of innovation of a company, in addition to its size and maturity, also depends on many other factors, including: type of innovation, enterprise, industry or business model.

Originality/value: The article is a review of the literature on innovative company. This work can help entrepreneurs who want to innovate their companies and achieve long-term growth because it allows to understand the impact of a company's size and maturity on its level of innovation. Moreover, managers can find out what sources of capital they can use depending on the characteristic of their enterprise.

Keywords: innovative company, innovations, age company, size company, sources of financing.

Category of the paper: Research paper.

1. Introduction

Enterprises operating in competitive markets, must build their position on the basis of innovations in order to effectively compete with others. Growing consumer demands result in the need to constantly implement innovations. The faster a company responds to the needs of the market, especially the niche market, the better it has a chance of survival. Innovations must be implemented at every stage of the company's operation. However, the scale and the type of innovation depend on the size, maturity and financial capacity of the company. Access to various sources of capital is of great importance, without which enterprises cannot start long-term and often uncertain innovative activities. The availability of various ways to raise capital, in turn, depends on the size and degree of development of the company.

Due to the above, the work focuses on presenting the features of an innovative company, especially age, size and sources of financing. These are features that influence each other and determine the innovative activities of enterprises. The work is based on an analysis of the literature.

2. Innovative company

Innovations bring many benefits to enterprises, therefore it is believed that they are the basis for the functioning of modern enterprises. They allow firm to stand out on the market and gain a competitive advantage. The concept of an innovative enterprise should take into account economic conditions, and above all, technological progress. Organizations in highly developed countries have replaced the extensive development model based on quantitative development, without qualitative and structural changes, with an innovative model based on human resources. Innovative enterprises are entities which can create, absorb and sell new products or services. They can make constant changes and adapt to changes taking place in their environment. They quickly respond to market needs by introducing new solutions, technologies and forms of marketing (O'Sullivan, 2000).

Innovative enterprises are distinguished by (Białoń, 2010):

- a wide range of R&D works,
- systematic introduction of scientific and technical novelties,
- high share of new technological, product and organizational solutions,
- introducing innovations to the market,
- having the ability to predict the future,
- flexibility of operation; having creative teams of employees,
- the ability to use the innovative potential,
- cooperation with clients; ability to continuously generate innovation.

An innovative company should be an organization which learns, *inter alia*, from through experience, based on knowledge and working in networks created by entities from the external environment. In innovative enterprises, the main place is taken by knowledge, organizational structures are flattened, intellectual capital is constantly enlarged and developed. An innovative enterprise can be considered as an organization that facilitates team learning among employees and is constantly changing. The company is a place where new knowledge and new skills are created. It is customary for innovative companies to cooperate with scientific and research units, but also with the client (Jasiński, 2000). Usually, innovative enterprises are able to find a niche in the market and maintain a long-term competitive advantage (Porter, 1980). The company's innovativeness is assessed on the basis of its involvement in innovative activities and the introduction of at least one innovation by it during the period under study (the recommended period should be from one year to three years). There are three types of innovative companies:

- companies with at least one innovation, their innovative activity is continuous,
- companies that have introduced innovations, but do not carry out further innovative activities,
- companies that have not implemented innovations but are actively working to do so in the near future.

It is very rare for a company to be inactive in innovation, but such situations may arise when actions were taken earlier than the research period and their implementation did not result in the introduction of innovations (OECD, 2018). The resources at the disposal of a company have a large impact on its degree of innovation activity. These include human capital, tangible and intangible assets, business experience and available financial resources.

3. Size of the innovative company

In line with Schumpeter's views, many economists argue that larger firms are more innovative (Cohen, and Klepper, 1996). The most popular measure of company size is the number of employees (preferably converted to full-time jobs) and turnover. Another measure may also be the value of assets held, useful for the productivity analysis (OECD, 2018). Large enterprises have greater financial, marketing, research, etc. opportunities, which facilitate the implementation of innovations. They also have a greater tolerance for potential losses due to unsuccessful innovations. Additionally, they can employ more skilled workers and therefore have a higher technological potential (Damanpour, 1992). Large, innovative companies create the flexibility and autonomy required for innovation by organizing smaller, specialized branches while maintaining the advantages of large sizes. Although some economists indicate that large companies may be a barrier to the development of innovation. Small businesses are more flexible, have a greater ability to adapt and improve, and accept and implement changes

faster (Mintzberg, 1979). The strength of the relationship between size and innovation depends on the industry. It should be emphasized that the size of the enterprise influences to a greater extent the innovation of production enterprises than service enterprises, as well as profit-oriented enterprises than non-profit enterprises. Small businesses tend to have a high level of innovation in industries where manufacturing costs are low (Damanpour, 1992).

The research conducted by N. Bosma and G. de Wit (2004) also confirms that along with the size of the company, its innovation grows. The authors point out that larger companies are better at coping with market uncertainty and have greater opportunities to apply for subsidies. however, this Research shows, that patenting innovations is associated more with a smaller enterprise size.

The size of the enterprise also affects the type of innovation introduced. Small companies are not interested in introducing process innovations, mostly medium-sized companies do it (Fang, 2009). With the size of the company, the likelihood of the emergence of product innovations increases, which stimulate market expansion, increasing both sales and employment, thus influencing the growth of the size of companies (Bogliacino, and Pianta, 2010). A. Vaona and M. Pianta (2008) took into account the strategies of innovative activity in their research and noticed that product innovations result from the search for technological advantage and are based on the strategy of market expansion and patent activity. In contrast, process innovations result from a price competitiveness strategy achieved through flexible production, larger markets and greater investment in machines related to innovations. Small companies have little opportunity to compete with large companies in the above-mentioned strategies, because they do not have such extensive sales markets and cannot incur such high investments in machines, which at the same time reduces their innovation compared to large organizations. Research based on the business model shows that large enterprises are successful in targeting innovation towards customer relationships, while medium-sized enterprises should target their innovation at suppliers. It is emphasized that smaller companies depend on the big ones to undertake innovative projects, and cooperation helps to overcome limitations. On the other hand, large companies are under great pressure, above all, from stakeholders to introduce innovations for sustainable development (Aguilar-Fernández, and Otegi-Olaso, 2018).

One of the more recent studies focuses on the relationship between company size and the implementation of eco-innovations which improve environmental performance (Carrillo-Hermosilla et al., 2010). The research shows that large companies use more advanced management processes and better cope with the external situation based on their experience, therefore they are more environmentally open. They better fulfill their social obligations and thus implement more eco-innovations. An additional advantage of large enterprises is organizational maturity and a clear internal structure. These companies are seen as specialists in implementing eco-friendly innovations because this innovations are more effective when

implemented on a large scale. Thus, it discourages small businesses from introducing eco-innovation (Lin et al., 2019).

Most studies confirm a positive relationship between the size of the company and the level of its innovation. However, it should be remembered that many factors can influence the strength of this relationship. These are i.a. type of innovation, sort of enterprise, industry or business model.

4. Age of an innovative company

Apart from the size of the enterprise, age is a very important indicator of innovative companies as it reflects accumulated experience. Older companies have a chance to gather more knowledge on how to implement changes and obtain the desired results from them. Longer time of learning can affect company's ability to innovate as well as its results. On the other hand, younger companies may be more agile in implementing innovations. The age of the enterprise is calculated as the number of years in which the enterprise was economically active (OECD, 2018).

Young companies introduce product innovations more often because they are more flexible and react faster to the needs expressed by the market, especially the niche market. In addition, they more easily overcome the constraints of capital resources when introducing new products. Older companies may introduce innovations in order to maintain their position or increase their competitive advantage. At the same time, mature companies are more oriented towards implementing process innovations (Pellegrino, and Piva, 2020).

In the low and medium technology sector, young innovative companies are perceived as being able to achieve better results from their innovative activities. They do not have a strong position in high-tech industries. Young companies complement the innovative strategies of mature companies, successfully invest in new solutions, but do not exceed long-term entities (Cincera, and Veugelers, 2014). It often happens that young companies introduce breakthrough innovations, on the basis of which mature companies introduce new innovations by improving and developing the full potential of these innovations. The effectiveness of these processes depends on the strength of intellectual property protection and control over these assets (Gans et al., 2002).

The quality of technical innovations declines with the age of the company. Research confirms that as the enterprise ages, the cost reduction benefits of learning are more than offset by the diminishing benefits of technological advances. The older the enterprise is, the lower the profits are, with the same degree of R&D intensity (Balasubramanian, and Lee, 2008).

A study of Italian companies confirms that aging means building resources and capacity, although the correlation between the frequency of product innovation implementation and age is negative. At the same time, the long-term tenure of the president and the long time since the introduction of the last innovation reduce the company's tendency to product innovations (Cuculelli, 2018).

On the other hand, a study conducted on Spanish companies confirms that young companies are more affected by a lack of financial resources than mature ones. The lack of skilled workers is an obstacle for companies, while only older companies actually perceive it. Finally, older companies face obstacles related to market conditions and demand, which means that they have not been able to keep up with its changes (Pellegrino, 2018).

Enterprises entering the market are usually associated with less innovation, but have a very high potential. At the same time, exiting firms have poor innovation performance. Middle-aged firms appear to be almost as active, if not more than newcomers (Huergo, and Jaumandreu, 2004).

