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Perceived Brand Authenticity as the Answer to Global Crises

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Abstract

Purpose: The aim of the article is to assess the impact of perceived brand authenticity and its different dimensions on the brand choice of young consumers.

Design/methodology/approach: The experiment was applied in the study. A sample of 180 Polish young respondents from Lodz region participated in the study in December 2022.

Findings: The research results confirm that perceived brand authenticity positively affects the brand choice in case of young consumers, even if a higher price is applied. The most important PBA dimension in the case of mineral water is the brand naturalness. The study also proved that the brand origin can increase the perceived brand authenticity.

Research limitations/implications: The sample is limited to young consumers and the studied brands represent only 1 category of products.

Originality/value: The key dimensions of perceived brand authenticity important for young Polish consumers were identified for the brand representing the food sector.

Keywords: authentic brand, perceived brand authenticity, brand origin, young consumer.

JEL: M30, M31

Postrzegana autentyczność marki odpowiedzią na współczesne kryzysy

Streszczenie

Cel: celem artykułu jest ocena wpływu postrzeganej autentyczności marki i jej różnych wymiarów na wybór marki przez młodych konsumentów.

Metodologia: w badaniu przeprowadzonym w grudniu 2022 roku, w którym uczestniczyło 180 młodych polskich respondentów z województwa łódzkiego, zastosowano eksperyment.

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Wyniki: wyniki badań potwierdzają, że postrzegana autentyczność marki pozytywnie wpływa na wybór marki w przypadku młodych konsumentów, także w przypadku zastosowania wyższej ceny. Najważniejszym wymiarem PBA w przypadku wody mineralnej jest naturalność marki. Badanie wykazało również, że pochodzenie marki może zwiększyć jej postrzeganą autentyczność.

Ograniczenia/implikacje badawcze: próba badawcza była ograniczona do młodych konsumentów, a badane marki reprezentowały tylko jedną kategorię produktów.

Oryginalność/wartość: dla marki reprezentującej sektor spożywczy zidentyfikowano kluczowe wymiary postrzeganej autentyczności marki, ważne z perspektywy młodych polskich konsumentów.

Słowa kluczowe: marka autentyczna, postrzegana autentyczność marki, pochodzenie marki, młody konsument

1. Introduction

In times of instability, including economic recession, political crises, international conflicts, pandemics and social pressure, consumers are increasingly looking for brands that offer them additional intangible values related to a sense of stability and authenticity. Today, a brand does not only serve as an element of product designation, but has become an added value for the consumer. The brand has a symbolic meaning for consumers, evoking a sense of security, and also serves to create the consumer's own image, harmonizing with their views and lifestyle. As a result, brands have become reference points that allow the consumer to assess both the tangible characteristics of the product and the intangible values associated with the brand (Grębosz-Krawczyk, 2020). They are the basis for dialogue and building lasting relationships between companies and consumers.

Both academics and practitioners confirm the importance of authenticity for brand management and consumers behaviours (Beverland & Farrelly, 2010; Bruhn et al., 2012; Leigh et al., 2006; Morhart et al., 2015; Newman & Dhar, 2014; Rose & Wood, 2005). This area of research is still evolving in the academic literature, which results in rapid growth and development in both the theoretical and practical aspects of the research. In recent years, researchers have concentrated on the identification of the brand authenticity elements (Morhard et al., 2015; Safeere et al., 2022; Xuezheng & Zhucheng, 2022). Morhard et al. (2015) and underlined that brand authenticity perceptions are influenced by different elements, especially indexical, existential, and iconic cues. However, the literature lacks a comprehensive assessment of the impact of various factors on brand authenticity. In this regard, a knowledge gap is recognised in the existing literature on branding concerning the identification and assessment of the impact of different dimensions of the perceived brand authenticity on the brand choice. This article seeks to shed light on the importance of perceived brand authenticity from young consumers perspective. Additionally, in Poland, issues of the brand authenticity are rarely described, especially with respect to the brand authenticity dimensions. Polish Authors analyse especially the environmental

friendliness or origin of the brand (e.g. Bryła, 2014; Witek-Hajduk & Grudecka, 2022). Due to the arguments, the following topic was chosen. It is important to identify if perceived brand authenticity (PBA) influence choices of young Polish consumers and which dimensions of the PBA are crucial for them. Taking into account the current crises (especially issues related to sustainable development), the research concerns a brand from the food sector.

The aim of the article is to assess the impact of perceived brand authenticity and its different dimensions on the brand choice of young consumers. Results of own empirical research conducted in December 2022 on a group of 180 young Polish consumers are presented.

The outline of the paper is as follows. The related literature concerning the concept of perceived brand authenticity (PBA) and the research questions are presented in section 1. Section 2 is dedicated to the presentation of the research methodology. The research results are presented with discussion in section 3. Finally, the conclusions, theoretical and managerial contributions and the limitations of the study are included in section 4.

2. Concept of Perceived Brand Authenticity

In recent years, many factors have emerged that have changed the traditional approach to brand management, including building its identity and shaping its image. The market, as a space of exchange, is not limited to the confrontation of income, prices and utility of goods. It is also a place where social relations are built, depending on the historical, cultural and institutional characteristics of society (Brémond et al., 2007). According to Ragas and Bueno (2006), as a society, we are absolutely addicted to brands because brands provide us with a sense of otherness in a group that does not feel different. For young consumers, the purchase of specific products is not only an act of consumption, but also an opportunity to demonstrate a specific value system, express their own views, attitudes and emphasize their independence.

Authenticity is an important concept whose meaning is a muddled amalgam of philosophical, psychological, and spiritual values (Steiner, 2006). A variety of associations related to the concept of the brand authenticity is implemented by different researchers (Grayson & Martinec, 2004; Leigh et al., 2006). Brown et al. (2003) emphasize that a successful balance between past and future creates an authenticity that is crucial for the brand identity. In the opinion of the authors, consumers are looking for truth and authenticity in a false, inauthentic world. As a consequence, authenticity has become one of the most striking features of contemporary consumer culture.

Brand authenticity has its sources as one of the key elements of brand identity (Aaker, 2010; Beverland, 2005; Kapferer, 2004; Upshaw, 1995) or a major value of brand image (Ballantyne et al., 2006). In his model,

Upshaw (1995) defines brand identity as a particular mix of positioning and personality, giving the product a unique and authentic character in the mind of the consumer. According to Ghodeswar (2008), a brand identity is a unique set of brand associations that signifies a promise to customers and includes a core and extended brand identity. Core identity is the central, timeless essence of the brand, which is expressed through its authenticity and is not susceptible to changes in the market environment and prevailing trends, and remains constant in the face of the brand's territorial expansion or its extension to new products. Aaker (2010) presents a similar approach, emphasizing the significance of the basic element of brand identity, i.e. the essence of the brand, which includes the values and vision of the brand and takes the form of an ambivalent and timeless declaration of identity. Lai and Aimé (2016) also point out that identity determines the roots, foundations of the brand and its "genetic code" based on an authentic approach (brand history, products, communication, completed projects, etc.). Brand identity is therefore a performative story that provides information about its essence and sense of existence. Consequently, brand identity creates an authentic, relevant, enduring and credible value promise associated with a product or organization and indicates the source of the promise (Kapferer, 2004).

Nowadays, consumers co-create brand meaning by carefully interpreting brand messages, adding their own personal stories, and constantly digging into the definition of brand authenticity. The identity of authentic brands is based primarily on positive connotations referring to both the physical features of the products they represent, as well as symbolic values referring to the brand experience, and sometimes also to its history and memories of consumers (Grębosz-Krawczyk, 2020). An authentic brand can derive its identity from a product known for years, brand name, permanent values represented by this brand or its graphic differentiators. Brand authenticity can have its source in the form of historical and geographical heritage. Authenticity determines the memory of a brand or how it is best remembered by consumers. It is imperative to keep igniting this memory of how individuals truly recall a brand, given its significant influence on consumer preference and choice (Pogorzelski, 2018). It is also important to emphasize their originality and uniqueness in comparison with competitors' brands (Brown, 2001; Brown et al., 2003; Kessous et al., 2015; Prieto & Boistel, 2014; Shivakanth Shetty et al., 2014).

The concept of perceived brand authenticity is described by the prism of heritage, origin, production methods, naturalness, credibility, self-verification, symbolism or moral values (Bruhn et al., 2012; Morhart et al., 2015; Safeer et al., 2021; Xuezheng & Zhucheng, 2022). Several conceptualizations and operationalizations of perceived brand authenticity were proposed (e.g., Bruhn et al., 2012; Eggers et al., 2013; Morhart et al., 2015; Napoli et al., 2014). Different measurement et antecedents were defined. Brand authenticity is consequently related to a variety of attributes

and there is no unique definition of the authenticity concept, particularly in the branding context. Six chosen dimensions adapted to the specificity of the food sector were selected and are presented in Table 1: continuity, originality, reliability, naturalness, integrity and symbolism.

Table 1
Factors and items of perceived brand authenticity

PBA factors	Item	Origin
Continuity (C)	I think the brand is consistent over time (C1)	
	I think the brand stays true to itself (C2)	Bruhn et al., 2012; Morhart et al., 2015; Wiedmann et al., 2011
	Brand offers continuity (C3)	
	The brand has a clear concept that it pursues (C4)	
The brand is different from all other brands (O1)		
Originality (O)	I think the brand is unique (O3)	Bruhn et al., 2012
	The brand clearly distinguishes itself from other brands (O4)	
Reliability (R)	The brand delivers what it promises (R1)	Bruhn et al., 2012; Erdem & Swait, 2004; Morhart et al., 2015
	Brand's promises are credible (R2)	
	The brand makes reliable promises (R3)	
Naturalness (N)	The brand does not seem artificial (N1)	Bruhn et al., 2012
	The brand makes a genuine impression (N2)	
	The brand gives the impression of being natural (N3)	
Integrity (I)	The brand gives up to its consumers (I1)	Beverland & Farrelly, 2010; Morhart et al., 2015
	The brand has moral principles (I2)	
	A brand true to a set of moral values (I3)	
	A brand that cares about its consumers (I4)	
Symbolism (S)	A brand that reflects important values people care about (S1)	Beverland & Farrelly, 2010; Morhart et al., 2015
	A brand that connects people with their real selves (S2)	
	A brand that connects people with what is really important (S3)	

When consumers experience a disruption of normalcy, their need for a sense of security and continuity increases. As a result, consumers become sensitive to the authenticity of brands that provide them with a sense of reliability, originality, integrity and continuity. In this case, brand authenticity is a mechanism used to deal with negative emotions about the present or concern for the future, and authenticity is a defence against a perceived threat. More often, however, authenticity of the brand is used to signal the guarantee of origin, quality, naturalness and symbolism helping maintain a specific lifestyle and being a tool to express one's own individual identity or cultivate social relations (Beverland & Farrelly, 2010; Bruhn et al., 2012; Erdem & Swait, 2004; Morhart et al., 2015; Wiedmann et al., 2011).

Nostalgic brands are also perceived by consumers as authentic (Brown et al., 2003; Fritz et al., 2017; Leigh et al., 2006). The concept of authenticity as a connection with the past can be explained in two ways. Firstly, nostalgic memories are both positive and negative and therefore perceived as more authentic (Stephan et al., 2012). Secondly, consistency and transparency in the history of the brand inspire a sense of authenticity and thus trust (Ford et al., 2018; Napoli et al., 2014; Pecot et al., 2018). Veracity of events and consistency over time are therefore the main elements of the authenticity of a nostalgic brand.

The scientific problem in this article was developed through the following research questions:

- Q1: Does perceived brand authenticity influence choices of young Polish consumers?
- Q2: Which dimensions of perceived brand authenticity are the key to young Polish consumers?
- Q3: Does marking the country of origin positively affect the perceived brand authenticity?

3. Research Methodology

A sample of 180 Polish young respondents (53% females) from Lodz region participated in the study in December 2022. Participation involved a 15-minute experiment. The experiment consisted of a blind product test of a mineral water brand. The manipulation was based on the concept of Morhart et al. (2015) for hand cream, however provenance was emphasized by indication of the country of origin. Additionally the experiment was conducted for three, not two, product versions. The manipulation involved participants reading a description of one anonymized mineral water brand. Three versions of mineral water brand were prepared. In the description, brand A was presented as French and highly authentic, brand B as Polish and highly authentic, and brand C as foreign and less authentic. The brand authenticity was manipulated by delivering varying information concerning the six chosen perceived brand authenticity dimensions (continuity, reliability,

originality, naturalness, symbolism, credibility, integrity). Each group of 60 participants evaluated one branded product. After reading the brand characteristics' description, participants tested the product (i.e. a mineral water sample that was identical across conditions) and completed the brand choice likelihood measure ("Would you choose this brand?" and "Would you choose this brand if its price was a little higher?") as well as several manipulation checks concerning six PBA dimensions.

In order to vary different brand authenticity dimensions:

- for the continuity dimension: the brand's creation date was indicated as 1918 (for highly authentic brands) or 2018 (for the less authentic brand);
- for the naturalness dimension: the highly authentic brands were presented as basing on the natural, pure and healthy springs and the less authentic brand as a natural one;
- for the integrity dimension: the brand was founded by French or Polish monks (for highly authentic brands) instead of a foreign businessmen (for the less authentic brand);
- for the originality dimension: unique characteristics differentiating a brand from other were underlined for highly authentic brands, as well as the country of origin. For the less authentic brand the typical ingredients were indicated and the country of origin information was missing;
- for the credibility dimension: the series of quality tests of each product were mentioned in the description of highly authentic brands, whereas the founders of the less authentic brand just underlined good quality production conditions;
- for the symbolism dimension: the brand slogan was proposed – "Feel nature – Feel like free" (highly authentic brands) or "Feel nature – Feel good" (the less authentic brand).

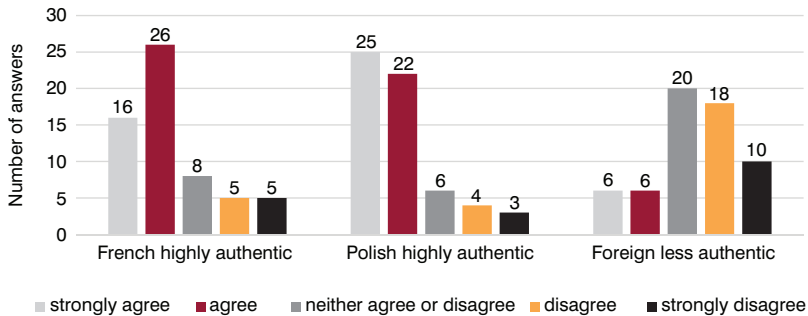
The same quantity and quality of information was deliver during manipulations for each brand. The same conditions were provided for all experiments.

4. Research Results and Discussion

The research results confirmed that participants evaluated the brands described as "authentic" significantly higher on each of the PBA dimensions than the participants in the less authentic brand condition. Respondents most often declared the choice of a product of the Polish and highly authentic brand (78% for strongly agree or agree). It is interesting that the French and highly authentic brand was chosen by a smaller group of consumers (70% for strongly agree or agree). The product signed with the foreign and less authentic brand was chosen the least often (20% for strongly agree

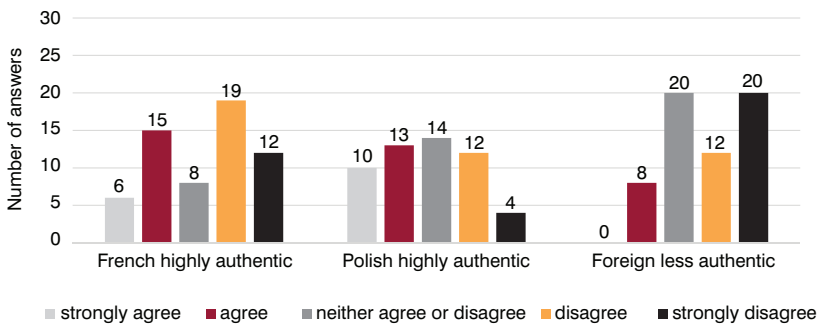
or agree) (Fig. 1). This confirms the conclusion of Morhart et al. (2015), Safer et al. (2021) and Xuezheng & Zhucheng (2022) that consumers are more likely to choose products supported by highly authentic brands than products signed with less authentic brands.

Figure 1
Brand choice in case of similar prices



In the situation of price increase, consumer preferences changed, but they still chose the Polish and highly authentic more often. In the case of the tested product with higher price, highly authentic brands were chosen more willingly (38% and 35% for strongly agree or agree) than the less authentic brand (13% for strongly agree or agree) (Fig. 2).

Figure 2
Brand choice in the case of higher prices



The research results also confirmed that the authenticity manipulation was successful: respondents in the case of the highly authentic brands conditions rated the brands higher on each of the PBA dimensions than respondents in the case of the less authentic brand condition (Table 2).