The youngest companies more often give up their innovative projects at the concept stage. However, most often older companies give up projects aimed at introducing radical and incremental innovations. (Coad et al., 2016).

A review of the literature on the age of the enterprise and its innovativeness indicates that younger companies are characterized by higher innovativeness, despite many barriers, mainly financial. It is worth noting that the degree of innovation may differ depending on the industry, the level of technological advancement or the type of innovation.

5. Methods of financing innovative enterprises

Finance is a key part of innovation, it enables research to be carried out, necessary technologies to be implemented, and innovation to be developed and commercialized. Innovative enterprises sometimes have difficulties in obtaining capital. This is due to the unique features of innovative activities. It cannot be fully protected, therefore there is a fear of imitating the developed solutions. This results in an increased risk for capital providers. What's more, innovation processes tend to be lengthy and uncertain (Bernstein, 2017). Acquiring an effective and cheap source of capital is a huge challenge for companies.

There are many sources of financing for innovative activities. Usually, enterprises finance their activities with equity capital, which can be divided into internal and external. Internal capital includes, among others: reinvested profit, depreciation expenses. External capital includes share capital increase, issue of shares/bonds, Venture Capital. The sources of capital can be divided into private capital (credits, loans, factoring) and public capital (subsidies from the state budget or public entities). In addition, there are other options for dividing sources of

capital. It is worth emphasizing that enterprise financing is closely related to the cost of capital and risk (Sosnowska et al., 2003).

Financial needs and the availability of various types of capital sources are closely related to the stage of development of a given organization. At the initial stage of business development, due to the lack or little experience, the enterprise may have limited access to external sources of capital. In the initial phase when research is developed and carried out, there is great uncertainty about the emergence of innovations and their quality. Enterprises usually finance their activities with equity. It is also possible to get money from crowdfunding. It is an increasingly popular way of financing young, innovative companies (Hervé, and Schwienbacher, 2018). It is also possible to receive public support at this stage. The market usually provides less money for innovation than the companies need. For this reason, many governments develop innovation policies that allow them to subsidize the innovative activities of enterprises. Authorities can use various instruments, such as research and development grants, pre-commercial procurement, tax breaks (Hölzl, and Peneder, 2019). With the development of the enterprise and the increase in the advancement of innovative activities, new opportunities for obtaining capital appear. Business angels or venture capitalists who are knowledgeable about new technologies and who can take a lot of risk can secure money for the company. Mature enterprises can obtain money from more traditional capital suppliers (bank, capital market). This allows for further expansion of the company and carrying out innovative activities on a larger scale (Figure 1) (Ottosson, 2019).

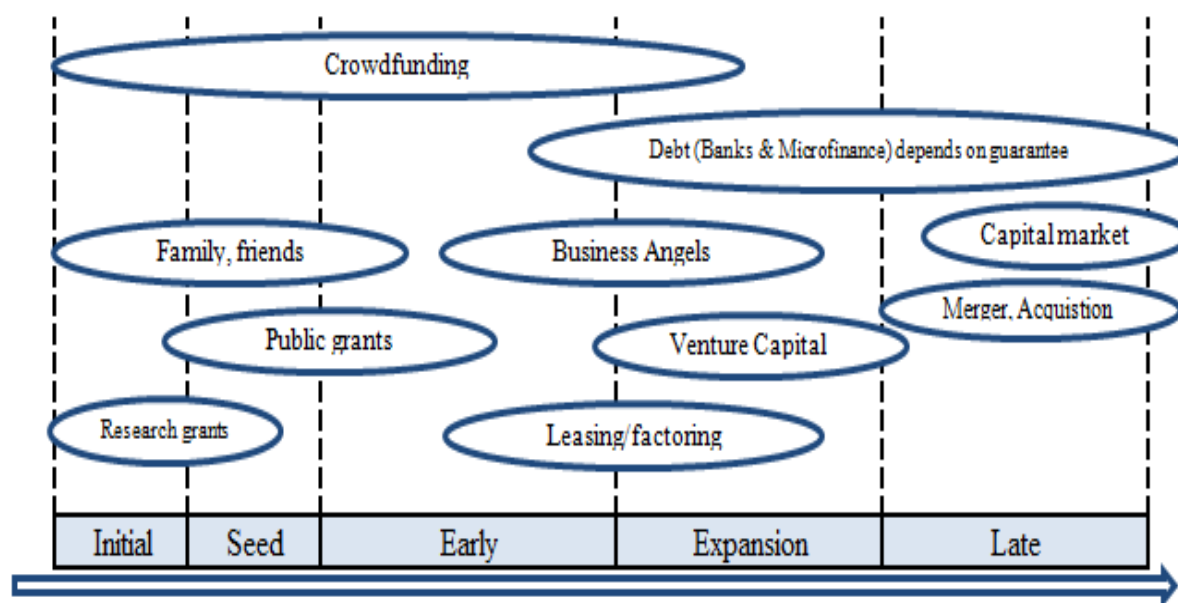


Figure 1. Sources of financing an innovative company depending on the stage of its development. Source: own study: Rossi, M., Lombardi, R., Siggia, D., & Oliva, N. (2015). The impact of corporate characteristics on the financial decisions of companies: evidence on funding decisions by Italian SMEs. *Journal of Innovation and Entrepreneurship*, 5(1), p. 3.

Access to these mentioned sources depends on the size of the enterprise. Large organizations can more easily finance their activities using their own funds, obtaining a bank loan, issuing bonds or raising capital on the stock exchange. Small and young enterprises have much more limited funding opportunities. They often have to rely on capital borrowed from family or friends before they can obtain capital from other sources (Bravo-Biosca et al., 2012).

6. Summary

Innovations are the basis for the functioning of enterprises in competitive markets. Innovative enterprises are able to adapt to environmental conditions and quickly respond to the needs of consumers. They are characterized by high expenditure on research and development, introducing new products and services to the market, and the use of modern technologies. Above all, they are the sources of knowledge generation through highly qualified employees. The presented research confirms the positive relationship between the increasing size of the company and the growing level of innovation. In the case of the relationship between the development stage and innovation, it is indicated that younger companies are more inclined to implement innovations than mature ones. It is worth noting that both large and more developed enterprises have greater opportunities to obtain capital for their innovative activities, due to their experience and the possibility of securing them. Small and young companies usually struggle with financial problems using their own funds or borrowing cash from friends. Young companies usually have a high innovation potential, while mature companies introduce small changes that allow them to maintain their long-standing position on the market.

It is impossible to clearly indicate the features of an innovative company, because the degree of innovation of companies, in addition to size and maturity, also depends on many other factors type of implemented innovation, sort of enterprise, industry or business model.

References

1. Aguilar-Fernández, M.E., & Otegi-Olaso, J.R. (2018). Firm size and the business model for sustainable innovation. *Sustainability*, 10(12), p. 4785.
2. Balasubramanian, N., & Lee, J. (2008). Firm age and innovation. *Industrial and Corporate Change*, 17(5), pp. 1019-1047.
3. Bernstein, S. (2017). Public equity markets and innovation. *ADB Working Paper, No. 772*, Tokyo: Asian Development Bank Institute (ADB).

4. Białoń, L. (ed.) (2010). *Zarządzanie działalnością innowacyjną*. Warszawa: Wydawnictwo Placet.
5. Bogliacino, F., & Pianta, M. (2010). Innovation and employment: a reinvestigation using revised Pavitt classes. *Research Policy*, 39(6), pp. 799-809.
6. Bosma, N., & de Wit, G. (2004). The influence of innovation on firm size. *EIM Business and Policy Research*. No. N200318.
7. Bravo-Biosca, A., Cusolito, A.P., Hill, J.P.W. (2012). *Financing business innovation: review of external sources of funding for innovative businesses and public policies to support them*. Washington: World Bank.
8. Carrillo-Hermosilla, J., Del Río, P., & Könnölä, T. (2010). Diversity of Eco-innovations: Reflections from selected case studies. *Journal of Cleaner Production*, 18, pp. 1073-1083.
9. Cincera, M., & Veugelers, R. (2014). Differences in the rates of return to R&D for European and US young leading R&D firms. *Research Policy*, 43, pp. 1413-1421.
10. Coad, A., Segarra, A., & Teruel, M. (2016). Innovation and firm growth: does firm age play a role? *Research policy*, 45(2), pp. 387-400.
11. Cohen, W.M., & Klepper, S. (1996). Firm size and the nature of innovation within industries: the case of process and product R&D. *The review of Economics and Statistics*, pp. 232-243.
12. Cucculelli, M. (2018). Firm age and the probability of product innovation. Do CEO tenure and product tenure matter? *Journal of Evolutionary Economics*, 28(1), pp. 153-179.
13. Damanpour, F. (1992). Organizational size and innovation. *Organization studies*, 13(3), pp. 375-402.
14. Fang, X. (2009). *Process Innovation, Product Innovation and Firm Size*. University of Illinois at Chicago.
15. Gans, J., Hsu, D., & Stern, S. (2002). When does start-up innovation spur the gale of creative destruction? *RAND Journal of Economics*, 33, pp. 571-586.
16. Hage, J. (1980). *Theories of organizations*. New York: Wiley.
17. Hervé, F., Schwienbacher, A. (2018). Crowdfunding and innovation. *Journal of economic surveys*, 32(5), pp. 1514-1530.
18. Hözl, W., Peneder, M. (2019) Financing Innovation. In: E. Carayannis (Ed.), *Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship*. New York: Springer, pp. 734-738.
19. Huergo, E., & Jaumandreu, J. (2004). How does probability of innovation change with firm age? *Small Business Economics*, 22(3), pp. 193-207.
20. Jasiński, A.H. (2000). *Innowacje i transfer techniki*. Białystok: Uniwersytet w Białymstoku.
21. Lin, W.L., Cheah, J.H., Azali, M., Ho, J.A., & Yip, N. (2019). Does firm size matter? Evidence on the impact of the green innovation strategy on corporate financial performance in the automotive sector. *Journal of Cleaner Production*, 229, pp. 974-988.
22. Mintzberg, H. (1979). *The structuring of organizations*. New Jersey: Prentice-Hall.

23. OECD (2018). *Oslo Manual 2018. Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition*. Paris-Luxembourg: OECD Publishing – Eurostat.
24. O'Sullivan, M. (2000). The innovative enterprise and corporate governance. *Cambridge Journal of Economics*, 24(4), pp. 393-416.
25. Ottosson, S. (2019). *Developing and managing innovation in a fast changing and complex world*. Springer Books.
26. Pellegrino, G. (2018). Barriers to innovation in young and mature firms. *Journal of Evolutionary Economics*, 28(1), pp. 181-206.
27. Pellegrino, G., & Piva, M. (2020). Innovation, industry and firm age: are there new knowledge production functions? *Eurasian Business Review*, 10(1), pp. 65-95.
28. Porter, M.E. (1980). *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. New York: The Free Press.
29. Rossi, M., Lombardi, R., Siggia, D., & Oliva, N. (2015). The impact of corporate characteristics on the financial decisions of companies: evidence on funding decisions by Italian SMEs. *Journal of Innovation and Entrepreneurship*, 5(1), pp. 1-14.
30. Sosnowska, A., Poznańska, K., Łobejko, S., Brdulak, J., & Chinowska, K. (2003). *Systemy wspierania innowacji i transferu technologii w krajach Unii Europejskie i w Polsce*. Warszawa: PARP.
31. Vaona, A., & Pianta, M. (2008). Firm size and innovation in European manufacturing. *Small business economics*, 30(3), pp. 283-299.

RISK ANALYSIS OF THE CONSTRUCTION VENTURE IN THE ECONOMIC ASPECT

Daniel TOKARSKI^{1*}, Artur SAWICKI²

¹ University of Lodz; daniel.tokarski@uni.lodz.pl, ORCID: 0000-0002-3475-1115

² Academy of Humanities and Economics in Lodz; asawicki@ahel.lodz.pl, ORCID: 0000-0002-0735-3496

* Correspondence author

Purpose: The purpose of the work was to analyze the construction project from the investor's position, with particular emphasis on the implementation phase. Factors influencing individual stages of the investment process may contribute to a change in the investor's risk level, which can be minimized at the right moment. The article attempts to qualitatively analyze selected risk factors, define them and possible reduction.

Design/methodology/approach: The topic of the article is the risk analysis of the process of organizing the construction of an estate of five single-family houses in terms of time and cost of implementation. The analysis was carried out with the use of modern tools to support the work of an engineer, with particular use of computer methods, with the help of the Risky Project 5.0 program.

Findings: The result of the analysis was the identification of risks for which preventive measures should be introduced. The main risks threatening the construction process and delaying the project implementation date turned out to be: the risk of equipment failure, the risk of absenteeism, and the risk of insufficient qualifications of employees. The key process of building an estate of five single-family houses turned out to be finishing works due to their diversity, scope of works, cost and labor intensity. The most important parameters of the project are the total cost of the project, as well as the investment completion time.

Originality/value: The publication covers the subject of cost logistics in the process of implementing a construction project, with particular emphasis on the implementation phase, as well as an analysis of selected risk factors, their definitions and possible reduction possibilities. Based on the project a qualitative risk analysis was performed, the result of this analysis was the identification of risks for which preventive measures should be introduced. After identifying the risk, it is recommended to be thorough estimation of risk factors and their evaluation, as well as planning the response to risk based on the selected model.

Keywords: construction economics, cost logistics, risk management.

Category of the paper: Case study.

1. Introduction

Risk as a possible state is present in all areas of human activity. The article will refer to the sphere of a construction project in the aspect of time and the cost of implementation. Construction projects are one of the most complex in terms of the implementation process, the implementation of a construction investment involves various groups of groups, i.e. designers, material producers, suppliers, contractors, and subcontractors. Each from individual participants in the process may have a different level of responsibility, other possibilities of internal or external influence on the project, which leads to disruptions in the overall implementation process. Therefore, a very important element of each project is the precise definition of the possibility of risk occurrence and the appropriate analysis of all possible events and the consequences of deviations from the assumed process (Miłosz, Szyjewski, 2001).

If want to limit the negative effects of random events that disrupt the implementation of the adopted plan, should be able to manage the risk. Risk is always related to the probability that a given event will not occur (Berliński, Gralak, Sitkiewicz, 2004). Risk management is a process aimed at developing and introducing a risk control strategy to a planned project. It makes it possible to forecast the occurrence of an undesirable event through the use of appropriate methods and processes, and the development of scenarios to prevent them. the risk management procedure should be an integral part of the documentation of complex, complicated and large investment or construction projects, etc., and should constitute the project management subsystem (Kaczmarek, 2005).

The basic phases of risk management are: risk analysis, assessment and communication. Risk analysis in its technical aspect, as defined in the standard (N-IEC 60300-3-9 Risk analysis in technical systems, 1999), is a process during which the probability of an undesirable event and its consequences are identified. They can be caused by activities, devices or systems used. The risk analysis includes the following elements that should be specified here: scope of the analysis, identification and analysis of threats and risk assessment (Skorupka, 2006). In order to properly manage risk, it must first be discovered, that is, identified (Royer, 2002). The existing methods for identifying risk include: SWOT analysis (strengths, weaknesses, opportunities, threats), brainstorming with its many variations and the Ishikawa diagram, as well as checklists (Jaworski, 2009). All of them are aimed at analysing, searching for or organizing activities at risk in order to reduce its effects as much as possible in the future.

Risk assessment is a process that consists of an organized, logical series of actions taken, often illustrated in the form of the so-called event trees or hazard trees that lead to the study of hazards related to the project under consideration (PN-EN 1050 Principles of risk assessment, 1996). At the same time, a specific ranking of adverse events is created, assessing both the frequency and the size of the losses caused. Then, the acceptable level of risk is determined and the analysis of various variants of the possibility of undesirable variants for the same event is carried out. All this leads to the collection of as much information as possible about the possible

future course of events and, consequently, to enable risk control by making appropriate decisions during the planned activities. The concept of risk communication should be understood as both the process of mutual exchange of information between individual participants of the investment process (at the investment planning stage regarding the elements of risk related to the implementation of the project), as well as control and monitoring during the implementation of the investment and the final assessment of actions taken after completion of the planned project. It is an important component of risk management – at this stage it is possible to eliminate previously unnoticed errors and spot new ones and remedy them early enough. Risk communication also allows to draw the right conclusions so as to avoid similar risky events in the future (Jamróz, 2006).

Only full and dynamic cooperation between the above elements of risk management can guarantee the achievement of total success. When designing a construction project, risk management usually concerns the deadline and the closely related cost (time-cost risk). However, in the process of implementing this facility, it is divided into the management of many components at risk, such as, for example, unforeseen soil and water conditions, weather conditions, availability of human resources, materials and equipment (Tokarski, 2017).

2. Motivation and purpose of the analysis

Risk at the level of implementation of a construction project is the probability of the occurrence of undesirable events and their consequences in the scope of conducted activity, having a direct or indirect impact on the development of a given construction process or its part. Taking into account the specificity of construction investments, risk management issues are of great importance and affect the results of individual logistics (construction) processes, and consequently, the implementation of the entire investment process. The risk in construction projects is significant due to the very large number of threats resulting mainly from the specificity of the work execution process, as well as the special impact of environmental hazards, failure of construction machines or employee absenteeism. Unfortunately, there are no analyses, models and tools that would support the risk management process of construction projects. Therefore, creating a risk management system model will allow in the future to support control and prevent the effects of threats in this type of projects. Taking this into account, it can be concluded that the risk related to planning, implementation and operation of a construction project is a complex issue that is difficult to clearly define, let alone manage it effectively. This certainly requires, apart from theoretical knowledge, some practical experience related to it. The article presents the results of the analysis of the conceptual approach to this issue. The authors of the article introduce the term "cost logistics", which he defines as optimization of planning, organizing and proper spending of funds.

3. Methodology

The subject of the study is the analysis of the technology design and organization of the construction of a single-family housing estate. The estate consists of five identical buildings located on adjacent plots of the same area and shape. The construction design together with the description of the building structure is part of a separate study. The implementation process of the construction project in question assumes: organizational works, earthworks, foundations, construction of the walls of the ground floor, construction of the floor on the ground, construction of the ceiling above the ground floor, construction of stairs, construction of the walls of the first floor, construction of the roof truss, construction of door and window joinery, installation, finishing works, elevations, paving works, as well as fencing the plot.