Table 2
 Perceived brand authenticity – research results

Item	Brand A French and highly authentic			Brand B Polish and highly authentic			Brand C Foreign and less authentic		
	n=60			n=60			n=60		
	<i>X</i>	<i>Me</i>	<i>Sd</i>	<i>X</i>	<i>Me</i>	<i>Sd</i>	<i>X</i>	<i>Me</i>	<i>Sd</i>
C1	3.52	4	0.72	3.78	4	0.63	2.88	3	0.88
C2	3.67	4	0.79	3.87	4	0.74	2.58	3	0.90
C3	3.48	3.5	0.83	3.78	4	0.78	2.82	3	0.87
C4	4.13	4	0.59	4.13	4	0.59	2.95	3	1.01
O1	3.92	4	0.64	4.15	4	0.60	3.38	3.5	1.00
O2	3.73	4	0.44	3.82	4	0.53	3.17	3	0.88
O3	3.72	4	0.45	3.90	4	0.57	3.32	3	0.76
R1	3.40	3	0.61	3.60	4	0.66	3.22	3	0.75
R2	3.48	3	0.50	3.58	4	0.53	3.42	3	0.59
R3	3.58	4	0.49	3.73	4	0.54	3.30	3	0.90
N1	4.02	4	0.67	4.05	4	0.67	3.10	3	1.08
N2	4.18	4	0.59	4.27	4	0.54	3.53	4	1.12
N3	4.23	4	0.64	4.25	4	0.65	3.20	3	1.14
I1	3.77	4	0.64	3.90	4	0.57	3.53	4	0.96
I2	3.47	4	0.67	3.73	4	0.63	2.83	3	0.99
I3	3.43	4	0.67	3.83	4	0.55	2.93	3	1.08
I4	3.82	4	0.59	3.83	4	0.55	3.20	3	0.95
S1	3.63	4	0.68	3.77	4	0.67	3.25	3.5	1.01
S2	3.62	4	0.55	3.68	4	0.56	3.22	3	0.91
S3	3.78	4	0.55	3.87	4	0.50	2.92	3	1.07

The highest values for all dimensions of PBA were received for the Polish highly authentic brand. Slightly lower or similar indications were obtained for the French highly authentic brand. The highest rated dimension of authenticity was the naturalness of the brand ($X_{FHA}=4.14$; $Me_{FHA}=4$; $SD_{FHA}=.64$; $X_{PHA}=4.18$; $Me_{PHA}=4$; $SD_{PHA}=.63$). It can be related to the chosen product category (mineral water) and its perception taking into

account that naturalness of products has recently become an important feature in the food sector., Authenticity is often associated with natural character that explained the results also in anthropology (Bruhn et al., 2012). The foreign less authentic brand was perceived as less natural ($X_{FLA}=3.27$; $Me_{FLA}=3$; $SD_{FLA}=1.13$). In the case of brand continuity, the highest values were received in case of the Polish highly authentic brand ($X_{PHA}=3.89$; $Me_{PHA}=4$; $SD_{PHA}=.78$) and the French highly authentic brand ($X_{FHA}=3.7$; $Me_{FHA}=4$; $SD_{FHA}=.71$). Respondents agreed that the brands are consistent over time and have a clear concept that they pursue. For the foreign less authentic brand, respondents' indications were lower ($X_{FLA}=2.88$; $Me_{FLA}=3$; $SD_{FLA}=.93$). Similar conclusions were formulated by Morhart et al. (2015). Conceptual similarities were also identified between continuity and the brand heritage by Merchant & Rose (2013) and Wiedmann et al. (2011). Participants also confirmed the importance of the symbolic dimension of PBA ($X_{FHA}=3.68$; $Me_{FHA}=4$; $SD_{FHA}=.60$; $X_{PHA}=3.77$; $Me_{PHA}=4$; $SD_{PHA}=.59$; $X_{FLA}=3.12$; $Me_{FLA}=3$; $SD_{FLA}=1.01$). The research results are consistent with results of Beverland & Farrelly (2010) and Mohart et al. (2015) who underlined that symbolism is a brand's potential to serve as a resource for identity construction. Highly authentic brands represent also higher originality than foreign the less authentic brand ($X_{FLA}=3.29$; $Me_{FLA}=3$; $SD_{FLA}=.89$). Respondents assessed them as distinguishing, unique and different from other brands ($X_{FHA}=3.78$; $Me_{FHA}=4$; $SD_{FHA}=.53$; $X_{PHA}=3.96$; $Me_{PHA}=4$; $SD_{PHA}=.59$) and perceived as more reliable and credible than the less authentic brand ($X_{FHA}=3.49$; $Me_{FHA}=4$; $SD_{FHA}=.54$; $X_{PHA}=3.64$; $Me_{PHA}=4$; $SD_{PHA}=.59$; $X_{FLA}=3.31$; $Me_{FLA}=3$; $SD_{FLA}=.76$). Similar situation was recorded in the case of brand perceived integrity ($X_{FHA}=3.62$; $Me_{FHA}=4$; $SD_{FHA}=.67$; $X_{PHA}=3.83$; $Me_{PHA}=4$; $SD_{PHA}=.58$; $X_{FLA}=3.13$; $Me_{FLA}=3$; $SD_{FLA}=1.03$). However, in the case of brand reliability and integrity, the differences between highly and less authentic brands were the lowest ones.

The study also proved that brand origin can increase the perceived brand authenticity as stated previously by Xuezheng & Zhucheng (2022) or Witek-Hajduk & Grudecka (2022). Polish young consumers declared the choice of Polish highly authentic brand more likely than the French one. In this case, we can talk about social "expanded authenticity". Consequently, For the purchase of specific product, it is an opportunity to choose a specific value system, as stated Mróz (2013).

The structure of postmodern society more and more often resembles a network of social mini-groups, based on quasi-archaic values, emotions and a characteristic lifestyle (Dziewanowska & Skorek, 2011). Individuals prioritize membership in their tribes over class affiliation. Importantly, they may belong not only to one, but to at least several communities and in each of them performs a different function (Cova, 1997). Belonging to a group can be based on shared history and experiences and, consequently,

be expressed in the choice of authentic brands that symbolically connect individual members of the group. By choosing a specific brand, the consumer can emphasize the relationship with a group using a given brand. The importance of the brand naturalness and the brand origin also confirms the significance of sustainable issues for a modern young consumer.

5. Conclusions

Nowadays, more and more consumers are looking for values of authenticity, security references, identity, emotion and re-enchantment, and consequently they are seeking a sense of security and stability (Grębosz-Krawczyk, 2019). Authenticity is the emotional pillar of a brand that is resistant to turbulent environment and protects the consumer from uncertainty. Consumers look for a sense of authenticity in the offered brands, and then use them to construct and confirm their own present identity. Understanding what makes a brand stand out, what its audience expects, and how to effectively express its identity is the key to successful brand positioning. The need to develop a coherent and well-thought-out brand concept, which is the basis for its credibility and distinction, is emphasized. An identity shaped in this way is the starting point for creating a brand image in the minds of potential buyers that will meet their expectations and, as a consequence, will lead to the development of a strong brand equity.

It can be stated that the paper has resulted in two contributions. From a theoretical perspective, it has provided a better understanding of the impact of perceived brand authenticity on a brand choice, as well as broader perspective on factors and items that contribute to the perceived brand authenticity. Additionally, the key dimensions of perceived brand authenticity important for young Polish consumers were identified for the brand representing the food sector. Theoretical considerations and empirical findings enrich the state of knowledge about the possibility of using the phenomenon of authenticity in brand management on the Eastern European market, due to the assessment of attitudes of Polish young consumers towards different components of brand authenticity. From a managerial perspective, it has shown the potential of local authentic brands in food sector. It is clearly visible that the national background affects the young consumers' attitudes and PBA.

Limitations of the study should be underlined. The sample is limited to young consumers and the studied brands represent only 1 category of products. To provide a more comprehensive picture of the evaluation of the attitudes of young consumers towards authentic brands, similar studies could be conducted for different products categories. The sample could be extended to different age groups and nationalities.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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Frugal Innovations: Implementation in Regions of Poland

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Abstract

Purpose: The objective of the study is to assess the complexity of applying the attributes of frugal innovations in innovative enterprises located in three regions of Poland (i.e. A, B and C), as well as to compare the three regions.

Design/Methodology/Approach: The study included 200 large innovative enterprises. The study listed the following number of enterprises belonging to individual regions: A – 154 entities, B – 39 entities, as well as C – 7 entities. Six hypotheses have been stated in the study. The empirical study considered quantitative methods and research techniques, i.e. the Computer Assisted Web Interview (CAWI) survey technique, and statistical analysis of quantitative data. The basic research tools were: the CAWI survey questionnaire, PS IMAGO PRO 7.0 software and Microsoft Excel.

Findings: The study indicated that: (1) in the A and B regions – both in the area of shaping relationships with customers and shaping innovative processes – moderately high values of Indicator of the Complexity of Shaping Relationships with Customers (ICSRC) and Indicator of the Complexity of Shaping Innovative Processes (ICSIP) indicators were recorded, as well as in the C region, the values are moderately low for both indicators, (2) in the A region, there is a higher level of the complexity of applying the attributes of the concept of frugal innovations with respect to shaping relationships with customers and shaping innovative processes than in the B and C regions.

Implications/limitations: In Poland, there are rather favorable conditions for the implementation of the attributes of the concept of frugal innovations – this is indicated by relatively small differences between the A and B regions. Therefore, in theoretically less developed voivodeships from the so-called Polish B region, frugal innovations are implemented. The research conducted indicates that greater emphasis should be placed on spreading knowledge about frugal innovations in the C Region, which can draw on the experience and support of the A region.

Originality/value: The study raises a new issue in domestic science, concerning the implementation of the attributes of the concept of frugal innovations in various regions of Poland, i.e. the A, B and C regions.

Keywords: frugal innovation; innovative process; management; regions; Poland.

JEL: O31

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Innowacje oszczędne: wdrożenie w regionach Polski

Streszczenie

Cel: celem badania jest ocena złożoności stosowania założeń koncepcji innowacji oszczędnych w innowacyjnych przedsiębiorstwach zlokalizowanych w trzech regionach Polski (tj. A, B i C), a także porównanie tych trzech regionów.

Projekt/metodologia/podejście: badaniem objęto 200 dużych innowacyjnych przedsiębiorstw. W opracowaniu uwzględniono następującą liczbę przedsiębiorstw należących do poszczególnych regionów: A – 154 podmioty; B – 39 podmiotów; C – 7 podmiotów. W badaniu postawiono sześć hipotez. W badaniu empirycznym uwzględniono ilościowe metody i techniki badawcze, tj. technikę badania Computer Assisted Web Interview (CAWI) oraz analizę statystyczną danych ilościowych. Podstawowymi narzędziami badawczymi były: kwestionariusz ankiety CAWI, oprogramowanie PS IMAGO PRO 7.0 oraz Microsoft Excel.

Ustalenia: badanie wykazało, że: (1) w regionach A i B – zarówno w obszarze kształtowania relacji z klientami, jak i kształtowania procesów innowacyjnych – odnotowano umiarkowanie wysokie wartości wskaźników Indicator of the Complexity of Shaping Relationships with Customers (ICSRC) i Indicator of the Complexity of Shaping Innovative Processes (ICSIP), a w regionie C wartości są umiarkowanie niskie dla obu wskaźników; (2) w regionie A jest wyższy poziom złożoności stosowania założeń koncepcji innowacji oszczędnych w obszarach kształtowania relacji z klientami i procesów innowacyjnych niż w regionach B i C.

Implikacje/ograniczenia: w Polsce istnieją dość korzystne warunki do wdrażania założeń koncepcji innowacji oszczędnych – wskazują na to stosunkowo niewielkie różnice pomiędzy regionami A i B. Dlatego w teoretycznie mniej rozwiniętych województwach z tzw. polskiego regionu B również wdrażane są innowacje oszczędne. Przeprowadzone badania wskazują, że większy nacisk należy położyć na szerzenie wiedzy na temat oszczędnych innowacji w regionie C, który może czerpać z doświadczeń i wsparcia regionu A.

Oryginalność/wartość: w opracowaniu poruszono nowe zagadnienie dla krajowej literatury naukowej, dotyczące wdrażania założeń koncepcji innowacji oszczędnych w różnych regionach Polski, tj. regionach A, B i C.

Słowa kluczowe: innowacja oszczędna, proces innowacyjny, zarządzanie, regiony, Polska.

1. Introduction

Choosing the right model for conducting innovative processes – and their subsequent implementation within an enterprise – is not a simple and easy task. It depends on a number of factors and circumstances – both internal and external. In fact, each innovative entity must find its own “golden mean” regarding the implementation of basic processes responsible for creating value for various types of stakeholders – also in line with the concept of frugal innovations.

Therefore, the article focuses on implementing the attributes of the concept of frugal innovations in Polish enterprises and the complexity of the phenomenon from two perspectives: (1) internal – i.e. shaping innovative processes, as well as (2) external – shaping relationships with customers. Frugal innovations seem to be a model that is increasingly needed in enterprises nowadays – both in underdeveloped and highly developed countries. In Poland, frugal innovations can be a mean to provide enterprises (in various

sectors) with specific sustainable development in changing environmental circumstances, which is reflected in easier access to large, homogeneous groups of customers, cost optimization, systematic improvement of quality, as well as focus on the value provided to stakeholders. Frugal innovations can be regarded as a “lever” for the dynamic of the development of innovative enterprises, making them “overtake” other innovative entities that approach innovation processes in a “traditional” way and in line with other, “conservative” models of operation.

The aim of the study is to assess the complexity of applying the attributes of frugal innovations in innovative enterprises located in three regions of Poland (i.e. A, B and C), as well as to compare the three regions.

It is important that the analyses presented in the study are intended to answer the following research question:

RQ1: How do innovative enterprises located in different regions of Poland (i.e. A, B and C) – characterized by a different level of socio-economic and technological development – approach the implementation of the attributes of the concept of frugal innovations?

The research problem is as follows: What is the level of complexity of applying the attributes of frugal innovations in innovative enterprises located in three regions of Poland (i.e. A, B and C), as well as assessing whether there are statistically significant differences between enterprises located in the three regions of Poland in terms of the complexity of applying the attributes of the concept of frugal innovations (with respect to shaping relationships with customers and shaping innovative processes)?

Results of the research will provide knowledge on how Polish enterprises implement the attributes of frugal innovations and whether they are capable to use the potential of the model in developing their business.

The article consists of six main parts, which in turn deal with the following issues: (1) literature review – peculiarity of frugal innovations, (2) research hypotheses, (3) research methodology, (4) empirical results (exposing the following issues: complexity level of applying the attributes of the concept of frugal innovations, and the comparison between three regions, as well as statistical differences between the A, B and C regions in the complexity of applying the attributes of the concept of frugal innovations), (5) conclusions and discussions, as well as (6) limitations and paths for future research.

2. Literature Review – Peculiarity of Frugal Innovations

Focusing on the peculiarity of modern innovations (including the frugal ones), it is worth noting that the innovative activity in contemporary socio-economic, as well as technical and organizational circumstances can take various forms. Some companies focus on maximizing the usability and functionality of innovations without care about the level of costs and the purchase price of innovation for customers/users. Others, in turn, are focused

on optimizing the efficiency of innovative processes, i.e. they reduce costs while maximizing the value delivered to the environment. It is difficult to state clearly which of the approach is more recommended for implementing by companies nowadays. However, taking into account the current changes – e.g. negative social effects of the COVID-19 pandemic, limitation of the availability of resources on a global scale, as well as social-economic status of individual regions, a decrease in the purchasing power of societies of many countries (e.g. due to the dynamically growing inflation), accumulation of socio-demographic problems, etc. – it is reasonable to direct companies towards the implementation of the attributes of the second of the above-mentioned approaches. In the literature it is called the concept of frugal innovations.

Frugal innovations can be defined in different ways, e.g.:

- This is a kind of “model” of creating new value for individual customers and even entire social groups (e.g. local communities). This is the concept that considers the creation of maximum available value for specific stakeholder groups (Dadlani, Wali & Mukerjee, 2022, pp. 114–116).
- Frugal innovations can be associated with “lean thinking”, that results in the reduction of waste resources and time in innovative processes (Janiszewski, 2020, p. 76).
- Frugal operation is economical, diligent and reflects sustainability in the use of resources (Merriam Webster Dictionary, 2022), as well as is simple, uncomplicated and generates low cost (Oxford Dictionaries, 2020).
- The basic attributes of frugal innovations include low costs and at the same time high financial efficiency, as well as meeting the most important needs of users (Makowski & Kidyba, 2018, p. 201; Hossain, 2020, p. 2).
- Frugal innovations are of specific approach to serve consumers with limited resources in emerging and developing markets, as well as in low-growth Western markets (Hyvärinen, Keskinen & Varis, 2016, p. 2).
- Frugal solutions/projects must be designed, manufactured, delivered and maintained to meet the needs of underserved consumers in poor environments (market segments) (Bhatti, 2012, p. 13).
- It is a transition from the “doing more with less” model to the “doing better with less” model (Radjou & Prabhu, 2016, p. 12 et seq.).

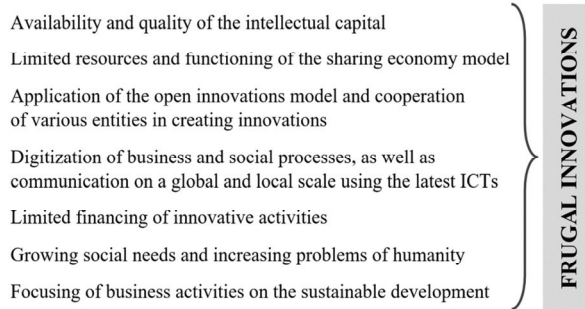
Frugal innovations, as a model for the operation of contemporary enterprises, possess both internal and external sources/determinants which relate to various dimensions of business activities, as well as the socio-economic and technological changes. The basic circumstances of shaping frugal innovations are presented in Figure 1.

Summarizing and at the same time integrating the above content, attributes of frugal innovations can be specified. The basic attributes are as follows (based on: Weyrauch & Herstatt, 2017, p. 8; Markiewicz, Bielawa & Tylżanowski, 2020, p. 26; Dadlani, Wali & Mukerjee, 2022, pp. 26–28):

- low price for the customer and a high availability on the market,
- optimal usability,

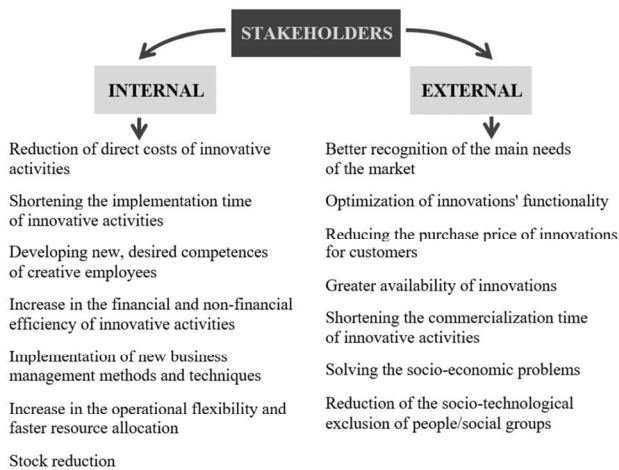
- new idea, new approach, new application,
- reduction of resource consumption, as well as conscious and justified cost reduction,
- drawing on technological development and new scientific knowledge,
- contributing to environmental and corporate sustainability.

Figure 1
Circumstances of shaping frugal innovations



Source: Author's own elaboration based on: Tiwari, Fischer & Kalogerakis, 2017, pp. 13–20; Harris et al., 2020, p. 814; Bhatti & Ventresca, 2012, p. 16.

Figure 2
Significance of frugal innovations for stakeholders



Source: Author's own elaboration based on: Tiwari, Kalogerakis & Herstatt, 2016, pp. 1–2; Tiwari & Kalogerakis, 2016, p. 5 et seq.

The attributes of frugal innovations listed above are the basis for specific benefits/values received by internal and external stakeholders (Fig. 2). The examples of frugal innovations are: Tata Motors' Nano car, low-cost Swiss Swatch watches, Oppy Mars rover, Five App for deaf-mute people to communicate with friends, Foldscope paper microscope, IKEA furniture, General Electric battery-operated ECG, as well as the MittiCool clay refrigerator (Woźniak, 2022, pp. 31–35; Markiewicz, Bielawa & Tylzanowski, 2020, pp. 28–29; Ratten, 2019, p. 44).

Moreover, it should be noted that the national and international literature is primarily focused on the indication and description of the attributes of frugal innovations implemented in certain types of enterprises. The complexity of application of attributes of frugal innovations in innovative enterprises has not been explored so far (especially in Poland – in terms of identification of the three regions: A, B and C), that points a significant research gap. Therefore, the obtained empirical results will be difficult to compare to the results of other Authors and to conduct discussions.

3. Research Hypotheses

Six hypotheses have been developed in this study. Hypotheses H.1 and H.2 refer to the level of the complexity of applying the attributes of the concept of frugal innovations with respect to shaping relationships with customers, as well as with respect to shaping innovative processes. There are no publications referring directly to Polish circumstances. Nevertheless, strong references to this problem can be found in the foreign literature. Focusing on the relationships with customer (and more broadly – with stakeholders), reference should be made to the research of Bhattacharjya, Bhaduri and Kakoty (2023). They note that “frugal innovation often requires cooperation among heterogeneous actors with diverse values, capabilities, interests and norms”. Thanks to the high complexity of the type of activities, it is possible to precisely assess the value provided to stakeholders (including customers). Similar conclusions were reached in the studies by Velananda et al. (2022), as well as Hossain et al. (2022). Nodari et al. (2022), as a result of research, proved that despite specific resource constraints, organizations implement frugal innovations, with a focus on eliminating “excess” costs, and increasing quality of services. It is on the factors that companies should primarily focus in innovation processes. In turn, Barnikol and Liefner (2022) noted during research that institutional and systemic circumstances are particularly important in innovation processes in entities focused on the implementation of the so-called advanced frugal innovations. Mahmood (2014) came to similar conclusions during research. The study by Pedroso et al. (2023) indicates that “social, environmental, economic, and technological aspects of frugal innovation play an important role in the process of idea creation, concept development, product development,

and product marketing”. Therefore, the complexity of external factors for enterprises is of great importance in innovation processes. In addition, the relatively high complexity of the implementation of factors determining innovations is highlighted in the research by Qu, Qin and Wang (2023). The authors pay particular attention to factors related to ICTs, but also to: organizational resilience, internal learning from failure, external learning from failure, and design thinking. Significance of the high complexity of ICT factors is also highlighted in the research by Nassani et al. (2022). The authors also highlight the complexity of the relationships with customers in innovative processes in accordance with the frugal model. On the basis, a specification of the hypotheses relating to the Polish circumstances was made. Hypotheses H.1 and H.2 are as follows:

- H.1. In all regions of Poland (i.e. A, B, C), there is a high level of the complexity of applying the attributes of the concept of frugal innovations with respect to shaping relationships with customers.
- H.2. In all regions of Poland (i.e. A, B, C), there is a high level of the complexity of applying the attributes of the concept of frugal innovations with respect to shaping innovative processes.

At this point, it is worth noting that the H.3–H.6 hypotheses refer to the comparison of three regions of Poland. At this point, it should be emphasized that the regions analyzed have different levels of socio-economic and technological development and it leads to differences in the level of the complexity of applying the attributes of frugal innovations. Such conclusions are prompted by the results of research published by: (Nazarczuk, 2013, p. 100 et seq.; Perło, 2014, p. 101 et seq.; Wojciechowska-Solis, 2018, pp. 122–129; Jędrzejczak-Gas & Barska, 2019, pp. 228–232; Kubiczek & Bieleń, 2021, p. 28 et seq.; Barska, Jędrzejczak-Gas & Wyrwa, 2022, pp. 7–11). Therefore, in this study there is a reasonable comparison of the A, B and C regions. Hypotheses H.3–H.6 are as follows:

- H.3. In the A region of Poland there is a higher level of the complexity of applying the attributes of frugal innovations concept with respect to shaping relationships with customers than in B and C regions.
- H.4. In the A region of Poland there is a higher level of the complexity of applying the attributes of frugal innovations concept with respect to shaping innovative processes than in the B and C regions.
- H.5. Comparing companies from all regions of Poland (i.e. A, B, C), there are statistically significant differences in the complexity of applying the attributes of frugal innovations concept (with respect to shaping relationships with customers) between all three regions.
- H.6. Comparing companies from all regions of Poland (i.e. A, B, C), there are statistically significant differences in the complexity of applying the attributes of the concept of frugal innovations (the area of shaping innovative processes) between all three regions.

4. Research Methodology

4.1. Research Methods

The deductive approach was used – mainly at the stage of critical analysis of national and foreign literature sources. The study used the method of systematic literature review – mainly to synthesize the results of previous research, as well as to identify areas where further research is needed. This is the key stage in creating a theoretical framework for own research. The purpose of a systematic review is to identify all empirical evidence that fits predetermined inclusion criteria to answer a specific research question or hypothesis. By using clear and systematic methods when citing scientific articles and other sources (reports, monographs, etc.), errors can be minimized at the synthesis and inference stage, thus providing reliable results (see: Snyder, 2019, pp. 333–339). The following databases were used for a systematic literature review in the study: Emerald, EBSCO, CEEOL, Web of Science and Google Scholar. The second stage of the research procedure was the specification of the criteria for the selection of papers (mainly scientific articles). The focus was on the following keywords: frugal innovations, frugality, and innovative process. Subsequently, exclusions were made for studies in the following form: industry communications, book reviews, monograph introductions, as well as reports and presentations from scientific conferences. From the collection of 463 publications, only those that referred to the area of interest of economic sciences, in particular management and quality sciences, were selected (86 publications). Subsequently, the content of the abstracts was verified and studies were specified in three groups: directly related to the examined issue (21 publications), partly related to the examined issue (9 publications), as well as poorly related to the research problem (56 publications). In addition, the analyses included publications with the highest citation score (Czakov, 2011, pp. 57–61). The process of systematic literature review was conducted between January 2021 and March 2022. On the basis of the systematic literature review, a specification of the purpose and research problem, as well as hypotheses was made. The key task in relation to own research was the operationalization of hypotheses, it was based on the results of the literature review.

The empirical study primarily considered the inductive approach, and the analysis and synthesis methods (see: Hajduk, 2012, p. 119; Sułkowski, 2012, p. 95 et seq.; Wojciechowska, 2016, p. 116 et seq.), as well as the quantitative research techniques (see: Lisiński & Szarucki, 2020, pp. 123–124). The following quantitative research techniques were used (based on: Sudoł, 2012, pp. 136–145; Apanowicz, 2005, p. 57 et seq.; Zaborek, 2009, pp. 41–49; Wojciechowska, 2011, pp. 47–54): CAWI survey technique, and statistical analysis of data. The basic research tools were: the CAWI survey

questionnaire, PS IMAGO PRO 7.0 software and Microsoft Excel (see: Woźniak, 2022, p. 85).

In the scope of the CAWI study, two basic composite indicators were identified, they were used for quantitative verification of research hypotheses (indicators reflect the level of complexity of enterprises' activities¹) (see: Woźniak, 2022, pp. 86–90):

- ICSRC – indicator of the complexity of shaping relationships with customers,
- ICSIP – indicator of the complexity of shaping innovative processes.

The indicators were developed using the factor analysis method (the PCA method, the rotation method – Varimax with Kaiser's normalization), and based on 39 detailed measures (Tab. 1)² (see: Woźniak, 2022, p. 86). Detailed measures have been identified on the basis of the literature analysis (see: Radjou, Prabhu & Ahuja, 2012, p. 18 et seq.; Mahmood, 2014, pp. 1–4; Radjou & Prabhu, 2016, p. 5 et seq.; Ślęzak & Jagielski, 2018, pp. 81–104; Beaulin, 2019, pp. 8–17; Ratten, 2019, p. 4 et seq.; Markiewicz, Bielawa & Tylżanowski, 2020, pp. 24–41; Bhatti et al., 2022, pp. 21–23, 171–188; de Marchi et al., 2022, pp. 984–1007; Velananda, Dissanayake & Wickramasinghe, 2022, pp. 17–28; Dabic et al., 2022, pp. 914–929).

Table 1

The average scores for the enterprises' activities in all three regions of Poland

Enterprises' activities/detailed measures	Average scores in regions		
	A	B	C
ICSIP – indicator of the complexity of shaping innovative processes			
Reducing the costs of conceptualizing innovations	3.56	3.44	2.71
Reducing the costs of R&D	3.59	3.26	2.71
Reducing the costs of manufacturing	3.73	3.38	2.71
Reducing the costs of commercialization and marketing	3.55	3.54	3.14
Reducing the costs of imitation activities	3.53	3.41	2.86
Reducing the costs of materials and raw materials	3.68	3.33	2.71
Increasing the production efficiency in innovative processes	3.71	3.46	2.86
Increasing the efficiency of financing innovative processes	3.82	3.64	2.57
Increasing the efficiency of marketing activities for innovative processes	3.75	3.46	2.71
Increasing the efficiency of knowledge management in innovative processes	3.82	3.41	2.29

Table 1 – continued

Enterprises' activities/detailed measures	Average scores in regions		
	A	B	C
Optimization of the employment of people responsible for the implementation of innovative processes	3.69	3.56	2.43
Optimization of employment at managerial positions responsible for the management of innovative projects	3.63	3.64	2.57
Increasing the level of using employee creativity in innovative processes	3.78	3.59	2.71
Developing cooperation with external entities (innovative networks)	3.72	3.54	3.00
Use of outsourcing (external business services)	3.42	3.54	3.14
Reducing production waste	3.64	3.56	2.86
Reducing the negative impact of innovation on the environment (e.g. natural)	3.75	3.59	2.71
Recognizing basic customer needs while complexly penetrating the market	3.73	3.72	3.00
Changes in the value system of society and in the mood of citizens	3.58	3.49	2.43
Social acceptance of innovative activities of enterprises	3.62	3.62	2.57
Emergence of inconsistencies between market reality and the needs of customers/society	3.57	3.28	2.71
Innovation policy in the country and the technology transfer system	3.68	3.49	3.00
Increase in new knowledge (technical, scientific, medical, etc.)	3.71	3.59	3.00
Changes in the structure of industry and/or the market	3.71	3.46	2.57
Changes in the specificity of the innovation process itself and the attributes of innovations	3.63	3.36	2.71
Socio-cultural and demographic situation in the country	3.60	3.23	3.00
Economic situation in the country	3.59	3.46	3.00
Regulations' system in the country	3.55	3.33	2.57
ICSRC – indicator of the complexity of shaping relationships with customers			
Ensuring low costs for customers to acquire innovations	3.58	3.44	2.29
Scaling up the distribution of innovations	3.75	3.41	3.14

Table 1 – continued

Enterprises' activities/detailed measures	Average scores in regions		
	A	B	C
Increasing the usability of innovation	3.75	3.54	2.57
Ensuring the universal and comprehensive nature of innovation for customers	3.73	3.56	2.57
Ensuring the scalability of innovation	3.66	3.36	3.00
Achieving the level of the minimum expected functionality of innovation in the opinion of customers	3.66	3.31	2.86
Ensuring the life span of innovation (long service life of innovation)	3.73	3.44	2.57
Creating innovations for the poorest social groups	3.65	3.21	2.57
Meeting customer needs related to environmental protection, as well as sustainable development of enterprises and the world	3.71	3.41	2.29
Developing alternatives, improvisation and practical methods to overcome a lack of resources or solve seemingly unsolvable financial, social and technological problems of customers	3.78	3.26	2.43
Training customers in the field of self-contained creation of solutions and development of acquired innovations	3.64	3.44	2.43

The interpretation of the average values of the ICSRC and ICSIP indicators was used. The study adopted a simplification of four levels of complexity – the same for both indicators (Woźniak, 2022, p. 114):

- low – values in range <1;2),
- moderate low – values in range <2;3),
- moderate high – values in range <3;4),
- high – values in range <4;5>.

The above ranges of ICSRC and ICSIP values were determined arbitrarily – on the basis of a simple division of the 5-point assessment scale into four equal parts. Of course, it is only the proposal of the author of the study, but it is based on the development of intervals of the same length. This solution seems to be the “fairest”. It is worth emphasizing that these are the “conventional” ranges and, in fact, the analysis of various entities (e.g. individual enterprises) may result in a change in the length of the ranges (after taking into account the peculiarity of their operation and the situational context of the analysis). Nevertheless, for the purposes of the study, the division seems to be sufficient – it serves a general (aggregated) assessment of the level of the complexity of applying the attributes of the concept of frugal innovations.

Moreover, when analyzing the results of the CAWI study, basic descriptive statistics (e.g. median, dominant, mean, standard deviation and skewness) for individual indicators/variables were also considered. The study also used the verification of normality of variables' distribution, the one-way ANOVA, as well as the Bonferroni post-hoc test, and the Kruskal-Wallis test for independent samples.

4.2. Research Sample

The study included 200 innovative enterprises according to PKD (i.e. Polish Classification of Activities) divisions: 10, 11, 13, 14, 20, 21, 26, 27, 29, 52, 59, 61, 62, and 65 (Tab. 2) (see: PKD, 2022). Random selection was used (systematic sampling in layers – the layers were determined by the PKD number) (Rószkiewicz, 2021, pp. 24–26). The condition for qualifying enterprises for the research sample was the implementation of innovative processes³ during the last five years of operation on the market (i.e. in the period from January 2017 to December 2021), which boiled down to the complete and correct implementation of at least 10 innovations. Only large enterprises were included in the study.⁴ The CAWI survey was conducted on a sample of business owners or managers responsible for risk management, innovation processes or project management, employed in enterprises operating in Poland in the most innovative sectors (based on: *Innowacyjność Polski. Chartbook*, 2020, p. 21; *Innowacyjność Polski. Chartbook*, 2021, p. 27) – one respondent from each surveyed enterprise. Overall, the study was conducted between April and July 2022. The CAWI study was carried out (at the level of data collection) by the IPC Research Institute (Wrocław, Poland) (see: Woźniak, 2022, p. 84, 93–95).