The expenditure has been calculated and determined for works performed in average local conditions, in areas enabling the delivery and storage of materials in the zone next to the facility, without taking into account special difficulties caused, among others, by in the immediate vicinity of active railway and tram tracks or other similar circumstances. The expenditures included in the KNR Catalog 2-02 take into account all technological processes, assuming the proper organization and technology of works, and taking into account all activities and expenditures necessary to perform elements or works. The catalog provides expenditure on the execution of structural elements or works for the adopted measurement units. The costs of labour and equipment work specified in the catalog apply regardless of the height or depth of execution, subject to vertical transport by a shaft or goods-passenger hoist to a height of more than 18 m. works and auxiliary activities:

- preparation of the workstation,
- internal horizontal and vertical transport of materials and accessories to the average distances and heights on the construction site, taken into account when determining the expenditure for costing purposes,
- positioning, relocating, carrying and removing temporary supports and portable scaffoldings, enabling the performance of works at a height of up to 4 m,
- stacking, sorting and sorting product materials on the construction site or in the warehouse at the facility,
- operating equipment that does not have a full-time service,
- checking the correctness of the works,
- removal of defects and faults as well as repairing damage caused during the execution of works,
- keeping the workstation clean and tidy,
- carrying out activities related to the liquidation of the workstation.

The schedule was created in order to estimate and optimize the construction time of the estate of five single-family houses. The preparation of the schedule began with determining the length of individual works. For this purpose, a bill of quantities was made and a detailed cost estimate was prepared on its basis. Then the number of brigades carrying out individual construction works was determined. The next stage was to determine the time of execution of these works (number of working days) and to determine the appropriate sequence of construction processes resulting from the technology. The sequence of individual works was optimized in such a way as to maintain the continuity of the work of the brigades and at the same time not to significantly extend the course of the investment. The simultaneous performance of several non-conflicting works within one plot in order to shorten the duration of the project (Radkowski, 2003). The commencement of construction works was set no earlier than March 16, and the final deadline for the completion of the shell and facade was set on November 18, 2019. A one-shift, 10-hour working time was assumed, lasting from 7:00 a.m. to 6:00 p.m. with a 1-hour break. The working week is 6 days, from Monday to Saturday. The course of works is carried out by 24 construction brigades, and their composition is constant for the entire course of the investment. The number of individual construction brigades is presented in Table 1.

Table 1.

The number of individual construction brigades

No.	Brigade	Number of employees
1	general construction workers I	5
2	general construction workers II	5
3	bulldozer	1
4	excavator	1
5	dump truck	1
6	surveyor	1
7	electricians	3
8	plumbers	3
9	carpenters	5
10	fixers	3
11	concrete workers	5
12	bricklayers	5
13	roofers	5
14	woodwork fitters	4
15	plasterers	6
16	floor builders	5
17	plaster brigade	4
18	tilers	4
19	painters	4
20	parquet flooring	4
21	the facade team	6
22	pavers	6
23	fireplace fitters	2
24	kitchen fitters	2

Source: own study based on research results.

One storey of the building constitutes the working plot. The exceptions are works carried out outdoors, in which the working plot is the entire building. Preparatory works, i.e. temporary fencing of the construction site and construction of social and sanitary buildings along with their demolition, are carried out for the entire investment. Continuity of work of heavy equipment: excavators and bulldozers, and possibly continuous work of other construction brigades were assumed. The cost estimate with the schedule is part of a separate study.

The risk analysis of the construction project was carried out using the Risky Project 5.0 Professional program. Risky Project is software for planning, scheduling, quantitative and qualitative risk analysis and measuring the progress of projects with many risks and uncertainties. Developed by Intaver Institute and introduced in Poland by EnergSys (Risky Project: Risk analysis software...).

The risks which the impact of the research on the course of the construction process have been examined include:

- risk of unfavourable weather conditions,
- risk of absenteeism of employees,
- risk of equipment failure,
- risk of insufficient qualifications of employees (employee productivity),
- risk of poor management of material resources,
- risk of non-compliance with standards.

Table 2 presents the values of risks in individual activities and their percentage probability of occurrence during the construction process.

Table 2.

Risk values in individual activities of the construction process of an estate of five single-family houses

No.	Name of activity	Risk	Chance of occurrence [%]
1	Organizational works	Risk of unfavourable weather conditions	1.0
		Risk of absenteeism of employees	2.0
		Risk of hardware failure	11.0
2	Earthworks	Risk of unfavourable weather conditions	1.0
		Risk of absenteeism of employees	2.0
		Risk of hardware failure	20.0
3	Foundations	Risk of unfavourable weather conditions	1.0
		Risk of absenteeism of employees	4.0
		Risk of hardware failure	15.0
		Risk of insufficient qualifications of employees (employee productivity)	5.0
4	The walls of the ground floor	Risk of unfavourable weather conditions	1.0
		Risk of absenteeism of employees	3.0
		Risk of hardware failure	15.0
5	The floor is on the ground	Risk of unfavourable weather conditions	1.0
		Risk of absenteeism of employees	2.0
		Risk of hardware failure	10.0

Cont. table 2.

6	Ceiling above the ground floor	Risk of unfavourable weather conditions	1.0
		Risk of absenteeism of employees	3.0
		Risk of hardware failure	20.0
		Risk of insufficient qualifications of employees (employee productivity)	5.0
7	Stairs	Risk of absenteeism of employees	5.0
		Risk of hardware failure	15.0
		Risk of insufficient qualifications of employees (employee productivity)	5.0
		Risk of non-compliance with standards	5.0
8	The walls of the first floor	Risk of unfavourable weather conditions	1.0
		Risk of absenteeism of employees	3.0
		Risk of hardware failure	20.0
9	The structure of the roof truss	Risk of unfavourable weather conditions	1.0
		Risk of absenteeism of employees	5.0
		Risk of hardware failure	20.0
		Risk of insufficient qualifications of employees (employee productivity)	15.0
		Risk of non-compliance with standards	7.0
10	Door joinery and window	Risk of unfavourable weather conditions	1.0
		Risk of absenteeism of employees	2.0
		Risk of hardware failure	10.0
		Risk of poor material resource management	5.0
11	Installations	Risk of absenteeism of employees	5.0
		Risk of insufficient qualifications of employees (employee productivity)	5.0
		Risk of non-compliance with standards	5.0
12	Finishing works	Risk of unfavourable weather conditions	3.0
		Risk of absenteeism of employees	8.0
		Risk of hardware failure	25.0
		Risk of insufficient qualifications of employees (employee productivity)	5.0
		Risk of poor material resource management	5.0
		Risk of non-compliance with standards	5.0
13	Elevations	Risk of unfavourable weather conditions	1.0
		Risk of absenteeism of employees	3.0
		Risk of hardware failure	15.0
		Risk of non-compliance with standards	5.0
14	Paving works	Risk of unfavourable weather conditions	1.0
		Risk of absenteeism of employees	1.0
		Risk of hardware failure	5.0
		Risk of poor material resource management	1.0
		Risk of non-compliance with standards	1.0
15	The fence of the plot	Risk of unfavourable weather conditions	1.0
		Risk of absenteeism of employees	2.0
		Risk of hardware failure	10.0

Source: own study based on research results.

4. Results

The risk analysis of the construction project was carried out using the capabilities of the Risky Project 5.0 Professional program. The Risk Matrix shows the impact of a given risk on the basis of the calculated probability of occurrence, which in the case of the risk of adverse weather conditions (13.2%) and the risk of poor material resource management (9.6%) is very low. Low probability of occurrence, because 21.3%, also has the risk of not maintaining standards at the construction site. Low probability, but with an increasing tendency as a result of the complexity of the processes at subsequent stages of construction, has a risk related to insufficient qualifications of employees – 34.4%. The course of works is carried out by 24 construction brigades, and their composition is constant for the entire course of the investment, therefore the probability of risk related to employee absenteeism was 37%. The risk related to equipment failure is classified as the one with the highest probability of occurrence – 88.9% - due to the high failure rate of machines during the construction process.

The Cost Analysis view shows the costs in a chart. Actual cost means actual costs so far, the current schedule shows the assumed budget, and the results are simulated data. By moving the slider under the graph, can track the cost in the subsequent phases of the project. The largest expenses are related to the construction of the roof truss structure (93,824.23 USD) and finishing works (145,437.00 USD). The cost of the current schedule was 556,993.00 USD, and after the risk-based simulation, the cost increased by 333.00 USD to 587,326.00 USD.

The Cash Flow view shows information about the cash flow for the selected time period. The expenses related to the process of building an estate of five single-family houses are systematized. The increase recorded at the turn of July and August is the reason for the increase in expenses related to the commencement of the "Finishing works" process, which is one of the most resource-intensive, both cost-effective and resource-intensive. The NPV (Net Present Value) of the current schedule was 558,610.00 USD, and after simulation, it was down 70,189.00 USD to 488,421.00 USD. As construction works approached the end, the expenses were gradually decreasing.