Table 2
Activity profile of enterprises

Activity profile	PKD number	% in research sample
Food & Beverage Manufacturing	10, 11	10
Manufacture of textile products and manufacture of clothing	13, 14	10
Manufacture of chemicals and chemical products	20	10
Manufacture of basic pharmaceutical substances, as well as medicines and other pharmaceutical products	21	10
Manufacture of computers, electronic and optical products, as well as manufacture of electrical equipment	26, 27	10
Manufacture of motor vehicles, trailers and semi-trailers, excluding motorcycles	29	10

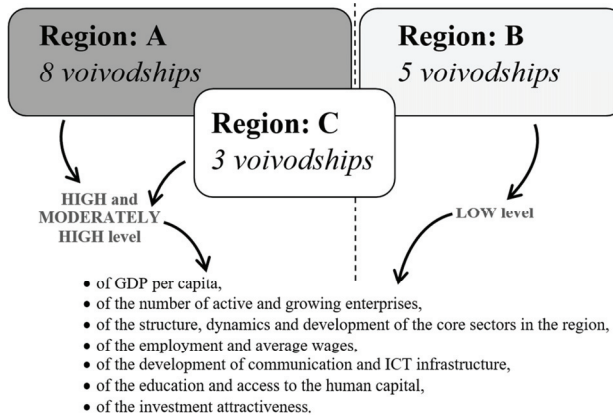
Table 2 – continued

Activity profile	PKD number	% in research sample
Warehousing and service activities supporting transport	52	10
Activities related to the production of films, video recordings, television programmes, sound and music recordings	59	10
Software, IT consultancy and related activities	62	10
Insurance, reinsurance and pension funds, excluding compulsory social security	65	10
Total		100

Source: Author's own elaboration based on: PKD, 2022; *Innowacyjność Polski. Chartbook, 2020*, p. 21; *Innowacyjność Polski. Chartbook, 2021*, p. 27).

The study covered entities operating throughout the whole Poland (16 voivodships). The enterprises were analyzed taking into account the spatial distribution according to the criterion of belonging to the A, B and C regions – reflecting the broadly understood level of socio-economic and technological development (Fig. 3).

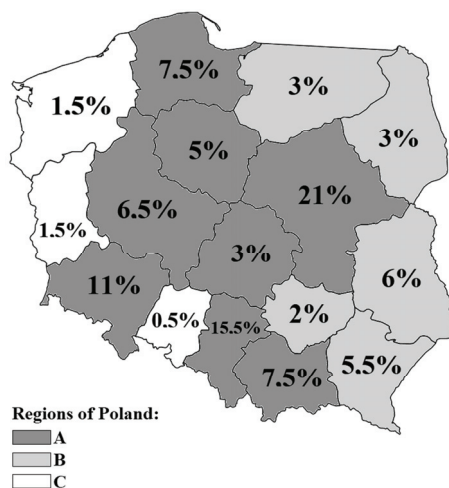
Figure 3
Specification of the A, B and C regions of Poland



Source: Author's own elaboration based on: Mayer & Kapiszewski, 2015.

The A region includes the following voivodeships: Pomorskie, Kujawsko-Pomorskie, Wielkopolskie, Dolnośląskie, Łódzkie, Śląskie, Małopolskie and Mazowieckie, the B region: Warmińsko-Mazurskie, Podlaskie, Lubelskie, Podkarpackie and Świętokrzyskie, and the C region: Lubuskie, Zachodniopomorskie and Opolskie (Mayer & Kapiszewski, 2015). The spatial structure of entities included in the empirical study, regarding the A, B and C regions is presented in Figure 4.

Figure 4
Spatial structure of entities included in the empirical study



The basic criteria distinguishing the regions indicated above are: the level of GDP per capita, the number of enterprises, the structure and dynamics of development of basic sectors in the region, the unemployment and employment rate, the average wages, the level of communication and ICT infrastructure, or the level of education and availability of human capital – constituting the investment attractiveness of a given region (Mayer & Kapiszewski, 2015).

Table 3
Specification of the research sample

Enterprises' attributes		Regions of Poland						Total	
		A		B		C		Number	% in research sample
		Number	% in region	Number	% in region	Number	% in region		
Sector	Industry	88	57	27	69	5	71	120	60
	Service	66	43	12	31	2	29	80	40
Age	1–5 years (“young”)	19	12	5	13	2	29	26	13
	6–10 years (“quite young”)	52	34	21	54	2	29	75	38
	11–15 years (“mature”)	32	21	5	13	3	43	40	20
	Over 15 years (“old”)	51	33	8	21	0	0	59	30
Scale of operation	Local (1 city/municipality/district)	3	2	0	0	1	14	4	2
	Regional (1–8 voivodeships in Poland)	18	12	4	10	0	0	22	11
	National (9–16 voivodeships in Poland)	75	49	22	56	3	43	100	50
	European (min. 1 country in Europe outside Poland)	35	23	10	26	1	14	46	23
	International (min. 1 country in the world outside Europe – including Poland)	23	15	3	8	2	29	28	14
Average annual turnovers	PLN 0–3 million	38	25	14	36	2	29	54	27
	PLN 3–6 million	74	48	16	41	4	57	94	47
	PLN 6 million and more	42	27	9	23	1	14	52	26
Total		154	100	39	100	7	100	200	100

The study listed the following number of enterprises belonging to the individual regions: A – 154 entities, B – 39 entities, as well as C – 7 entities. A detailed specification of the companies included in the research sample is contained in Table 3.

5. Empirical Results

5.1. Level of the Complexity of Applying the Attributes of the Concept of Frugal Innovations, and the Comparison Between Three Regions

The first problem examined was the assessment of the level of the complexity of applying the attributes of the concept of frugal innovations (Tab. 4).

Table 4
Descriptive statistics for the ICSRC and ICSIP indicators

Descriptive statistics	ICSRC			ICSIP		
	Region			Region		
	A	B	C	A	B	C
N	154	39	7	154	39	7
Mean	3.6948	3.3963	2.6104	3.6539	3.4709	2.7657
Median	3.7273	3.3636	2.6364	3.6566	3.5558	3.0000
Dominance	5.00	3.36	3.00	5.00	5.00	3.00
Standard deviation	0.75308	0.99727	0.46566	0.72405	0.85148	0.80159
Variance	0.567	0.995	0.217	0.524	0.725	0.643
Skewness	-0.426	-0.439	-0.092	-0.195	-0.287	-0.970
Kurtosis	0.792	0.089	-2.043	0.181	-0.233	1.286
Gap mark	4.00	4.00	1.18	4.00	3.58	2.44
Min	1.00	1.00	2.00	1.00	1.42	1.28
Max	5.00	5.00	3.18	5.00	5.00	3.72

As it can be noticed, in the A and B regions – both with respect to shaping relationships with customers and shaping innovative processes – moderately high values of indicators were recorded. Within the C region, on the other hand, the values are moderately low for both indicators (Tab. 4). On the basis of the above results, it is possible to falsify the H.1 and H.2 hypotheses, as well as assume that:

- In all regions of Poland (i.e. A, B, C), there is no high level of the complexity of applying the attributes of the concept of frugal innovations with respect to shaping relationships with customers.
- In all regions of Poland (i.e. A, B, C), there is no high level of the complexity of applying the attributes of the concept of frugal innovations with respect to shaping innovative processes.

shaping innovative processes). The first step was to examine the normality of the distribution of ICSRC and ICSIP variables in each region of Poland. ICSRC and ICSIP variables are normally distributed in all regions (Tab. 5–7).

Table 5

The ICSRC and ICSIP distribution normality test – the A region

No.	H ₀	Test	Significance ^a	Decision
1.	The ICSRC distribution is normal with the mean of 3.69 and the standard deviation of 0.75308.	Kolmogorov-Smirnov test for one sample	0.127	No grounds for rejecting the H₀ hypothesis
2.	The ICSIP distribution is normal with the mean of 3.65 and the standard deviation of 0.72405.	Kolmogorov-Smirnov test for one sample	0.288	

^a Significance level is 0.050. Lilliefors method based on Monte Carlo trials (10000) with an initial value of 2000000.

Table 6

The ICSRC and ICSIP distribution normality test – the B region

No.	H ₀	Test	Significance ^a	Decision
1.	The ICSRC distribution is normal with the mean of 3.40 and the standard deviation of 0.99727.	Kolmogorov-Smirnov test for one sample	0.185	No grounds for rejecting the H₀ hypothesis
2.	The ICSIP distribution is normal with the mean of 3.47 and the standard deviation of 0.85148.	Kolmogorov-Smirnov test for one sample	0.975	

^a Significance level is 0.050. Lilliefors method based on Monte Carlo trials (10000) with an initial value of 2000000.

Table 7

The ICSRC and ICSIP distribution normality test – the C region

No.	H ₀	Test	Significance ^a	Decision
1.	The ICSRC distribution is normal with the mean of 2.61 and the standard deviation of 0.46566.	Kolmogorov-Smirnov test for one sample	0.346	No grounds for rejecting the H₀ hypothesis.
2.	The ICSIP distribution is normal with the mean of 2.77 and the standard deviation of 0.80159.	Kolmogorov-Smirnov test for one sample	0.585	

^a Significance level is 0.050. Lilliefors method based on Monte Carlo trials (10000) with an initial value of 2000000.

Subsequently, the analysis was carried out using the one-way ANOVA method. Verification of hypotheses about the homogeneity of variance for both ICSRC and ICSIP indicators in the three considered regions resulted in a confirmation – so both indicators are characterized by a homogeneity of variance (Tab. 8). In turn, the F test gave rise to the general conclusion that there are statistically significant differences in the values of both indicators between the A, B and C regions (Tab. 9).

Table 8
Homogeneity of variance tests

		Levene test	df1	df2	Significance
ICSRC	Based on the mean	2.315	2	197	0.101
ICSIP	Based on the mean	0.610	2	197	0.544

Table 9
One-way ANOVA – the F test

		Sum of squares	df	Average square	F	Significance
ICSRC	Between groups	9.858	2	4.929	7.715	0.001
	Within groups	125.866	197	0.639		
	Total	135.724	199			
ICSIP	Between groups	5.937	2	2.969	5.240	0.006
	Within groups	111.616	197	0.567		
	Total	117.553	199			

However, general information on the existence of the statistically significant differences between all regions is not sufficient. It is important to know specifically between which regions there are statistically significant differences. To answer the question, the Bonferroni post-hoc test was used. This test showed that statistically significant differences in the values of both ICSRC and ICSIP indicators do not exist between all regions – they are only between the regions as follows (Tab. 10):

- A and C, as well as B and C – with respect to shaping relationships with customers,
- A and C – with respect to shaping innovative processes.

Table 10
The Bonferroni post-hoc test

Dependent variable	(I) Region	(J) Region	Difference in means (I–J)	Standard error	Significance	95% confidence interval	
						Lower limit	Upper limit
ICSRC	A	B	0.29853	0.14329	0.115	-0.0474	0.6445
		C	1.08442*	0.30890	0.002	0.3385	1.8303
	B	A	-0.29853	0.14329	0.115	-0.6445	0.0474
		C	0.78588	0.32811	0.050	-0.0064	1.5781
	C	A	-1.08442*	0.30890	0.002	-1.8303	-0.3385
		B	-0.78588	0.32811	0.050	-1.5781	0.0064
ICSIP	A	B	0.18303	0.13493	0.530	-0.1428	0.5088
		C	0.88824*	0.29089	0.008	0.1859	1.5906
	B	A	-0.18303	0.13493	0.530	-0.5088	0.1428
		C	0.70521	0.30898	0.071	-0.0408	1.4513
	C	A	-0.88824*	0.29089	0.008	-1.5906	-0.1859
		B	-0.70521	0.30898	0.071	-1.4513	0.0408

* The difference in means is significant at the level of 0.05.

The Kruskal-Wallis test for independent samples is a confirmation of the analysis using the one-way ANOVA method, which indicated that the ICSRC and ICSIP distributions are not the same for all region categories (Tab. 11). The Kruskal-Wallis test also explicitly indicated that the statistically significant differences are between regions as follows (Tab. 12–13):

- A and C, as well as B and C – with respect to shaping relationships with customers,
- A and C – with respect to shaping innovative processes.

Table 11
The Kruskal-Wallis test for independent samples

No.	H ₀	Test	Significance ^{a,b}	Decision
1.	The ICSRC distribution is the same for all region categories	Kruskal-Wallis test for independent samples	0.001	Reject H₀ hypothesis.
2.	The ICSIP distribution is the same for all region categories	Kruskal-Wallis test for independent samples	0.024	

^a Significance level is 0.050.

^b Asymptotic significance is presented.

Table 12
Pairwise comparisons for each region – the ICSRC indicator

Sample 1– Sample 2	Test statistics	Standard error	Standardized test statistics	Significance	Adjusted significance ^a
C–B	61.910	23.729	2.609	0.009	0.027
C–A	80.425	22.340	3.600	0.000	0.001
B–A	18.515	10.362	1.787	0.074	0.222

Each row tests the H₀ hypothesis that the distributions of Sample 1 and Sample 2 are the same. Asymptotic significance (two-sided tests) is presented. Significance level is 0.050.

^a Significance values for multiple tests are adjusted by the Bonferroni method.

Table 13
Pairwise comparisons for each region – the ICSIP indicator

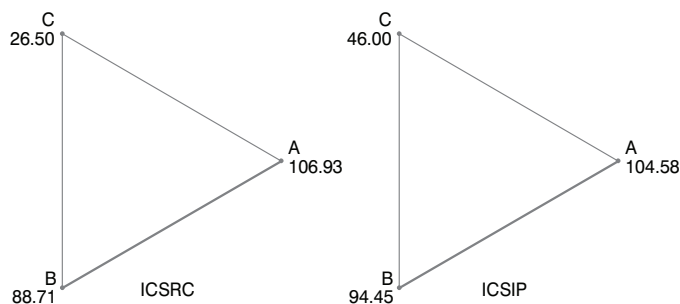
Sample 1– Sample 2	Test statistics	Standard error	Standardized test statistics	Significance	Adjusted significance ^a
C–B	48.154	23.756	2.027	0.043	0.128
C–A	58.584	22.366	2.619	0.009	0.026
B–A	10.431	10.375	1.005	0.315	0.944

Each row tests the H₀ hypothesis that the distributions of Sample 1 and Sample 2 are the same. Asymptotic significance (two-sided tests) is presented. Significance level is 0.050.

^a Significance values for multiple tests are adjusted by the Bonferroni method.

A graphic representation of the statistical differences between the A, B and C regions is included in Figure 6 – the thinner the connection, the stronger statistical differences between the regions.

Figure 6
Pairwise comparisons for each region –ICSRC and ICSIP indicators



Each node represents the mean sample rank for the region.

On the basis of the above results, the H.5 and H.6 hypotheses can be partially confirmed, as well as it can be concluded that:

- Comparing companies from all regions of Poland (i.e. A, B, C), there are statistically significant differences in the complexity of applying the attributes of the concept of frugal innovations (with respect to shaping relationships with customers) between the A and C regions, as well as the B and C regions.
- Comparing companies from all regions of Poland (i.e. A, B, C), there are statistically significant differences in the complexity of applying the attributes of the concept of frugal innovations (with respect to shaping innovative processes) between the A and C regions.

6. Discussions and Conclusions

Frugal innovations can be a source of a number of benefits for companies operating in various regions of the world (Ratten, 2019), including Poland. Taking into account specific regions in Poland – specified on the basis of the level of the socio-economic and technological development, i.e. A, B and C regions – on the basis of the study, diverse complexity of implementing the attributes of the concept of frugal innovations can be observed. Nevertheless, it can be generally assumed that the phenomenon is not “new” in Poland and is implemented in enterprises at a moderate level. In Poland, there are rather favorable conditions for the implementation of the attributes of the concept of frugal innovations – this is indicated by relatively small differences between the A and B regions. Therefore, in theoretically less developed voivodeships from the so-called Poland B, frugal innovations are implemented. The study also indicated that in the A and B regions – both in the area of shaping relationships with customers and shaping innovative processes – moderately high values of the ICSRC and ICSIP indicators were recorded, as well as in the C region, the values are moderately low for

both indicators. Such situation can be considered beneficial. However, in the C region, which is not the least developed in Poland, the complexity of implementing the attributes of the concept of frugal innovations is the lowest (which does not mean that it is very low at all).