The Risk Graph view determines the cost or duration versus risk. In the case of the Task duration (Current Schedule) chart, the risk, due to the duration, is most likely to occur in the "Finishing work" process - 182/281 days. The smallest, however, during Paving works – 5/281 days. Total Task Cost (Current Schedule) illustrates the risk due to the total cost of the task, which turned out to be the highest during the finishing works (145,437.00 USD) and the construction of the roof truss structure (93,824.23 USD). The lowest cost is the construction of stairs (1,879.16 USD) and paving (8,519.83 USD). Increased costs of construction works may come from increased (compared to standard) outlays for their performance, exceeding contractual deadlines or the need to employ overtime workers and machines.

Using the Success Rate, the probability of success or completion was calculated for individual tasks. The results are marked in different colors on the Gantt chart. Tasks with a high success rate are shown in green, with medium in yellow, and with low in red. In the case of the construction process of an estate of five single-family houses, all planned tasks have a high success rate – 100.00%.

The Crucial Tasks view shows the correlation between risks and the likelihood of completing tasks. The higher the correlation, the more risk influences the performance of the task. The uncertain ones whose variable duration has the greatest impact on the project are shown in red. In the case of the construction of an estate of five single-family houses, the least certain activity is "Finishing works". The only critical activity of finishing works includes all types of risks included in the project.

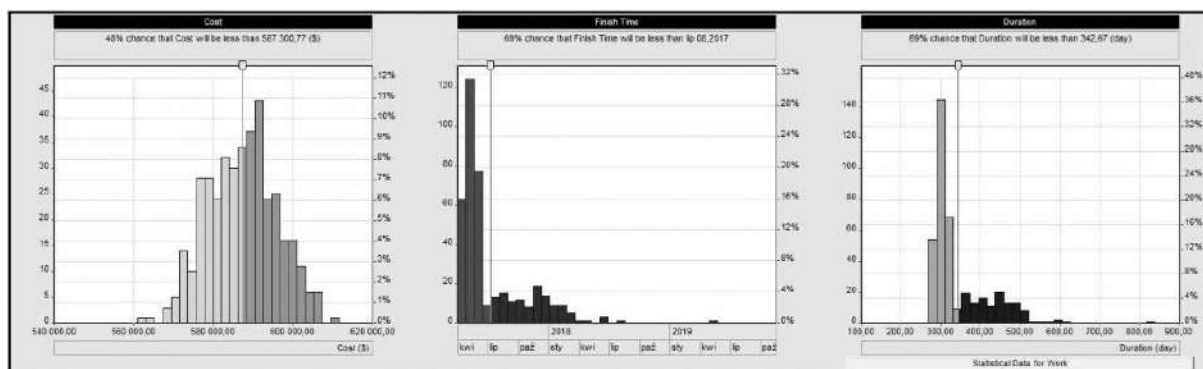


Figure 1. Project Summary, Option I.

The Project Summary lists the budget, duration, and end dates for the project. With the help of the program, three variants of the effectiveness of the implementation of activities related to the construction process were analysed. And so for option I – the most likely one,

- the scope of the budget was 587,300.77 USD with a 48% probability,
- the duration of the construction process with a 69% probability was estimated at 343 days,
- the completion date of the construction process with a 69% probability is scheduled for no earlier than 07/07/2019.

Option II – 80% probability,

- the scope of the budget was 594,910.03 USD,
- the duration of the construction process was estimated at 405 days,
- the completion date of the construction process is scheduled for no earlier than 02/10/2019.

Option III – 95% probability,

- the scope of the budget was: 601,696.66 USD,
- the duration of the construction process was estimated at 493 days,
- the completion date of the construction process is scheduled for no earlier than 29/01/2020.

The most favourable option is the most likely one due to the lowest costs, completion date and duration of the construction process. The Project Report provides information on the three most important parameters of the project, the three most critical tasks and the three most critical risks.

5. Conclusions

The publication covers the subject of cost logistics in the process of implementing a construction project, with particular emphasis on the implementation phase, as well as an analysis of selected risk factors, their definitions and possible reduction possibilities. Based on the architectural design of a housing estate of five single-family houses and the design of technology and construction organization, a qualitative risk analysis was performed, the result of this analysis was the identification of risks for which preventive measures should be introduced. The analysis showed that the most important parameters of the project are the total costs of the project, which in the case of excluding risks amounted to 586,993.00 USD, and with included risks increased by 333.00 USD and amounted to 587,326.00 USD. Another important parameter is the time of completion of the investment, which, in the case of no risks included, provides for the completion of works on 11/04/2019, while with the risks taken into account, the process was extended by 87 days and its completion date is scheduled for 07/07/2019. Project duration in the case of no risks included the risks taken into account was 281 days, while after taking into account the risks, the process was extended by 63 days and amounted to 344 days. The main risks threatening the construction process and delaying the project implementation date turned out to be: risk of equipment failure, the probability of an incident was 88.9% and occurred in 14 out of 16 activities; the risk of employee absenteeism, the probability of which was 37%, and occurred in 15 activities; the risk of insufficient qualifications of employees (employee productivity), the probability of which was 43.4% and occurred in 6 activities. The key process of building an estate of five single-family houses turned out to be finishing works due to their diversity, scope of works, cost and labour intensity.

The conducted research does not exhaust the issues of identification and hierarchy risk factors in construction projects. However, they draw a picture the problem of risk analysis and assessment. The method of risk analysis presented by the authors can be used for its initial estimation. Detailed analysis requires more application sophisticated methods, e.g. RAMP (Risk Analysis and Management for Project), ICRAM (Model for International Construction Risk Assessment), MOCRA (Method of Construction Risk Assessment) and tools (e.g. Pertmaster, Risk 4.1 for Project, Primavera Project Planer, Statistica Neural Network). The possibilities of using the above-mentioned methods and tools will be presented in the following articles by the authors.

References

1. Berliński, L., Gralak, H., Sitkiewicz, F. (2014). *Enterprise. Managing the environment*. Bydgoszcz: AJG-OPO Publishing House.
2. Jamroz, J. (2006). *Risk management in the project, training materials of the Management Consulting and Training Center*. Gdansk.
3. Jaworski, K.M. (2009). *Methodology of designing construction realization*. Warsaw: PWN.
4. Kaczmarek, T.D. (2005). *Risk and risk management. Interdisciplinary approach*. Warsaw: Difin Publishing House.
5. Miłosz, M., Szyjewski, Z. (2001). *Project scheduling: Microsoft Project 2000*. Lublin: Polish Information Society.
6. PN-EN 1050 Principles of risk assessment 1996.
7. PN-IEC 60300-3-9 Risk analysis in technical systems 1999.
8. Radkowski, S. (2003). *Basics of safe technique*. Warsaw: PW Publishing House.
9. *Risky Project: Project risk analysis and project risk management software*. Available online <http://www.intaver.com>, 29.01.2021.
10. Royer, P.S. (2002). *Project Risk Management*. Vienna, Virginia: Management Concepts Inc.
11. Skorupka, D. (2006). The method of integrated risk assessment of the implementation of construction investments. *Building Designer News*, 2, pp. 21-25.
12. Tokarski, D. (2017). Risk analysis in terms of time and cost of the process of strengthening the foundations of historic buildings in terms of variants. *Buses: technology, operation, transport systems*, 18(12), pp.1790-1794.

FUNCTIONING OF THE MEDICAL SERVICES MARKET IN POLAND: SELECTED PROBLEMS

Rafał ZACHOROWSKI

University of Economics in Katowice, College of Finance, Katowice; rafal.zachorowski@uekat.pl,
ORCID: 0000-0003-1196-6882

Purpose: The medical services market in developed countries is subject to market principles only to a limited extent. In fact, its size and directions of development are determined by all stakeholders through their influence on consumers and payers of health services. The aim of this study is to identify the main market participants and forms of influence used to modify the supply and demand for health services.

Design/methodology/approach: The basic research problem concerns the identification of interest groups influencing the size of the health services market and forms of influence on other market participants to ensure the implementation of the set health and economic objectives.

Findings: The influence of medical market interest groups leads to an increase in the quantity and quality of medical services provided to consumers in excess of market demand. It also causes a permanent failure to meet the demand for free health services.

Practical implications: The planning of health expenditures should take into account the activity of interest groups operating in the health services market, which leads to an inefficient allocation of financial resources expected by society to finance health services and public, economic, and social institutions operating in its immediate vicinity.

Social implications: The present paper is a voice in the discussion on the rationalization of health expenditures incurred by society. The decision on the scope of health services provided is ultimately a political decision. However, it is necessary to rationally channel the financial flows from public and private payers to health and peri-health care providers, medical equipment and pharmaceutical manufacturers, and private and public health sector administration.

Originality/value: Identification of entities directly influencing the health services market in Poland.

Keywords: medical services market, health care financing, health insurance.

Category of the paper: Conceptual paper.

1. Introduction

Continuous progress is being observed in the field of medical science. A similar process is also taking place in expanding access to medical services and organizational improvement of health care. However, society continues to formulate ever more far-reaching expectations concerning the level and quantity of these services. This necessitates an increase in health care expenditures and changes in the functioning of this system, which is directly related to the health policy pursued by a given country. Health care is one of the main functions of the modern state (Paszowska, 2020).