In other words, the study showed that in individual regions of Poland, enterprises implement attributes of the frugal innovation model to a rather different extent. Thus, there is not a fully “uniform” situation in the whole country in this regard. Such a situation may indicate that in the region probably either customers/users/local communities do not report a demand for this type of innovation, or there is no properly developed system for informing about possibilities of implementing the frugal innovation model and the benefits of it – both for enterprises and their external environment.⁵ Thus, the research conducted indicates that greater emphasis should be placed on spreading knowledge about frugal innovations in the C region, it can be drawn on the experience and support of the A region. In the case, e.g. tax incentives and supporting industry clusters can be used. Therefore, the results of the study emphasize the need to undertake research at the national (or at least regional) level with respect to systemic improvement of programs and projects aimed at the development of “frugal” innovation activities in the C region. Such solutions also require the development and implementation of specific procedures and regulations (concerning e.g. the applying for funding for the development of innovative activities in accordance with the “frugal” model – this is due to the fact that “transitioning” to the model also requires a reorganization of the enterprise). Developing a campaign promoting the model – along with the indication of measurable benefits may be a useful solution in the long-term “equalization” of the levels of interest in the model of frugal innovations by enterprises in the C region. It should be clearly emphasized that entrepreneurs are not fully aware of the existence of the model and the possibility of its implementation in their internal innovation system in Poland. Therefore, system-wide implications may have a strong impact on solutions dedicated to managers and employees. However, managerial implications are unlikely to exist on their own without systemic (nationwide/regional) support. First, it is necessary to prepare an appropriate “ecosystem” for “frugal” innovative activities, and only then show managers the directions of change in their enterprises. This will avoid institutional inconsistencies and “barriers”. The above implications are consistent with the research results and recommendations of Mahmood (2014), as well as Barnikol and Liefner (2022), they noted that institutional and systemic circumstances are particularly important in the processes of improving innovative activities in entities focused on the implementation of frugal innovations. This is also in line with the narrative of Pedrosa et al. (2023), they expose social, environmental, economic, and technological circumstances of improving processes of conducting frugal innovations.

It can also be noted that the results of the study are only partially consistent with the results published, e.g. by Velananda et al. (2022), Hossain et al. (2022), as well as Bhattacharjya, Bhaduri and Kakoty (2023). The authors note that it is important and necessary to interact with various entities (mainly customers) and pay attention to the values they expect in developing the model of frugal innovations. However, in empirical studies, the importance and complexity of the implementation of activities in this respect are at a moderately low level. The results obtained are also only partially consistent with the results achieved by Nodari et al. (2022) who argues that the implementation of measures aimed at reducing costs while ensuring the quality of innovations introduced to the market deserves special attention of entrepreneurs/managers. Here, too, an empirical study showed a moderately low level of respondents' assessment. The same applies to the results obtained in terms of the complexity of ICTs-related activities. The importance of the factors and the complexity of their implementation are relatively low in the surveyed companies, while researches conducted by Nassani et al. (2022), as well as Qu, Qin and Wang (2023) suggest that the complexity should be at a high level.

7. Limitations and Future Research

The research limitations are mainly related to the fact that subjective opinions of respondents were analyzed. It was also based on a limited list of factors constituting the basic attributes of the concept of frugal innovations. The study detailed a total of 39 measures/factors. What is more, in the empirical analysis the specifically developed composite indicators (ICSRC and ICSIP) were used, they simplify the real situation and respondents' assessments. It is also worth noting that the study took into account a different number of enterprises qualified for all three regions of Poland.

Further research should focus on identifying the basic classes of enterprises (with low, moderate and high values of the ICSRC and ICSIP indicators) in each region of Poland (i.e. A, B and C), as well as identifying the basic attributes of the enterprises. Such an approach can provide a basis for exposing the dominant types of enterprises in each region. Further research should also be focused on estimating the correlation between enterprises belonging to individual regions of Poland and the attributes of enterprises, as well as the correlation between the enterprises' affiliation to a given region and the complexity of applying the attributes of the concept of frugal innovations.

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The author declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

Endnotes

- ¹ The higher value of the indicator, the higher complexity of actions. All factors (i.e. detailed measures) were assessed by respondents on a 5-point scale (score “1” means a very low level/importance, and score “5” means very high level/importance).
- ² The developed indicators (ICSRC and ICSIP) take the form of weighted averages – this is to highlight the most important factors and components in the opinion of respondents and to give them higher weightings. This approach is treated as more reliable than relying on a simple arithmetic mean. In addition, the indicators only present the average assessment by respondents of the factors/actions included in the study, and present a general “picture” of the examined problem. However, one can assume the Cronbach alpha coefficient, as well as the KMO measure, and the Bartlett test as components of the staged validation of both indicators. For the ICSRC indicator, the values were as follows – Cronbach alpha (0.930), KMO measure (0.937), Bartlett test ($p < 0.001$). The ICSRC indicator has 1 component. However, for the ICSIP indicator, they were the values – Cronbach alpha (0.963), KMO measure (0.949), Bartlett test ($p < 0.001$). The ICSIP indicator has 3 components. Therefore, all the above values allowed for the construction and subsequent analysis of both indicators. In addition, a content validity of the questions in the questionnaire was conducted – this task remained the responsibility of the author of the study (this was done on the basis of the systematic literature review). Criteria of significance and representativeness have been taken into account. On the other hand, the face validity was carried out on a group of 5 deliberately selected entrepreneurs (the so-called subject matter experts), dealing with innovative activities in Poland. In this way, it was determined whether they understood the questions well, and whether their way of perceiving the questions coincided with the intention of the author of the study. The Cronbach alpha measure was taken into account as part of the construct validity (Klimas, 2021, pp. 123–160; Czakon, 2019, pp. 3–10).
- ³ This is about innovation in general, i.e. not only frugal innovations. The aim of the screening question in the questionnaire was to include innovative units in the broad sense. On the other hand, the survey questionnaire (in the main questions) did not directly ask about the implementation of frugal innovations – mainly because this concept could be unknown to respondents and could mislead them. The study asked only about the attributes of the frugal innovations, which gave grounds to assess properly the complexity of their use in Polish enterprises.
- ⁴ This is due to the fact that large enterprises do not have the so-called resource constraints (staff, financial, information, etc.) in innovative processes, and there is greater certainty that they successfully implement innovative processes and implement innovations on the market (see: Maiti et al., 2020, p. 1526 et seq.; Bakhtiari et al., 2020, p. 507 et seq.).
- ⁵ This is only the author’s guess. This issue requires additional, in-depth research.

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Credit Risk Modeling Using Interpreted XGBoost

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Abstract

Purpose: The aim of the paper is to develop a credit risk assessment model using the XGBoost classifier supported by interpretation issues.

Design/methodology/approach: The risk modeling is based on Extreme Gradient Boosting (XGBoost) in the research. It is a method used for regression and classification problems. It is based on a sequence of decision trees using a gradient-based optimization method of the loss function to minimize the errors of weak estimators. We use also methods for performing local and global interpretability: *ceteris paribus* charts, SHAP and feature importance approach.

Findings: Based on the research results, it can be concluded that XGBoost achieved higher values of performance metrics than logistic regression, except sensitivity. It means that XGBoost indicated a smaller percentage of all bad client. Results of local interpretability enable a conclusion that in the case of the client in question, the credit decision is positively influenced by credit scores from external suppliers, while it is negatively influenced by minimal external scoring and short seniority. The number of years in the car and higher education are also positive. Such information helps to justify a negative credit decision. Results of global interpretability enable a conclusion that higher values of the traits associated with the z-scores are accompanied by negative Shapley values, which can be interpreted as a negative effect on the explanatory variable.

Research limitations/implications: XGBoost, A *ceteris paribus* plot, SHAP, and feature importance methods can be used to develop a credit risk assessment model including machine learning interpretability. The main limitation of research is to compare the results of XGBoost only to the logistic regression results. Future research should focus on comparing the results of XGBoost to other machine learning methods, including neural networks.

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Originality/value: One of the key processes in a bank is the credit decision process, which is the evaluation of a client's repayment risk. In the consumer finance sector, the processes are usually largely automated, and increasingly the latest machine learning methods based on neural networks and ensemble learning methods are being used for the purpose. Although machine learning models allow for achieving higher accuracy of credit risk assessment compared to traditional statistical methods, the main problem is the low interpretability of machine learning models. The models often perform as the "black box". However, the interpretation of the results of risk assessment models is very important due to the need to explain to the client the reasons for assessing their credit risk.

Keywords: credit risk, risk modeling, XGBoost, machine learning interpretability, explainable artificial intelligence.

JEL: C63, C88, D81

Modelowanie ryzyka kredytowego z wykorzystaniem interpretowalnego algorytmu XGBOOST

Streszczenie

Cel: celem niniejszych badań jest opracowanie modelu oceny ryzyka kredytowego z wykorzystaniem klasyfikatora XGBoost z uwzględnieniem interpretowalności tego modelu.

Metodologia: w niniejszych badaniach w celu modelowania ryzyka wykorzystano metodę Extreme Gradient Boosting (XGBoost). Jest to metoda stosowana do problemów regresji i klasyfikacji. Opiera się na sekwencji drzew decyzyjnych wykorzystujących gradientową metodę optymalizacji funkcji straty w celu minimalizacji błędów słabych estymatorów. Wykorzystano również metody umożliwiające dokonanie lokalnych i globalnych interpretacji: wykresy *ceteris paribus*, SHAP i badanie ważności cech.

Wyniki: na podstawie wyników badań można stwierdzić, że XGBoost osiągnął wyższe wartości metryk efektywności niż regresja logistyczna, z wyjątkiem wartości metryki czułości. Oznacza to, że XGBoost wskazał mniejszy odsetek wszystkich złych klientów. Wyniki interpretacji lokalnej pozwalają stwierdzić, że w przypadku klienta na decyzję kredytową pozytywnie wpływają oceny punktowe od zewnętrznych dostawców, liczba lat samochodu oraz wykształcenie wyższe, natomiast negatywnie wpływają niska zewnętrzna ocena scoringowa oraz krótki staż pracy. Taka informacja pozwala na uargumentowanie negatywnej decyzji kredytowej. Wyniki interpretacji globalnej pozwalają wnioskować, że wyższym wartościom cech związanych ze wskaźnikami towarzyszą ujemne wartości Shapleya, co można interpretować jako negatywny efekt wpływu na zmienną objaśniającą.

Ograniczenia/implikacje badawcze: metody XGBoost, *ceteris paribus* plot, SHAP i feature importance mogą być wykorzystane do opracowania modelu oceny ryzyka kredytowego z uwzględnieniem interpretowalności uczenia maszynowego. Głównym ograniczeniem badań jest porównanie wyników XGBoost jedynie z wynikami regresji logistycznej. Przyszłe badania powinny skupić się na porównaniu wyników XGBoost z innymi metodami uczenia maszynowego, w tym z sieciami neuronowymi.

Oryginalność/wartość: jednym z kluczowych procesów realizowanych w bankach, jest proces podejmowania decyzji dotyczących udzielenia kredytów, czyli ocena ryzyka spłaty zobowiązania przez klienta. W sektorze finansów konsumenckich procesy te są zwykle w dużym stopniu zautomatyzowane, a coraz częściej wykorzystuje się w tym celu najnowsze metody uczenia maszynowego oparte na sieciach neuronowych i metodach uczenia zespołowego. Choć modele uczenia maszynowego pozwalają na osiągnięcie wyższej dokładności oceny ryzyka kredytowego w porównaniu z tradycyjnymi metodami statystycznymi, to głównym problemem jest niska interpretowalność modeli uczenia maszynowego. Modele te często występują jako „black box”. Interpretacja wyników modeli oceny ryzyka jest jednak bardzo ważna ze względu na konieczność wyjaśnienia klientowi powodów oceny jego ryzyka kredytowego.

Słowa kluczowe: ryzyko kredytowe, modelowanie ryzyka, XGBoost, interpretowalność uczenia maszynowego, wyjaśnialna sztuczna inteligencja.

1. Introduction

Banks, due to the nature of their business, collect large volumes of data on client and their financial products. The data can be used for statistical modeling and the generation of machine learning algorithms that can help predict future events based on historical data, thereby improving decision-making processes.

The credit decision process, which is the evaluation of a client's ability to repay a debt is the key process in a bank, from an operational perspective. In the consumer finance sector, the processes are usually largely automated, and the latest machine learning methods based on neural networks and ensemble learning methods are being increasingly used for the purpose. The algorithms are often referred to as black boxes, meaning that the method of operation of such algorithms is complex and often unintuitive. In the context of credit risk models, a deeper understanding of the algorithm allows one to deepen business knowledge, prevent errors, but also respond to regulatory requirements.

Although machine learning models allow to achieve higher accuracy of credit risk assessment, as compared to traditional statistical methods (Addo et al., 2018), the main problem is the low interpretability of machine learning models. The models often perform as the "black box". However, the interpretation of the results of risk assessment models is very important due to the need to explain to the client the reasons for assessing their credit risk.

The aim of the paper is to develop a credit risk assessment model using the XGBoost classifier supported by interpretation issues. We use the XGBoost classifier (Li et al., 2021) because it allows risk modeling in relation both to a large and a small sample of data. Most other machine learning models (for example neural networks) require a large sample of data. Both local and global interpretability has been analyzed.

The rest of the paper is divided as follows: the background and methods description are presented after the introduction part of the paper. Next the results of research related to developing and assessing the XGBoost classifier are presented. The last part of the paper presents the analysis of local and global interpretability of the developed XGBoost, discussion, and conclusion.

2. Background

Financial organizations analyze clients in terms of their ability to repay the credit. The aim of the process is both accurate in the forecast and effective, i.e. optimal use of the resources of the organization dealing with lending activities (Kuziak & Piontek, 2022). The problem of credit risk assessment also concerns information asymmetry between the lender and

the borrower (Bazarbash, 2019). Reducing this asymmetry takes place both through access to information about the client and the use of appropriate statistical methods that will allow assessing the probability with which the client will repay the liability (Siddiqi, 2017). Application scoring is the basic type of credit risk modeling (Louzada et al., 2016). It is used in the process of granting new financing agreements, including credits and loans. The scoring assesses the applicant's risk of default based on the client's data, information about the product for which the client has applied, and data provided by the credit bureau. The result of the model is used to decide whether to grant credit. Scoring is only a part of the entire application process, it also covers other elements such as legal analysis and verification of completeness and correctness of data. With the current degree of automatization, this is a very important part of the contracting process, especially in the consumer finance sector. In practice, scoring is not usually the only method of credit evaluation. Some applications are analyzed through the so-called manual process, in which an analyst has to decide whether to accept or reject the application (Louzada et al., 2016) and makes the decision.

Fraud scoring is another type of the scoring model used in the credit decision process. The purpose of the scoring is to analyze applications for possible defrauding. The result of the scoring can be used to select applications that should be more closely scrutinized for the risk of possible extortion. Fraud scoring is particularly important in the context of the digitalization of the sector, but also new methods of cybercrime (Zhou et al., 2018).

Scoring methods are also applicable in the analysis of credits or loans and advances already made to clients. According to the guidelines of the European Banking Authority (EBA), banks should screen assets for significant increases in credit risk. For this purpose, banks use behavioral scorings (Goel & Rastogi, 2023). Their score is calculated based on the client's repayment history, but also other data (sociodemographic or financial conditions). The result of behavioral scoring is indirect, by reclassifying exposures between phases, used to create allowances for expected losses. As a result, the result of such scoring affects the costs and ultimately the bank's profit. Banks use the results of the behavioral model, by identifying clients with good payment discipline, in cross-upselling, for example, by offering credit card limit increases to clients with high behavioral scores (Björkegren & Grissen, 2022). Different statistical methods have been used for credit risk modeling, such as the multiple discriminant analysis (Mvula Chijoriga, 2011), Z-score Altman, E. I. (2018), and logistics regression (Falconieri et al., 2020). Credit risk modeling is also performed by artificial intelligence methods, such as artificial neural networks (Akhtar et al., 2019), genetic algorithms (Metawa et al., 2019), support vector machines (Harris, 2013), random forest, rough set theory (Yeh et al., 2017) or XGBoost (Givari et al., 2022) or clustering methods (Kou et al., 2014). The results of the

existing approach are very distributed. Accuracy of prediction is from 64% to 93% and depends mainly on the characteristics of the analyzed data set.

Interpretability of models based on artificial intelligence is an important problem. Two main types of interpretability are indicated in related research.

The first type is local interpretability. It is a state in which the estimation result for a particular case (a single observation) can be explained in the context of the variables used in the model. Local interpretability can be particularly useful in situations where the decision is incomprehensible to the user of the algorithm or where the decision has resulted in an incorrect decision. For this reason, local interpretability is particularly important in areas such as medicine or finance (Botari et al., 2022).