2. Outline of the evolution of the health care system

Almost from time immemorial, society has placed a high value on the health of its members (Brzezinski, 2020). With the establishment of the state, however, health institutions were not nationalized. Almost until the nineteenth century, they were the responsibility of religious, private, and social institutions. Health care was thus the domain of a kind of artisans operating in the open medical services market as highly skilled service providers. Doctors, apothecaries, surgeons (functioning originally as independent professions), and dentists offered their services as one or, at most, a dozen-person enterprise. There were also hospitals and shelters providing a kind of mass health care and its palliative variant, employing a much more numerous staff, dominated by carers and nurses. It was not until the 19th century that, as a result of reforms undertaken in leading European countries, health care, in addition to other social policy issues, became the domain of state activities (Trzeciakowski, 2013).

The modern state is primarily the coordinator of the health care system, in which individual tasks are carried out by public, private, or social entities. By the 1990s, the health care system had been based on central planning and financing of health services by the state budget (Wielicka, 2014). Several elements of this system are still in place, although some progress in decentralization was made after 1989. Nowadays, concern for the health of the population and the organization of the health care system has attained a ministerial level in most countries of the world. The health sector is one of the most important elements of the functioning of the economy of any country. After all, the health of the population, ensuring the highest possible survival rate of children, extending the time of good health status of people of working age, and providing adequate care for pensioners and post-working age people are connected with the ongoing improvement of the productivity of the average worker, ensuring that the workforce is extended by well-prepared employees and that older people fulfill a variety of social roles.

Each of these elements determines the economic development of the state. From this perspective, the importance that states place on health care is obvious.

However, irrespective of the motivations and objectives behind their actions in this field, states must take into account two factors: the effect of their actions and their cost.

3. Participants of the medical services market in Poland

Similar to many other countries, the dominant form of economy in Poland is the market economy. According to economic theory, both the price and the volume of provided services result from the play of supply and demand reported by consumers and producers (Milewski, Kwiatkowski, 2005). In this case, the market ensures an optimal allocation of resources, allowing both consumers and producers to use their resources efficiently.

A very important factor shaping the market for health services is that it is subject to market rules to a limited extent. The market mechanism, in which the mutual interplay of supply and demand leads to the formation of an optimal price for a product or service (the market price) does not function in contemporary Polish health care. Limitations in this respect include far-reaching regulation of both the provision of health care services and organizational forms of health care institutions, regulation of medical professions, and quality standards of medical equipment and materials. Activities in the medical services market are also far from free-market principles. It should be taken into account that 71.5% of expenditures on health services are paid from public funds ("Monitor Polski" 2020, item 898), which results in significant limitations of the market mechanism. Health care facilities, similar to other health care businesses, mostly operate in isolation from the actual demand for their services. Market demand is generated by public institutions. The demand for medical services is reported from several sources. These include patients, medical professionals, representatives of the pharmaceutical industry and medical device manufacturers, and medical decision-makers. The media system also has an important influence on demand formation.

Table 1 shows the sources of funding for various functions performed by the health system. The data in the table confirm the dominant role of the public health insurance system in financing treatment and rehabilitation. However, it may be noted that other sources of funding may also play a predominant role in financing other functions of the health system. In particular, households, i.e. individual patients, are the main source of funding for purchasing medicines and medical equipment. However, long-term care and health prevention are the domain of direct government action. The table also illustrates that individual health activities are of interest to different social groups and institutions. Furthermore, the evaluation of the situation on the market of health services by experts from individual market segments also focuses on different aspects of the health care system. Unfortunately, the interest of private insurance institutions is

particularly low in the areas of health care that represent a particularly heavy financial burden for patients. On the other hand, these institutions strive to expand their market share in the segments dominated by public entities such as the government, local governments, and the public health insurance system.

Table 1.

Total health expenditure: the division into individual functions of the health care system and sources of its financing in Poland in 2018

Millions EUR	Compulsory health insurance	Households	Budgetary expenditure	Voluntary health insurance	Nonprofit community organizations	Enterprises
Percentage of funding from a source						
Treatment and rehabilitation	15602.01 79.16%	1707.84 8.67%	470.92 2.39%	1738.43 8.82%	137.9 0.70%	51.72 0.26%
Medicines and other non-durable medical goods	2238.64 34.18%	4126.61 63.00%	178.47 2.72%	0 0.00%	6.76 0.10%	0 0.00%
Long-term care	725.85 37.27%	8.11 0.42%	1116.74 57.34%	0 0.00%	80.62 4.14%	16.35 0.84%
Additional health services	325.23 27.84%	147.11 12.59%	511.33 43.76%	178.56 15.28%	3.82 0.33%	2.37 0.20%
Health prevention	33.58 4.67%	0.00 0.00%	432.60 60.14%	0.00 0.00%	66.36 9.23%	186.78 25.97%
Medical equipment and other durable medical goods	198.56 30.13%	403.47 61.22%	50.48 7.66%	0 0.00%	6.27 0.95%	0.27 0.04%
Health care management	190.55 33.19%	0.00 0.00%	377.16 65.69%	6.41 1.12%	0.00 0.00%	0.00 0.00%
Other services in the health care system	67.32 38.74%	39.62 22.80%	2.44 1.40%	0.00 0.00%	64.41 37.06%	0.00 0.00%
TOTAL:	19381.74 61.53%	6432.76 20.42%	3140.14 9.97%	1923.4 6.11%	366.14 1.16%	257.49 0.82%

Source: own work based on: Eurostat data (HLTH_SHA11_HCHF) as of 23 February 2021.

Patients are the primary recipients of health services. This group should be treated as broadly as possible. Patients are all current and potentially ill people requiring health services. This group expresses their expectations in a formal way by reporting to health care facilities, and the reasons for reporting are recorded and treatment is usually provided after diagnosis. Databases maintained by individual medical institutions and the data aggregated at the voivodeship and national level by the National Health Fund, the Ministry of Health, and Statistics Poland allow for predicting changes in the structure of demand for medical services in the coming years. Scientific studies in medicine and health sciences occupy a key place in the process of predicting the development of health needs. These prognoses are used to plan future funding streams, sources of fund collection, and various investments in health care infrastructure and the education of health care workers and other providers to ensure the functioning of the entire system.

Patient-reported demand for health services does not closely match the objectives of the health system. On the one hand, patients make demands for medical services that are not only unnecessary but may even expose them to unpleasant consequences. These include various

alternative medicine and aesthetic medicine services. On the other hand, patients often underestimate the symptoms and try to pass the disease, which often ends up with the disease progressing to more and more life-threatening stages (Halik, 2001). The state of epidemic risk, in which patients avoid contact with health care while being the epidemic focus and potentially spreading infectious diseases to their closer and further surroundings, also has a similar effect on social health.

It should be noted that the state offers a limited range of services available to patients in the public health sector (contracted services). However, households can also participate in the free market for medical services.

The market for medical services has been fragmented throughout history, with different parts operating in different legal and economic contexts. Households purchase medical services directly only in selected market segments and after fulfilling certain conditions. Given the universality of the health insurance system in Poland, it should be noted that the vast majority of households are entitled to use services contracted with service providers by the National Health Fund. This means that these consumers are willing to purchase medical services only if the availability of the service offered under the public system is limited, or if its quality is significantly lower than that offered on the free market. This situation is made possible by a variety of impediments to access to the provider: long waiting lines for an appointment or treatment, exhaustion of the amounts contracted by the provider, a significant distance to the health center providing specific services, various practices that limit access to services of a corrupt nature. Another reason may be a significantly higher rating of the quality of the private services offered. It is characteristic of Polish conditions that patients transfer the quality of services related to the stay, registration, atmosphere in a health care facility to the assessment of the quality of the medical service itself. This difference in quality must be sufficient to make it worthwhile, in the consumer's opinion, to pay extra money to obtain that benefit.

Only those patients who, for various reasons, choose to purchase services at a higher price are brought into the free market of medical services. Providers operating in the free market of medical services must take this premise into account. On the one hand, they are subject to price pressure from public providers but on the other hand, the purchasers of their services are people who choose private treatment in most cases due to the inefficiency of public providers. For this reason, they are willing to pay higher medical costs. Activities paid out of pocket by patients must not involve particularly expensive medical procedures. Because of their cost, the group of potential consumers would not be very large, and this would not provide sufficient revenue for privately-funded medical facilities. Hence, private providers are dominated by those performing standard, low-cost diagnostic and treatment procedures, most often organized in the form of private practices, or small units focused on the delivery of relatively low-cost treatment procedures, only in selected medical disciplines.

A variety of nonprofit organizations also engage in health care activities. In this way, they pursue their statutory objectives and their activities may even cover significant segments of the market. Some of these organizations focus on improving the health care infrastructure while others on improving quality in selected, narrow areas of individual health sciences. They usually require support and interest in their activities from a sufficient group of people affected by specific health problems. While supporting these groups, the organization also benefits from their involvement in order to raise funds for its activities. A significant group of organizations is involved in health care activities sporadically, mostly in the form of providing individual support to specific individuals. Therefore, financing medical services by non-profit organizations has at least two facets. One is to step into the role of a single consumer who participates in the market of medical services on the demand side. The second facet is the organizations which, in addition to the demand, also undertake market activities on the supply side by means of teams providing medical services which they organize on a temporary or permanent basis. These teams mostly function as an intermediary that purchases the services of medical professionals on the market or uses their work in the form of volunteering. Few organizations become actual service providers operating in the medical market on similar principles as private providers, and in some cases even as public providers. The nature of market participation depends to the highest degree on the field in which the organization intends to pursue its objectives.

Medical professionals play an important role in the health care system. Their primary activity is to modify the demand for health services reported by patients. Doctors with experience can often estimate the real health needs of the population more accurately than patients. Their prognoses are based on cases of patients who visit health care facilities but do not require treatment to the extent that they request it. Physicians also often have knowledge of the percentage of patients with certain conditions who do not seek treatment at health facilities. These data are drawn from scientifically designed screening studies conducted by researchers, not from official government health statistics. The group of professionals is also a source of error in prognoses of health needs. The reason for this is usually that a higher priority is placed on the range of services that a particular professional specializes in. Furthermore, he or she perceives deficiencies in infrastructure and service quality usually in areas with which they have direct professional contact. Medical experts are thus inclined to overstate the needs of the medical disciplines they represent relative to competing disciplines. Collectively, all health professionals and paramedical service providers strongly believe that health care infrastructure is substantially underinvested and that the costs of health services are underpriced. Decision-making institutions in the state are much more strongly influenced by experts than by patients, who create the actual demand for health services.

The influence of doctors and other medical professionals on potential patients is often associated with the phenomenon of information asymmetry. The knowledge of medical professionals concerns not only the current state of health of the patient and includes not only

the current health problems but also knowledge about their evolution, various methods of treatment, and possible threats of complications. Information asymmetry leads to the generation of the demand for health system services. This phenomenon is referred to as supply-driven demand. In theory, physicians should act as ideal agents, but in practice, they significantly influence the choices made by their patients. Information asymmetry involves both the inability of patients to identify their own health needs, but also the inability to identify how to meet those needs. In both cases, the doctor's opinion is decisive (Łoś, Puciato, 2011, pp. 17-24).

On the medical services market, a strong group is the representatives of the pharmaceutical industry and manufacturers of medical equipment or equipment used in the broadly defined medical services. The activities undertaken by them are marketing activities aimed at patients, who are sensitized to the symptoms of diseases against which their products are targeted; at medical professionals, who are offered various benefits in return for their actions in favor of drugs, devices, or treatment methods branded by corporations; and also at decision-makers, who can indirectly support the sale of products of pharmaceutical corporations by redirecting their spending streams. Policymakers can also directly influence the revenues of pharmaceutical manufacturers by placing medicines on reimbursement lists. It must be stressed that medical products are an essential part of medical treatment, but manufacturers have a direct and indirect impact on diverting healthcare funding streams to achieve financial gain. With them, in subsequent periods, the volume and quality of the production of therapeutic agents increases, which, however, is not equivalent to solving the health problems of the population (Makowska, 2012, pp. 143-154).

In the functioning of the market for medical services, the role of the press as a media system that has a strong influence on the perception of health needs should also be stressed. This is especially true of the popular press and radio and television broadcasts. In the last decade, social networks have joined the opinion-forming media, using various types of communicators. In contrast to the previously mentioned groups, the press is a source of particularly emotional descriptions, usually one-sided, which can mobilize public opinion very effectively to exert pressure to change the level and direction of public funding for health care. These descriptions never postulate an adjustment of the structure of expenditures to needs, but they demand an increase in public expenditures in a general way, or by indicating the most important medical disciplines according to individual authors. They actually create a very strong incentive for politicians to increase funding for the directions indicated. Such actions taken under the influence of press articles are rarely thought out and are often the source of wrong decisions on allocating resources within the health care system.

Medical decision-makers play an extremely important role in shaping the market for medical services. Their decisions, which are of key importance to financing the services for patients, are made as a result of pressure received from medical professionals, representatives of manufacturers of medical equipment and materials, and signals coming from the media system. It is difficult to define the role of the politician in the decision. It is usually much easier

to indicate the source of the pressures that led to the corresponding changes in health care funding. It should also not be forgotten that both politicians and representatives of the groups mentioned above, are also patients and perceive information about the health needs of society from their own, sometimes traumatic, health experiences. These emotions are related to the specificity of medical services that are related to issues of life and death, and the most basic human needs (Markowska-Kabała, 2013, pp. 79-88).

The considerations presented above show that the role of particular groups in the market of medical services is different.

4. Insurance in the Polish system of medical services

Currently, health insurance is not very popular in Poland. Furthermore, its popularity and market share have not increased significantly over the last twenty years. Hence the various initiatives aimed to provide insurance companies with a larger market share. These initiatives have several directions. The first one is to present insurance services addressed to individuals, companies, and organizations. In exchange for an insurance premium, customers are offered to fund certain health services. There is currently no health insurance on the market that finances particularly expensive medical procedures or diagnostics for people with rare diseases that require innovative treatment procedures or expensive experimental therapies. The services offered by insurance institutions usually include standard medical services that can be financed by the National Health Fund but they are not very popular. These types of policies are usually chosen by those households who would also seek help from non-public health care facilities in case of illness. This situation does not portend a significant increase in the share of insurance in the market in the near future, as most households will not be willing to purchase insurance services and will continue to pay for private medical health care using their own funds (Owoc, 2009, pp. 102-107).

Another direction of insurance companies' activities is information and advertising. Its aim is to improve the insurance awareness of Poles and to increase the sales of insurance policies, including health insurance policies. It should be pointed out that these actions offer some chances of success in a longer perspective. Individual European countries shape their health service financing policies differently, which results in significant differences in their insurance models. These differences lead to very different conditions for insurance companies in individual states to participate in the medical services market. Consequently, there are differences in the share in the financing of health services and therefore also in access to the financial resources that households intend to use to purchase these health services.

Another proposed solution is to take over the insurance market through legal mechanisms. This means various forms of transferring compulsory health insurance from the public system run by the National Health Fund to the postulated private system. This solution results in a rapid takeover of the medical services market and a significant increase in private insurance in the system. This is associated with an increase in insurance awareness and the emergence of competition between insurers but without an increase in competitiveness between service providers. Such a solution, due to the purpose of the functioning of public health care, which is to provide the widest possible group of recipients with an adequate level of health care, should be assessed negatively (Budowanie system..., 2008).

One form of health insurance is subscriptions. They are offered by a much wider group of entities, which within the framework of their activity offer a slightly modified product compared to conventional health insurance. Under the subscription, customers acquire the right to free (subscription-based) medical services, usually of an outpatient nature, in certain selected fields of medicine. This product is usually offered to private companies and less frequently to state-owned enterprises and organizations. The latter purchase services that are usually related to legally required medical services for employees. These may include periodic medical examinations, preliminary examinations, certain separate medical procedures related to specific professions - examination of drivers, uniformed services, etc. Subscriptions can also be addressed to individuals, but in this case they are not particularly popular. It should be noted that subscription services actually make economic sense for health insurance, which means similar difficulties in selling them as for insurance policies. They compete with the public health insurance system, which is based predominantly on the provision of free services (Sak-Skowron, 2009).

5. The role of the National Health Fund on the medical services market

The most important demand-side institution on the health care market in Poland is the National Health Fund (NFZ). The National Health Fund was established in 2003 by the Act on public insurance in the National Health Fund. This fund became the sole payer of health services. It is supplied with a substantial amount of funds coming from obligatory or voluntary contributions of millions of Poles. With these funds, it dominates the purchasing market, in a somehow monopolized way. The strength of the NFZ stems from its legal empowerment and the specific domination of the state in health care services. The health care system is highly complex, consisting of numerous segments: hospitals, outpatient clinics, pharmacies, sanatoria, emergency services, etc. The NFZ plays a coordinating role with regard to the diverse services offered by service providers. Apart from its purely economic activity as a payer of public health

care services, the NFZ is obliged to balance the quantity, quality, and availability of health care services between individual sectors of medicine and also in territorial terms.

As indicated earlier, the state, through its institutions, especially the publicly funded public health care system, pursues first and foremost the social objectives of ensuring equal access to health services for the widest possible range of recipients. The provision of public health care is not intended to achieve the best possible market results, but to achieve the best possible quality of health care, which is not subject to monetary valuation. Therefore, the goal is to achieve a certain material result at the best possible price, regardless of its economic value. Companies, including insurance companies that finance the functioning of the health care system, have to reckon with the real market valuation of their products offered to households. These, on the other hand, take into account in their choice the public system maintained from obligatory public tributes, which does not require additional spending of household budgets.

The important difference between public insurance and insurance company financing should be emphasized. This concerns the business profit. As a rule, NFZ does not generate profit. In a situation of inter-period savings, related to the annual character of the state budget and contracting health services also in annual periods, any funds that are saved in one period are transferred to the next year. Insurance companies operate differently. The activity they undertake on the market should ultimately be profitable. Profit is generated both by investing the collected premiums in various financial instruments and by calculating premiums in the offered policies. The premium includes a variety of elements, one of the most important being profit. This means that when comparing the system financed by the National Health Fund and the system financed by policies, it is necessary to take into account the outflow of accumulated funds in the private insurance system to guarantee a profit for shareholders. On the other hand, all the funds collected in the National Health Fund remain at the payer's disposal. Another aspect to look at is the cost of acquiring customers. The intensification of market competition between insurers will be related to their expenditure of considerable premium funds spent on maintaining the agency apparatus and marketing activities. Currently, spending for this purpose in the National Health Fund is minimal (Łączne Sprawozdanie Finansowe NFZ, 2020).