Global interpretability is the second type of interpretability of machine learning models. It involves understanding how the model makes decisions based on a holistic view of its features and each of its learned components, such as weights, parameters, and structures. The model's global interpretability helps understand the distribution of the target outcome based on the variables (Molnar et al., 2020). Examples of dynamically developed interpretability methods include LIME (Di Cicco, 2019), SHAP (Silva et al., 2022) or integrated gradients (Sundararajan et al., 2017) which use mathematical theorems of the game theory or local regression models to build explanations.

Based on the existing research in the field of credit risk modeling it can be concluded, that they take into account the issues of interpretability of machine learning results to a small extent. Therefore the research question of this study is formulated as follows: How to develop a credit risk assessment model including machine learning interpretability? The main contribution of the research concerns the development of a credit risk assessment model using the XGBoost algorithm, taking into account local and global interpretability.

3. Methods

The risk modeling is based on Extreme Gradient Boosting (XGBoost) in the research. It is a method used for regression and classification problems. It is based on a sequence of decision trees using a gradient-based optimization method of the loss function to minimize the errors of weak estimators. It is an open-source library with implementations available in many programming languages (including C++, Python, and R). The algorithm was described by (Chen & Guestin, 2016). The XGBoost implementation is particularly well-known for its popularity on platforms running machine learning and artificial intelligence competitions (Nielsen, 2016). XGBoost uses the Classification and Regression Tree (CART) algorithm by default. CART is a binary tree, i.e. each non leaf node has two sub-nodes. Branches in the tree can be determined by entropy values

or the Gini impurity measure (Gini impurity) (Chen & Guestin, 2016). Based on the value, the best splitting point is chosen by selecting the value that will best separate the classes occurring in the set. In the case of numeric variables, all possible splitting values are analyzed, while with categorical variables the splitting point for a given variable is fixed. The tree can be deep enough to ideally classify into two classes, they can lead to a model overfitting effect. The number of nodes can be adjusted, i.e. the macro number of nodes can be set (Chen & Guestin, 2016). In the boosting process, successive classifiers are generated sequentially. If the estimator is based on decision trees, the first classifier is generated as in the case of a random forest, but the next classifier takes into account the classification quality of the previous classifier. Cases of incorrect predictions are marked with higher weights to improve classification. The final model result is based on the weighted prediction of individual estimators. A single classifier is a decision tree. The classifier learns sequentially by adding more trees, taking into account the classification results of previous trees based on probabilities. In subsequent iterations, boosting also uses bootstrapping, but as incorrect classifications of previous classifiers have increased weights, they are more likely to be correctly clustered. The result of an algorithm based on boosting can be expressed as (Chen & Guestin, 2016):

$$\hat{y}_i = \sum_{k=1}^K f_k(x_i)$$

Where :

K is the number of classifiers used,

x are the explanatory variables,

f is the classifier belonging to the used set of classifiers.

In the XGBoost learning process, it is possible to select parameters that will affect the final classifier. Adjusting the parameters can help improve the quality of the classifier, and on the other hand, they help achieve the desired trade-off between load and variance. To reduce model overfitting, methods based on classifier regularization have been used. Regularization involves tuning the weights given in successive iterations. The parameters responsible for regularization include:

- *learning_rate* – a parameter that regulates the learning process in successive iterations of the boosting process. The value adjusts the weights selected in successive iterations. The default value is 0.3. Higher values can lead to overlearning of the classifier.
 - *reg_alpha* – L1 regularization parameter; default value 0.
 - *reg_lambda* – L2 regularization parameter; default value 1.
- For L1 and L2 parameters, higher values limit the degree of overfitting.

In addition, individual decision trees can also be adjusted, by pruning during the generation of the classifier or after the entire process. The parameters responsible for the shape of the trees are:

- *max_depth* – the value of the parameter determines the maximum depth of individual trees, i.e. the maximum length of the branches. The default value used is 6. Too large a value can lead to over-learning of the model and slows down the learning process.
- *gamma (min_split_loss)* – the value of the parameter determines the minimum spike in the value of the loss function at which the split will be preserved. This step is performed after the tree is generated.

By default, subsequent trees within an iteration are generated as based on the entire learning sample, but you can limit the number of both observations and variables. The parameters responsible for limiting the sample and the pool of variables include:

- *subsample* – denotes the portion of the learning sample that will be used to generate the next tree. The default value is 1, which means that on subsequent iterations the classifiers learn on the entire sample. Smaller values make the algorithm more conservative.
- *colsample_bytree* – specifies the fraction of variables from the X matrix that will be selected to be taken into account when generating the next tree. The default value is 1, at which all variables can be used.

Additional parameters include:

- *n_estimators* – indicates the number of trees generated by the boosting process. With a value of 1, the classifier is a single decision tree, so the boosting method is not applied. By default, the value of 100 is applied.
- *scale_pos_weight* – parameter used in the binary classification process with unbalanced classes in the learning sample; the default value used is 1. According to the documentation, the suggested value is [negative class count]/[positive class count].

In addition to the parameters set for the XGBoost classifier class object, the learning process can also be adjusted by changing the parameters in the *fit()* method. Through the *eval_set* argument, a dataset can be indicated that is not used for model estimation but is used to analyze the predictive power of data outside the learning sample. In subsequent iterations, the predictive power of the model on the specified sample is analyzed on an ongoing basis according to the specified *eval_metric*. For binary classification models, available metrics include the area under the ROC curve (AUC). If the parameters are used, the number of iterations that are subject to analysis for the value of the metric is also provided. If the quality of the classifier does not improve by the given number of subsequent iterations, the learning process stops and the one with the highest value of the metric is used as the final estimator. When using a validation set, the parameter *n_estimators* represents only the maximum number of estimators used (Chen & Guestin, 2016).

In the research, we use also methods for performing local and global interpretability: *ceteris paribus* charts, SHAP and feature importance approach.

Ceteris paribus charts are also known as “what-if plots”. For a given case, the effect of a change in a given variable on the estimate of the explanatory variable is analyzed under the assumption of no change in the other independent variables used. In the case of a classification problem such as a credit risk assessment – the effect of a change on the logarithm of the odds quotient (log-odds) or probability is evaluated. Such an analysis helps to understand what the algorithm’s decision would look like with a change in a given variable (Kužba et al., 2019).

The SHAP (Shapley Additive Explanations) library enables an interactive analysis of a predictive model. It is a model-independent method (model agnostic approach), which means that the interpretation does not analyze the structure of the model’s performance, but only the impact of individual variables on the final result. The logic behind the library is based on Shapley’s values used in game theory. The values are used to analyze the influence of each player on the outcome of a team game (Silva et al., 2022).

The feature importance approach relies on the indication statistical contribution of each feature (variable) to the underlying model when making decisions. We use such techniques as the frequency of use of variables, coverage, and gain. (Du et al., 2019).

4. Results

4.1. Tools and Data Source

Data preparation and estimation and analysis were developed in the Google Colaboratory environment. It is a free integrated development environment (from IDE) that allows code execution in Python language within the cloud. Google Colaboratory is based on Jupyter Notebooks. Python language version 3.7.13 and libraries were used for the analysis: Numpy 1.21.6, Pandas 1.3.5, Sklearn 1.0.2, XGBoost 0.90, Scipy 1.7.3, Seaborn 0.11.2, Matplotlib 3.2.2, Shap 0.40.0, Optbinning 0.14.1, Statsmodels 0.10.2.

The analysis was conducted on a Home Credit dataset made available as part of a competition held on the Kaggle.com platform. Home Credit is a loan company founded in 1997 in the Czech Republic, it offers its services in nine countries. The dataset was prepared in CSV format.

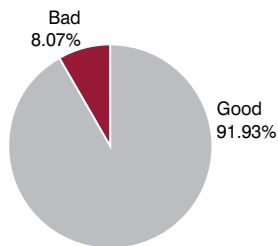
The dataset contains information about the client (age, gender, education) and the product (type of loan, day, and time of application). The dataset also contains information about the client’s debt history from internal data sources, as well as from credit bureaus. The information from credit bureaus also includes information on external scoring results. The data

was largely unchanged from the source data, but some changes were applied to data that could help identify individuals or credit bureaus. Information on dates of birth and employment was replaced by the number of days relative to the date of application. Information about the building in which the applicant lives and credit scores from credit bureaus has been normalized.

4.2. Data Processing

The dataset contains 307,511 rows and 122 columns. The unique key for each client is the SK_ID_CURR column. The explained variable is located in the TARGET column. Its definition has not been defined, but by the column designation, it has been based on days of delay in repayment. Figure 1 shows that bad contracts account for about 8% of the total set of data.

Figure 1
Pie chart showing the share of classes present in the dataset

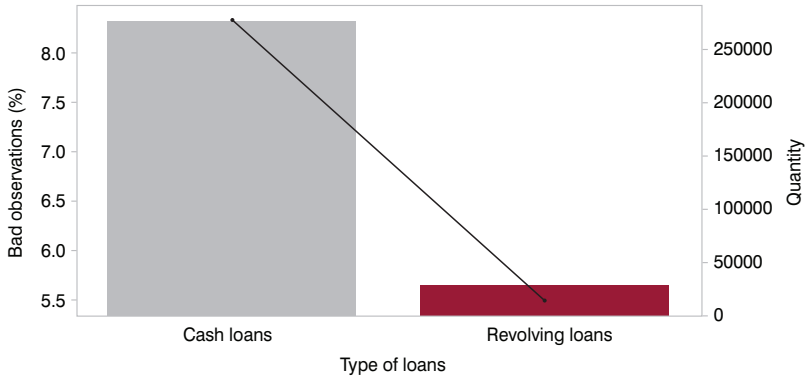


Among the variables that can be used in the modeling process, there are 105 numerical variables and 15 categoric variables. Many of the variables are characterized by a significant proportion of missing values. Some of them may be due to client characteristics, but also to the way the application is filled out. No information provided by the client during the application or no information from credit information bureaus can possess the degree of risk, so variables having missing values will be used in the estimation process.

Among the variables, there is information on the type of loan, it determines the specifics of taking funds. Among the loans, there are both cash loans and revolving loans. As can be seen in Figure 2, the degree of risk varies by type – revolving loans, which constitute a minority in the entire set, are characterized by a lower share of bad observations.

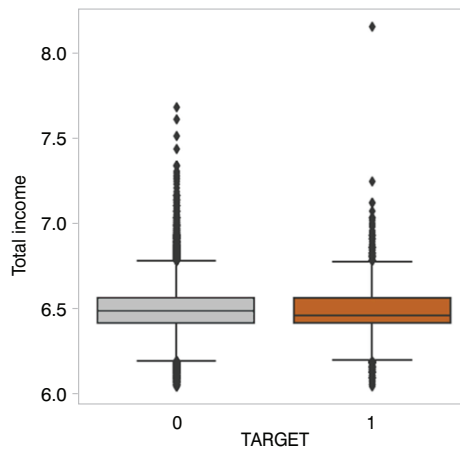
Information about the loan taken by the client also includes the amount of the loan, the amount of the installment, and the value of the financed purchase for a specific loan purpose. Among the information about clients' financial situation, there are variables specifying income, type of income, occupation, and variables specifying whether the client owns their property and their car, along with the age of the car owned.

Figure 2
Graph of the share of “bad” cases by type of loan



Income in the set is characterized by a very wide range of values – the median is about 147 thousand, while the highest value is 117 million. To reduce the impact of outliers on the estimation results, a logarithmic transformation will be applied. In the case of the value 0 (no income shown), the missing value will be shown within the logarithmized variable. Figure 3 shows the newly created variable by the class occurring in the set.

Figure 3
Box plot of the variable *Total income* with class division

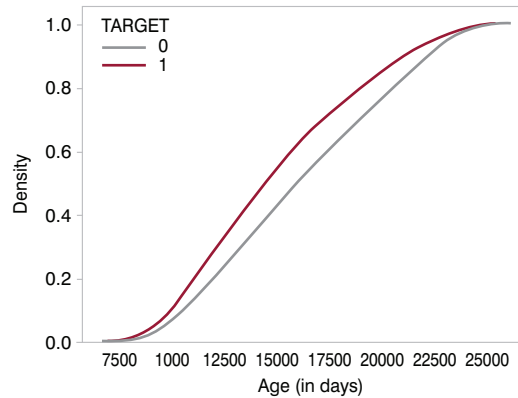


As can be observed, the median logarithm is lower for clients with repayment problems, but the differences in the distributions are not significant.

The socio-demographic variables are age (in days), education, gender, marital status, and the number of children. The variables can have a major impact on a client's ability to repay a debt, as an example, Figure 4 shows graphs of cumulative density distributions of each class against the Age (in days) variable.

Figure 4

Graph of cumulative distributions of the Age (in days) variable by class



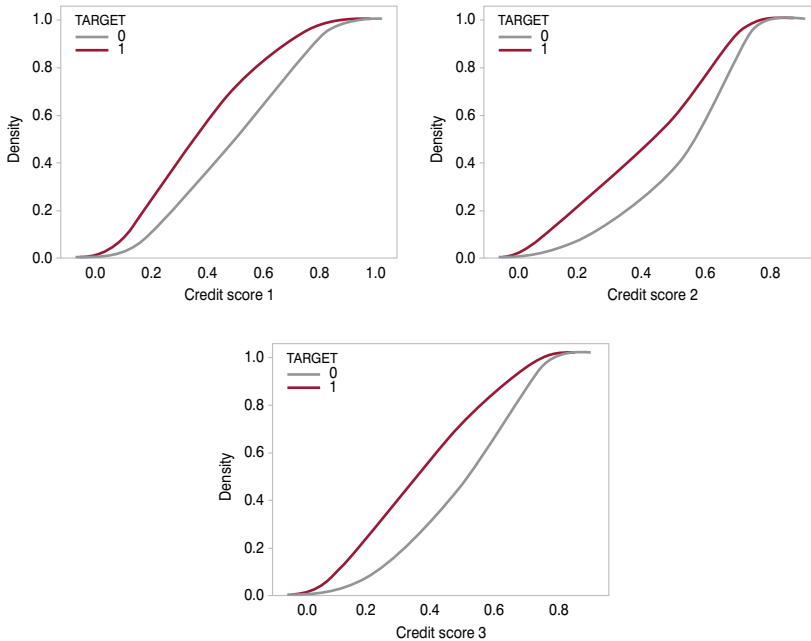
Since the curve for bad contracts (TARGET = 1) is above the curve for good contracts, this may suggest that young clients pose a higher risk to the lender.

Based on the source data, additional variables were created that could potentially improve classification performance:

- the ratio of total credit to earnings earned by the client,
- the value of the financed purchase divided by the value of the loan, the value referred to in banking as LTV (Loan to Value),
- the difference between the income and the installment amount,
- the number of days of employment divided by the number of days since the client was born,
- income divided by the number of children,
- whether the value of the financed purchase field is empty; a binary variable,
- whether the age of the car owned field is empty; a binary variable (value of 1 for clients who declared having a car, but its age is unknown).

The dataset also contains information on delays and entries into default status of more than 30 and 60 days in repayments among family and people related to the client (four variables in total). The dataset also includes credit scores from three credit information of institutions. The data was normalized, i.e. moved to the interval from 0 to 1. In Figure 5, it can be seen that the variables have high predictive power.

Figure 5
Plots of the cumulative distributions of the Credit score 1, Credit score 2, and Credit score_3 variables by class



Based on them, variables will be added to the collection:

- the average of the scores,
- the maximum value from the point grades,
- the minimum value from the point grades,
- the difference between the maximum and minimum point grades.

The set also contains information about the number of client checks in credit reference bureaus in the last hour, and day (not including the last hour) and analogously for the week, month, quarter, and year. The remainder of the collection consists of variables about the building in which the client lives and binary variables about the individual documents the client was asked for at the time of application. The document data has been anonymized, so we don't know which documents it refers to.

The collection was divided into a training sample, representing 70% of the total collection, and a validation sample, which will use the remaining 30% of the collection. The samples were drawn, but the same proportion of bad contracts was kept in each sample.

4.3. Risk Modeling Using XGBoost

Numeric variables have been retained in their original form, while categorical variables have been transformed into binary (dummy) variables. Each categorical variable will be stored as k columns, where k is the number of categories within the variable. The XGBoost classifier, when creating nodes in successive trees, always uses the variable that maximizes the ability to separate observations from the classes present in the set, so no prior selection of variables for the mode list is required. The first step will be to select the appropriate parameters to carry out the learning process. For this purpose, cross-validation will be used. The training sample will be divided into four subsamples. For each set of parameters, the learning process will be carried out four times. In each iteration, one of the samples will be used as a validation sample, and the others will be used as learning samples.

Each iteration is evaluated in terms of the classifier quality. The metric used will be the AUC ROC, the area under the graph of the classifier quality assessment curve (Receiver Operating Characteristic). The score is then averaged over all four iterations. The iterative analysis will be carried out using the GridSearchCV class provided within the Scikit Learn library. In each iteration, the learning process will be stopped if for the next 10 iterations, the score on the validation subset does not improve. Table 1 shows the parameters along with the values considered in the search for the best combination of parameters.

Table 1
The set of searchable parameters of the XGBoost algorithm

Parameter	Searched values
objective	“binary:logistic”
max_depth	2, 3, 4, 5
learning_rate	0.05, 0.1, 0.2, 0.3
scale_pos_weight	11.387
reg_alpha	0, 5, 10, 15
subsample	0.6, 0.9, 1
colsample_bytree	0.6, 0.8, 1
n_estimators	300

The *scale_pos_weight* value was set as the ratio of good cases to bad cases, while as the case of this problem analyzed in this work involves binary classification, the objective parameter was set as “binary: logistic”. In addition, the learning process used the *early_stopping_rounds* parameter, it

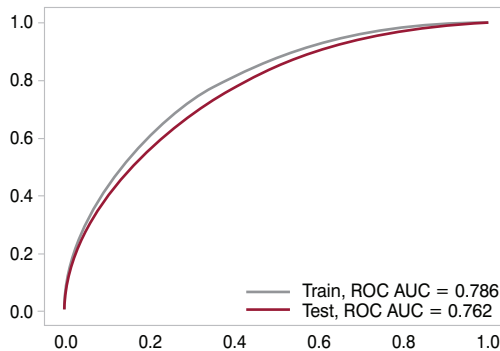
took the value of 10, meaning that the process ended if, for 10 consecutive iterations, the ROC value of the AUC on the cross-validation test sample did not improve. The highest average value of the area under the ROC curve was achieved for the values shown in Table 2.

Table 2
The selected set of parameters in the XGBoost algorithm

Parameter	Selected values of parameters
objective	“binary:logistic”
max_depth	3
learning_rate	0.1
scale_pos_weight	11.387
reg_alpha	10
subsample	0.9
colsample_bytree	0.8
n_estimators	500

The set of parameters was then used to learn the model on the entire training sample. In the process of learning the model, the same completion assumptions were used as in the cross-validation (*early_stopping_rounds* = 10) with the maximum number of iterations set as 500. Finally, the highest AUC ROC value on the test set was observed for 343 iterations. The ROC curve of the model is presented in Figure 6.

Figure 6
ROC curves for the XGBoost classifier based on the training and test sample



The area under the ROC curve is slightly larger, but no overfitting was observed. Results of the quality of the classifier are presented in table 3.

Table 3
Metrics of predictive power for the XGBoost classifier

	Training set	Testing set
ROC AUC	78.6%	76.2%
Gini	57.2%	52.4%
KS Statistics	42.8%	38.7%

4.4. Evaluation of the Developed Method

Results will be compared to the logistic regression method using the WOE transformation. Confusion matrices will be used to compare the effectiveness of the models. In the case analyzed, we were dealing with an unbalanced data set. The search class accounted for about 8% of the total dataset. Details of the counts of each class are presented in Table 4.

Table 4
Sample sizes by the explanatory variable

	Training set	%	Testing set	%
Target = 1 (bad client)	17 377	8.07%	7 448	8.07%
Target = 0 (good client)	197 880	91.93%	84 806	91.93%

When using classification algorithms, the selection of a probability cut-off point above which observations will be labeled as a wanted class (Target = 1) is an important element. In the case of the XGBoost algorithm, the difference in the size of each class was taken into account using the `scale_pos_weight` parameter, so the cut-off point will be a probability of 50%. In the case of logistic regression, the cutoff point will be set as 8.07% – observations for which the probability of occurrence of a class denoting a bad client is higher will be marked as bad. Thus, the share of each class in the predictions will be the same as in the training set. The confusion matrix of the XGBoost classifier is shown in Table 5, while the confusion matrix for the logistic regression model is shown in Table 6.

Table 5
The confusion matrix of the XGBoost classifier

		Prediction	
		Good client	Bad client
Real state	Good client	59 875	24 931
	Bad client	2 401	5 047

Table 6
Confusion matrix of the logistic regression model

		Prediction	
		Good client	Bad client
Real state	Good client	58 127	26 679
	Bad client	2 350	5 098

Based on the confusion matrix, metrics were determined that describe the performance of the final classification. They are presented in Table 7.

Table 7
Comparison of metrics of prediction efficiency for the XGBoost algorithm and logistic regression

Metrics	XGBoost	Logistic regression
Accuracy	70,4%	68,5%
Sensitivity	67,8%	68,4%
Precision	16,8%	16,0%
Specificity	70,6%	68,5%
F1-score	27,0%	26,0%

The metrics were counted under the assumption that the class searched for is the default case, i.e. a bad client. As can be observed, XGBoost achieved higher values of performance metrics than logistic regression, except sensitivity. It means, that XGBoost indicated a smaller percentage of all bad clients. The F1-score metric, which places the same emphasis on misidentifying a good client as well as a bad client, indicates that XGBoost is a slightly better classifier for the case under study. For metrics that are independent of cutoff points, and based only on the probability values of the class sought, XGBoost performs better. A comparison of the values of statistics determining the quality of prediction is presented in table 8.

Table 8
Comparison of metrics of the predictive power of the XGBoost classifier and logistic regression

Metric	XGBoost		Logistic regression	
	Training set	Testing set	Training set	Testing set
ROC AUC	78.6%	76.2%	74.7%	74.8%
Gini	57.2%	52.4%	49.3%	49.6%
KS Statistics	42.8%	38.7%	36.6%	37.1%

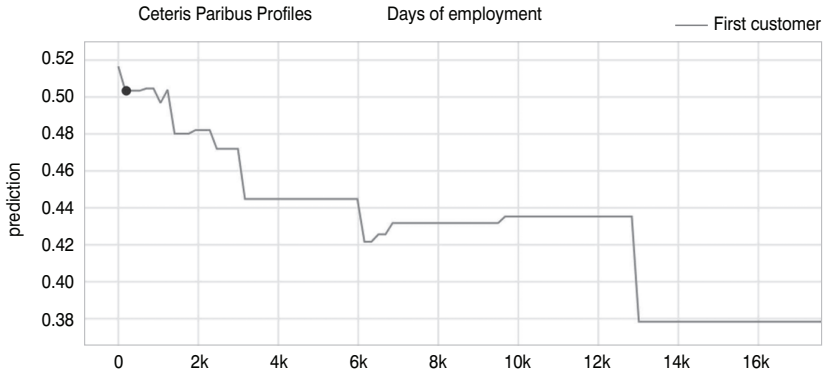
The difference in the value of the Gini metric is 2.8% on the test set. The improved predictive ability of the model used to evaluate loan applications is a tangible benefit to the bank. Lower portfolio loss is the lower cost of risk, which directly translates into profit generated by the organization (Goel & Rastogi, 2023). However, the use of such complex classification methods is associated with the loss of the benefits of logistic regression design, i.e. a very easy interpretation of results. Performance of complex algorithms, such as XGBoost, can be interpreted using the methods presented later in the article.

5. Interpretability of the Developed Model

5.1. Local Interpretability

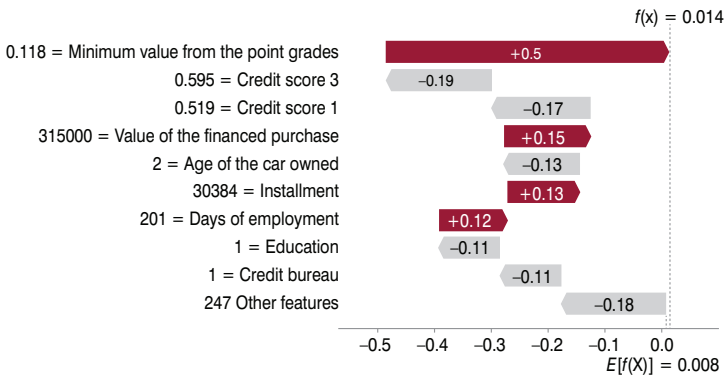
In the case of the credit risk problem, local interpretability methods allow one to understand why, according to the algorithm, a credit application was rejected or accepted. A wrong decision in the case of a bank affects efficiency of the organization. Denying credit to a good client is a loss of potential profit for the bank while granting a loan to a person who cannot repay the debt is a higher cost of risk. Similar to analysts making credit decisions in a manual process, where the ability to justify decisions is required, there is increasing talk of the need for similar feedback in the case of decision-making algorithms. Figure 24 shows the dependence of the explained variable on the number of days of employment variable for one of the clients in the test sample. Assuming that the applications of customer clients for whom the probability of problems in repayment is higher than 50% are rejected, the client would not currently receive a positive credit decision. However, as can be seen in the graph shown in Figure 7, if the period of employment had been longer (instead of 503 days, the client would have been employed in his current job for 1050 days), the credit decision would have been positive.

Figure 7
A ceteris paribus plot of the number of days of employment variable for one of the clients



As can be observed, the relationship is not monotonic at each od-cut, but on average, as seniority increases, the probability of problems in repayment decreases. No monotonicity, which would be preserved in the estimation of the model by the logistic regression method, is due to the process of the algorithm generation. The SHAP method allows the final result to be broken down into individual variables. An analysis of such a chart allows conclusions to be drawn about the relevance of individual variables (in the case of a particular client) and the direction of their influence on the final decision. In the case of the client analyzed in the previous example, the influence of individual variables is presented in Figure 8.

Figure 8
Diagram of the influence of the explanatory variables on the outcome in the case of one of the clients

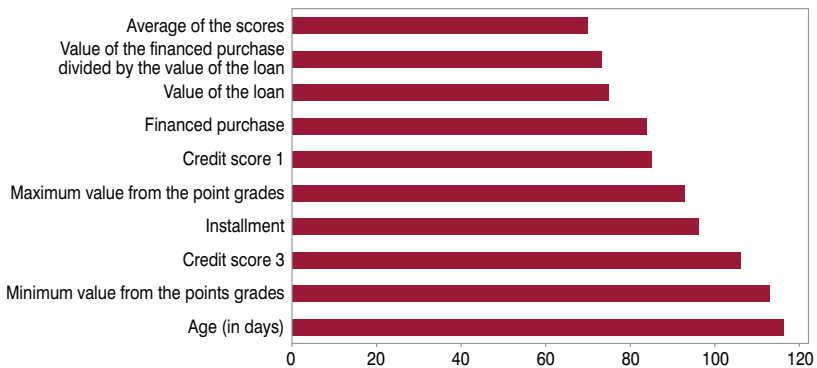


In the chart shown, the X-axis represents the natural logarithm of the chances of occurrence of the sought-after class (positive values indicate probabilities above 50%). In the case of the client in question, the credit decision is positively influenced by credit scores from external suppliers (numbers 1 and 3), while it is negatively influenced by minimal external scoring (resulting from a low score according to supplier number 2) and short seniority. The number of years in the car and higher education are also positive. Such information helps to justify a negative credit decision.

5.2. Global Interpretability

The first way to examine the performance of the XGBoost model is to analyze the feature importance of individual variables. This is a method implemented in the XGBoost library. Significance of variables (feature importance) can be measured using various techniques. The first is the frequency of use of variables across all nodes in all decision trees occurring in the model. Figure 9 shows the ten features based on which divisions are most often created within decision trees in the classifier presented in the previous section.

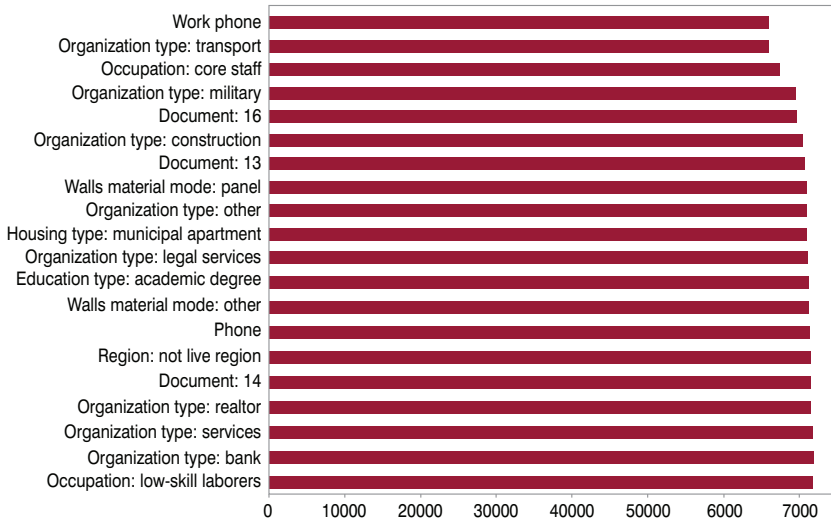
Figure 9
Variable relevance chart by frequency of variable use



As can be observed, the most frequently used variables were those denoting the age of the client (in days), variables based on external scoring values, and variables denoting the value of the installment and the financed good. Another way of determining the relevance of individual variables is coverage, which means the total number of observations that have been separated within the tree by a given variable. Figure 10 shows a bar chart with the top 20 variables according to the metric.

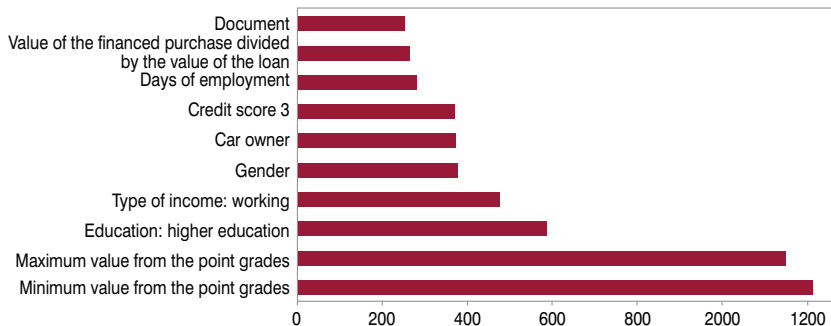
This metric does not add significant information about the relevance of individual variables, as they are large variables created by discretizing variables.

Figure 10
Significance chart of variables according to the coverage metric



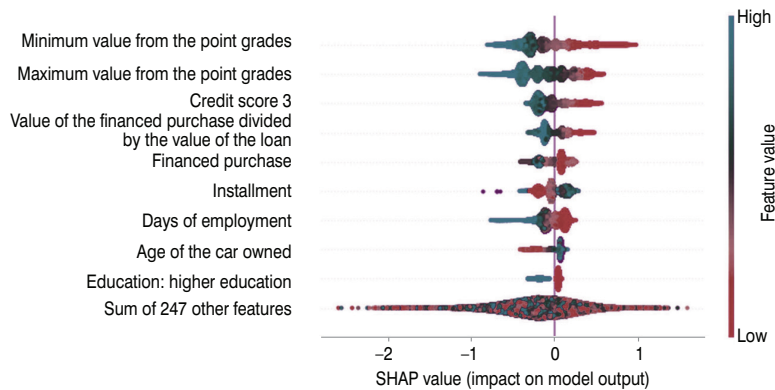
The last metric that can be used to analyze the relevance of variables is gain, the improvement that the use of a given variable brings to the final classification result. The Gain value is also the basis for determining the optimal nodes within each tree in the XGBoost algorithm. The ten most important features in the model based on the measure are shown in Figure 11. The features most important from the information “gain” perspective are the variables based on external scoring and the variables of the source of income, education, and gender. As can be observed, the choice of metrics has a large impact on the final order of significance, so all available options should be used for a complementary analysis.

Figure 11
Significance chart of variables by the Gain metric



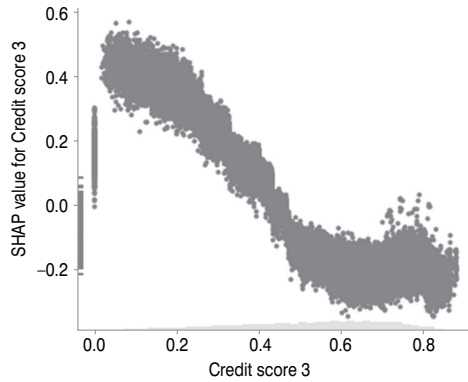
Significance of individual variables alone is important for understanding the model, but it is not possible to tell from it the direction of the variable's effect on the explanatory variable. Beeswarm charts available within the SHAP library can help in such an analysis. An example of such a chart is shown in Figure 12.

Figure 12
Beeswarm chart for the XGBoost classifier



As can be observed, higher values of the traits associated with the z-scores are accompanied by negative Shapley values, which can be interpreted as a negative effect on the explanatory variable. Since the explanatory variable takes the value of 1 in the case of a bad client, such a re-location is consistent with intuition. The situation is reversed for the age of the car owned variable describing the age of the car of the client applying for the loan. In the case of the variable, owners of older cars are assessed by the algorithm as potentially riskier. Analysis of the presented graph may indicate inconsistencies in the algorithm or the operation of the algorithm based on inconsistent intuition and business knowledge. The relationship between the value of a variable and its impact on prediction can also be shown in a dot plot. Figure 13 shows such a relationship for the variable credit score 3. According to intuition – lower scoring from an external credit information provider on average lowers the chance of a positive decision by the algorithm.