6. Conclusions

The market for medical services is imperfect. The largest purchaser and at the same time provider of health services is the public sector. The level of expenditures allocated by the state within the framework of the public health insurance system and through direct state budget expenditures exceeds the expenditures that could be incurred by households for the same purpose, even if it were assumed that the compulsory tributes allocated to health care by the state would remain in household budgets. The participation of the state in the health care market

is aimed at implementing a policy of making health care services available to the widest possible population. The details of this policy are determined by the play of interests of various communities. The most important community here is patients. Their expectations are modified by the opinions of professionals who are at the same time health care providers operating on the health care market, and the media, which impose demanding attitudes towards health services and health care on the society. Furthermore, companies producing for the health care market strongly influence policymakers, prompting them to increase public funding for medical services.

All the above entities attempt to influence the market in ways that, in addition to satisfying the public interest, deliver additional benefits to all these groups. Their combined action should be taken into account when evaluating the functioning of the health care system because awareness of the existence of important group interests allows for the objective assessment of the system and determination of a much wider than declared impact of the postulated systemic changes in health care.

The investigations presented in this study show that limiting public financing of health care means shrinking the market for medical services, limiting access to this market, especially for the less affluent people, and reducing the prices of services and products below those currently observed. However, such a result is achieved at a significant overestimation of demand for health services. Another consequence of the ongoing situation is that patients become less responsible for their health and demand more and more free services from the state. This significantly limits the possibility of developing private health care services.

It is suggested that further explorations should focus on evaluating the actual health effects achieved through the implementation of the health policy and on the attempts to determine the effectiveness of spending public funds for this purpose. The results would be used to develop the framework and assumptions for systemic changes aimed at improving the level of health care in Poland and better utilization of financial resources spent for this purpose by the state.

References

1. Arah, O.A., Klazinga, N.S., Delnoij, D.M., Asbroek, A.T., & Custers, T. (2003). Conceptual frameworks for health systems performance: a quest for effectiveness, quality, and improvement. *International journal for quality in health care*, 15(5), pp. 377-398.
2. Brzeziński, T. (2020). *Historia medycyny*. Warszawa: PZWL Wydawnictwo Lekarskie.
3. *Budowanie systemu prywatnych ubezpieczeń zdrowotnych w Polsce. Propozycja rozwiązań*. (2008). Warszawa: Instytut Badan Strukturalnych.
4. Folland, S., Goodman, A.C., Stano, M., Suchecka, J., Korona, M., Siciarek, M. (2011). *Ekonomia zdrowia i opieki zdrowotnej*. Oficyna a Wolters Kluwer business.

5. Halik, J. (2001). Badania socjologiczne jako źródło wiedzy o funkcjonowaniu systemu opieki zdrowotnej. In: J. Hryniewicz (Ed.), *Mierniki i wskaźniki w systemie ochrony zdrowia*. Warszawa: Instytut Spraw Publicznych.
6. Hłowiecka, K. (2016). Analiza i ocena narzędzi regulacji podaży świadczeń opieki zdrowotnej o kreślonych w ustawie o świadczeniach opieki zdrowotnej finansowanych ze środków publicznych. *Ubezpieczenia Społeczne. Teoria i praktyka*, 3, pp. 67-85.
7. Jewczak, M. (2017). Potrzeby zdrowotne społeczeństwa polskiego a skłonność do płacenia za świadczenia zdrowotne. *Problemy Zarządzania*, 15(3(69)), pp. 159-174.
8. Kleczkowski, B.M., Roemer, M.I., Werff, A.V.D. (1984). *National health systems and their reorientation towards health for all: Guidelines for policy-making*. World Health Organization.
9. Klich, J. (2008). Globalizacja usług zdrowotnych. *Gospodarka Narodowa. The Polish Journal of Economics*, 223(4), pp. 21-40.
10. Kujawska, J. (2017). Pozycja lekarza podstawowej opieki zdrowotnej w państwach Europy Środkowo-Wschodniej. *Problemy Zarządzania*, 15(3(69)), pp. 67-81.
11. *Łączne Sprawozdanie Finansowe Narodowego Funduszu Zdrowia z siedzibą w Warszawie za okres 01.01-31.12.2019 r.* Retrieved from <https://www.gov.pl/attachment/95e23951-ef17-420a-80cb-8a06746b099e>, 07.04.2021.
12. Łoś, A., Puciato, D. (2011). Niedośkonały rynek świadczeń zdrowotnych. *Handel Wewnętrzny*, 1, pp. 17-24.
13. Mądrała, A. (2013). *System ochrony zdrowia w Polsce. Diagnoza i kierunki reformy*. Akademia Zdrowia, 2030.
14. Makowska, M. (2012). Lekarze i firmy farmaceutyczne – standardy etyczne wzajemnych relacji w Unii Europejskiej. *Annales – Etyka w życiu gospodarczym*, 15, pp. 143-154.
15. Markowska-Kabała, I. (2013). Identyfikacja interesariuszy mających wpływ na zakres i przebieg zmian w systemie ochrony zdrowia. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, 277, pp. 79-88.
16. Milewski, R., Kwiatkowski, E. (2005). *Podstawy ekonomii*. Warszawa: PWN.
17. Miller, M., Zieliński, A. (2002). Zdrowie publiczne – misja i nauka. *Przegląd Epidemiologiczny*, 56, pp. 547-557.
18. Obwieszczenie Prezesa Głównego Urzędu Statystycznego z dnia 30 września 2020 r. w sprawie Narodowego Rachunku Zdrowia za 2018 r., *Monitor Polski* z 2020, poz. 898.
19. Owoc, J. (2009). Ubezpieczenia zdrowotne – szanse i zagrożenia. *Wiadomości Ubezpieczeniowe*, 2, pp. 102-107.
20. Paszkowska, M. (2020). *Polski system ochrony zdrowia*. Warszawa: Difin.
21. Reibling, N., Ariaans, M., Wendt, C. (2019). Worlds of healthcare: a healthcare system typology of OECD countries. *Health Policy*, 123(7), pp. 611-620.
22. Sak-Skowron, M. (2009). Sieci, sieci medyczne i efekty sieciowe w służbie zdrowia. *Zeszyty Naukowe MBA*, 3, pp. 50-64.

23. Skrzypczak, Z., Suchecka, J. (2018). Financial Consequences of the Act on Reimbursement of Medicines for the National Health Fund and Patients. *Problemy Zarządzania, 16(5(78)) Public and Private Sectors in Health Care*, pp. 35-50.
24. Sowada, C., Sagan, A., Kowalska-Bobko, I., Badora-Musiał, K., Bochenek, T., Domagała, A., Zabdyr-Jamróz, M. (2019). *Poland: Health system review. Health systems in transition*. World Health Organization, Regional Office for Europe. Retrieved from <https://apps.who.int/iris/handle/10665/325143>.
25. Stańdo-Górowska, H. (2012). Kształtowanie wydatków na opiekę zdrowotną jako problem społeczno-ekonomiczny. *Nierówności społeczne a wzrost gospodarczy*, 26, pp. 70-79.
26. Trzeciakowski, L. (2013). *Otto von Bismarck*. Wrocław: Ossolineum.
27. Ustawa z dnia 23 stycznia 2003 r. o powszechnym ubezpieczeniu w Narodowym Funduszu Zdrowia, Dz.U. z 2003 r., nr 45, poz. 391.
28. Wielicka, K. (2014). Zarys funkcjonowania systemów opieki zdrowotnej w wybranych krajach Unii Europejskiej. *Zeszyty Naukowe Politechniki Śląskiej, Seria: Organizacja i zarządzanie*, 70, pp 491-504.
29. World Health Organization (2010). *The world health report: health systems financing: the path to universal coverage: executive summary* (No. WHO/IER/WHR/10.1). World Health Organization.

REVIEWERS

Prof. **Tadeusz GALANC**, College of Management Edukacja, Poland

PhD **Michaline GREBSKI**, Northampton Community College, USA

Prof. **Wiesław GREBSKI**, The Pennsylvania State University, USA

Prof. **Izabela JONEK-KOWALSKA**, Silesian University of Technology, Poland

Prof. **Aleksander LOTKO**, Kazimierz Pułaski University of Technology and Humanities in Radom, Poland

Prof. **Malgorzata LOTKO**, Kazimierz Pułaski University of Technology and Humanities in Radom, Poland

Prof. **Ryszard ŁUBNIEWSKI**, College of Management Edukacja, Poland

Prof. **Aneta MICHALAK**, Silesian University of Technology, Poland

Prof. **Andrzej PACANA**, Rzeszów Technical University, Poland

Prof. **Sebastian SANIUK**, University of Zielona Góra, Poland

PhD **Bożena SKOTNICKA-ZASADZIEN**, Silesian University of Technology, Poland

Prof. **Radosław WOLNIAK**, Silesian University of Technology, Poland