Figure 13
Shapley score plot for the credit score 3 variable



6. Discussion

Based on the results of the study, it can be concluded that the XGBoost algorithm achieves better credit risk forecasting results than logistic regression. The value of the Gini metric was almost three percentage points higher for the XGBoost classifier, proving its superiority. The difference may seem insignificant, but its impact on profitability can be significant from a bank's perspective. However, the effectiveness of each algorithm depends on the information value contained in the data set, which is influenced by the characteristics of the market in which the bank operates and the bank's ability to acquire the data, so it is necessary to compare different algorithms for each data set.

The interpretability of the XGBoost algorithm has been also analyzed. The analysis of the relevance of individual variables in the model was carried out by analyzing the branching that occurs in successive trees generated in the learning process. The method allows for a deeper understanding of the algorithm and an increased business knowledge of the client portfolio. Methods based on Shapley values, based on decision trees for algorithms, are optimized which allowed to reduce their computation time, allowing understanding the direction of the influence of individual variables on the sought class. *Ceteris paribus* charts can be used in explaining individual credit decisions and determining the conditions under which the decision would be different. Importantly, the methods can also be used with other algorithms, such as support vector-based models and neural networks. With regulatory changes potentially requiring banks in the future to more deeply understand the models used in their decision-making processes, the methods can respond to new requirements.

7. Conclusion

Due to the optimization of iterative processes, the developed credit risk assessment model using the XGBoost classifier supported by interpretation issues is a potentially interesting alternative to the standard methodology of creating a scoring card. Due to the multitude of parameters set before the learning process, the XGBoost classifier allows you to easily select parameters so that the predictive ability is at a high level. These parameters also make it possible to control the phenomenon of model overfitting, which, due to incorrect decisions, can cause large losses for the bank. The selection of parameters in the work was made using cross-validation for each possible combination of parameters, but there are other methods of such analysis. To use an approach based on Bayesian reasoning is an interesting alternative. The selection of parameters can also be carried out through optimization using genetic algorithms (Alibrahim & Ludwig, 2021).

In the case of many banks, the use of advanced decision-making algorithms in credit decision processes will also require adaptation of the IT infrastructure, which may also entail additional investment expenditures. However, as was presented in the paper, the algorithms can have a real impact on the effectiveness of the decision-making process. Summarizing the answer to the research question, it can be stated that XGBoost, A ceteris paribus plot, SHAP, and feature importance methods can be used to develop a credit risk assessment model including machine learning interpretability.

The main limitation of research is to compare the results of XGBoost only to the logistic regression results. Future research should focus on comparing the results of XGBoost to other machine learning methods, including neural networks.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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Technology Intelligence as a One of the Key Factors for Successful Strategic Management in the Smart World

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Abstract

Purpose: Due to the poor recognition in the literature of the phenomenon of Technology Intelligence in contemporary organizations, the aim of the paper is to attempt to recognize the essence and significance of Technology Intelligence of organizations operating in a Smart World.

Design/methodology/approach: The paper is conceptual-empirical in nature. The operationalization proposal is based on the identification and assessment of the Technology Intelligence of organizations as one of the key pillars of effective management in the Smart World.

Findings: An organization's Technology Intelligence significantly accelerates and improves the quality of many organizational processes, including smart strategic management. Unfortunately, it does not drive itself, but is one component of a larger system of activities. In order for it to realize its full potential, it must be supported by intelligently matched resource capabilities developed in the individual pillars of the Smart World (Intelligent People, Intelligent Technology, Intelligent Collaboration, Organization Intelligence). Technology Intelligence cannot function effectively without their support.

Research limitations/implications: The results of the research indicate that the interviewed companies already have some potential for Technology Intelligence, primarily in understanding the technology landscape. Unfortunately, they often still lack the resources and competences to apply the insights in practice (deficiencies in relation to the other pillars of the Smart World). The main constraints seem to be financial and human resources. Organizations should simultaneously develop their potential in all pillars of the Smart World.

Originality/value: The original contribution of the study is to systematize knowledge about the essence and importance of Technology Intelligence in the Smart World and to propose a methodology for examining its maturity in enterprises.

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Keywords: Smart World, Strategic management, Competitive Advantage Organizational Intelligence, Technology Intelligence, Technology and Competitiveness, Appropriate Technology, Firm Growth.

JEL: M2, L210, L250, D220, O330

Inteligencja technologiczna jako jeden z kluczowych czynników skutecznego zarządzania strategicznego w Smart World

Streszczenie

Cel: w związku ze słabym rozpoznaniem w literaturze przedmiotu zjawiska inteligencji technologicznej we współczesnych organizacjach za cel pracy przyjęto próbę rozpoznania istoty i znaczenia inteligencji technologicznej organizacji funkcjonujących w Smart World.

Projekt/metodologia/podejście: artykuł ma charakter koncepcyjno-empiryczny. Propozycja operacjonalizacji opiera się na identyfikacji i ocenie inteligencji technologicznej organizacji jako jednego z kluczowych filarów skutecznego zarządzania w Smart World.

Wyniki: inteligencja technologiczna organizacji znacząco przyspiesza i poprawia jakość wielu procesów organizacyjnych, w tym inteligentnego zarządzania strategicznego. Niestety nie napędza się ona sama, lecz jest jednym z elementów większego systemu działań. Aby mogła wykorzystywać swój pełny potencjał, musi być wspierana inteligentnie dobranym potencjałem zasobów rozwijanym w poszczególnych filarach Smart World (Inteligentny Człowiek, Inteligentne Technologie, Inteligentna Współpraca, Inteligencja Organizacji). Inteligencja technologiczna nie może efektywnie funkcjonować bez ich wsparcia.

Ograniczenia/implikacje badawcze: wyniki badań wskazują, że ankietowane przedsiębiorstwa posiadają już pewien potencjał inteligencji technologicznej, przede wszystkim w rozumieniu krajobrazu technologicznego. Niestety, często jeszcze brakuje im zasobów i kompetencji, aby zastosować te spostrzeżenia w praktyce (braki w odniesieniu do innych filarów Smart World). Głównymi ograniczeniami wydają się być zasoby finansowe i ludzkie. Organizacje powinny jednocześnie rozwijać swój potencjał we wszystkich filarach Smart World.

Oryginalność/wartość: oryginalny wkład niniejszego opracowania polega na usystematyzowaniu wiedzy na temat istoty i znaczenia inteligencji technologicznej organizacji funkcjonujących w Smart World oraz zaproponowaniu sposobu badania jej dojrzałości w przedsiębiorstwach.

Słowa kluczowe: Smart World, zarządzanie strategiczne, przewaga konkurencyjna, inteligencja organizacyjna, inteligencja technologiczna, technologia i konkurencyjność, odpowiednia technologia, rozwój firmy.

1. Introduction

We are all becoming more and more aware of the fact that we are living in a unique environment – the so-called Smart World. A world that realizes the ideas of increasingly widespread use of broad intelligence and intelligent solutions. (Huawei, 2021) A world that should become better and better for the benefit of all, through both increasing technological sophistication and greater social and environmental responsibility. This world should be more convenient, more efficient, more responsive to social needs, and more humane (Adamik, Nowicki & Puksas, 2022). In connection with the tasks, it is undergoing breakthroughs, both technological, social and cultural. Technological breakthroughs play a special role. This is because the breakthroughs are

dynamically accompanied by disruptive changes (Christensen et al., 2018) which, as they occur (e.g. as another new technology becomes public and is incorporated), cause profound transformations not only of products, routines, competencies, but also of the functioning of entire organizations (including their business models), industries, and even economies and societies. They thus generate a chain of breakthroughs. Under such conditions, the so-called “Technology Intelligence” of organizations becomes important (Awamleh & Ertugan, 2021). It enables modern companies to see that they need “the right technologies for the Smart World”, not just “technologies”, and their customers need the “right products”, not just “products”, chosen intelligently and with specific parameters. In the Smart World, not everything that is new and spectacular will gain recognition and guarantee market success. It must also represent concrete value and quality. Technology Intelligence enables the organizations that use it to discover, select, evaluate, more efficiently develop, deploy, or exploit more valuable technologies, products, and other cutting-edge technical solutions than others (Talaoui & Kohtamäki, 2020). This way enables their faster technological transformation (Albukhitan, 2020; Aybek, 2017), a smoother path to technological maturity (Nogalski & Niewiadomski, 2019), and competitive advantage (Daňa, Caputo & Ráček, 2020; Feng, Sun, Chen & Gao, 2020) in the Smart World. Given the lack of recognition in the literature of the phenomenon of Technology Intelligence in contemporary organizations with respect to strategic management in the Smart World, a research gap was identified in this field. As a result, as the purpose of the study was assumed an attempt was made to recognize the essence of Technology Intelligence of organizations and answer two questions: 1) Can Technology Intelligence be seen as a key factor (Game-Changer) of smart strategic management in the Smart World? 2) Are organizations able to efficiently use Technology Intelligence in their business praxis?

In order to achieve this goal, desk research was conducted on the characteristics of the pillars of the Smart World. The research was deepened with regard to one of the pillars – Organizational Intelligence – and its specific element – Technology Intelligence – as was identified as a fundamental source of success for organizations operating in the Smart World. The analysis of the literature combined the issues of Strategic Management, Technology Intelligence of the organization and the requirements of the Smart World, was supported by analyses of the results of own empirical research. Both a desk study of the issue and a survey research of companies operating in the Smart World have been carried out. The qualitative research was based on the analysis of “Trend Maps”. They focused on identifying key contemporary technological trends. Quantitative research based on survey research concerned identification of the ability of organizations to assess the significance and to assess the level of implementation of the new technological trends. The level of implementation of top technological trends (and their new technologies) was considered to be a kind of manifestation

of the Technology Intelligence of the surveyed organizations. The research results were summarized with conclusions and recommendations for further research in the area.

2. Literature Review

2.1. Pillars of Smart World

An exhaustive and focused literature review was carried out in order to identify key and central issues for the areas of “Smart World” and “Technology Intelligence of the Organization”. It was based on widely available literature sources and selected key citations. This type of literature review was chosen due to the very limited resources in the Scopus and Web of Science databases for articles with the keywords “Smart World”, “Organizational Intelligence” and “Technology Intelligence” in the fields of “Business Management”, “Management” and “Business”. It was decided to fill the gaps with targeted searches in other widely available source databases and platforms, e.g. Scholar Google, Research Gate, Ebsco, etc. Sources were selected whose authors deal with the issues of managing organizations in the Smart World, taking into account the issues of Organizational Intelligence in its various forms, especially with the use of Technology Intelligence (and new technologies). In this way, they efficiently combine the topics that are important for the study. Unfortunately, most of the articles dealt with the above-mentioned issues separately or did not concern management sciences and therefore could not be included.

The results of the research carried out showed that Smart World is a unique environment that rests on several essential pillars. Each of them seems indispensable, as it brings a specific quality to the way the entities operating in it operate and enables, or facilitates, the development of the other pillars (Adamik, Nowicki & Puksas, 2022). The foundation of its concept is a well-developed and well-chosen, **intelligent human factor (smart human)**. The state of their intelligence depends on the state of their knowledge, understanding of the environment, culture and value system, so being smart means being proactive, focused, aspirational and goal-oriented in applying innovative ideas to achieve the desired future (Smart Future Initiative, 2016). Skills in abstract thinking, learning, perceiving dependencies and relationships between different facts, and drawing conclusions based on it are particularly important. The ability to adapt to new conditions and perform new tasks using the means of thinking is also important. It has been scientifically confirmed that the knowledge, competencies, attitudes and skills of individuals, groups and even generations are derived from the technology they use, and therefore the rate of technological development taking place in the locations and times in which they operate. This translates into requirements for desirable employee competencies and attitudes.

Desirable competencies are: 1) hard competencies (specialized and technical knowledge) and soft competencies (ability to work in teams, ability to manage oneself in time); 2) open attitude to novelty and change, adaptability, proactivity, creative skills; 3) understanding of digitization, processes and solutions based on new technologies, 4) ability to use modern machines and equipment, information systems, work with data, analyze, process and synthesize data and information, 5) understanding the principles of safe use of technology and work with data, 6) understanding what type of technology can be used to improve business indicators in the immediate environment; 7) interdisciplinarity, 8) analytical and design thinking, 9) ability to learn from failures, 10) no resistance to taking responsibility; 11) ability to respond to customer needs and behavior; 12) willingness and ability to cooperate, share knowledge within interdisciplinary teams, in a multicultural environment, 13) ability to diagnose and constructively communicate problems, needs and solutions, especially in the areas of new technologies; 14) communication skills, ability to communicate using virtual tools. The pace of development, the way of construction, operation and quality of operation of the entire smart enterprise depends on the above human factor capabilities.

Since we live in a world of Economy 4.0, (Saniuk, Cagaňová & Saniuk, 2021) another pillar of the Smart World is the “right” **technological potential**. A Smart World requires building on the achievements of the digital revolution linked to increasing computing power, ever-increasing data speeds, **smart technologies** and Internet-based applications. This is based on the ability to use four key technologies: integrated cyber physical systems, production process optimization and predictive maintenance systems, Industrial Internet of Things (IIoT) and solutions that guarantee cyber security. They should be efficiently encapsulated with tailored to the needs of the organization, “right” technologies, the so-called companion technologies (e.g. Vertical/Horizontal Software Integration, Machine-to-Machine Communication, Internet of Services, Big Data and Analytics, Clouds, Additive Manufacturing, Augmented Reality, Virtual Reality, Digital Twin, Artificial Intelligence, Neural Networks and Mass Customization). In a Smart World, objects (machines, cars, computers, cell phones, etc.) are supposed to intelligently serve people in a way based on close and broad collaboration, together constituting a kind of universe of many interconnected devices (Bani Yasin et al., 2019).

The above pillars of Smart World are complemented by the requirement for **social responsibility (CSR) and environmental responsibility linked to sustainable business development**, which is more than just technological development (see Directory of Key Intelligence in the Industry 4.0 Era) (Adamik, 2021). Activities of organizations in the Smart World should be oriented toward the creation and implementation of proactive and innovative technological solutions that will shape increasingly qualitatively better, and at the same time more humane and environmentally sustainable,

conditions for social and economic functioning (De Sousa Jabbour et al., 2018). This involves a greater emphasis on, among other things, the ethics and social responsibility of business operations, a deepening commitment to the ecology of production and circular operations, including maximizing the use of renewable energy sources, incorporating the development of a circular economy, and changing the transportation network (cars, buses, trains) to electric and hydrogen-powered vehicles.

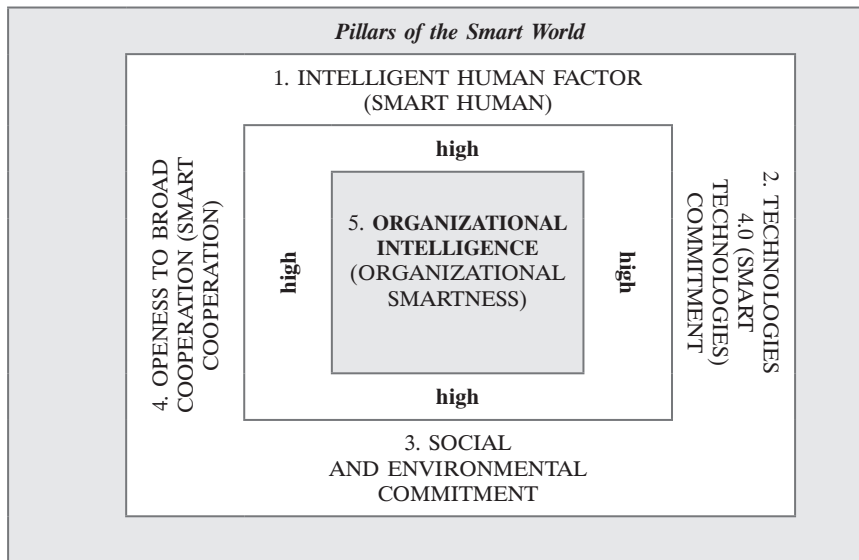
The fourth pillar of Smart World, is the requirement for organizations to be open to **broad cooperation**, inter-organizational partnerships and co-creation, etc. (**smart cooperation**) (Adamik & Sikora-Fernandez, 2021; Kiel, Muller, Arnold & Voigt, 2017; Al-Kasasbeh, Al-Kasasbeh & AL-Faouri, 2016; Saunila, Nasiri, Ukko & Rentala, 2018; Zawawi & Wahab, 2019). In this way, Smart World is betting not only on the genius of the individual, but also on the strength of relationships that will strengthen the dynamics of development in the long term, as well as the sustainability of the partners' competitive advantages. They should be built on both real and virtual levels.

The set of pillars is crowned by the fifth, it supports all of the above. Therefore, it most extensively supports the operational and strategic management processes of organizations of the Smart World era. It relates to the need for organizations to develop the so-called strategic foresight, i.e. the ability to create space for entrepreneurship and creativity, to expand the possibility of solving future problems by taking into account new challenges, and therefore new ways of operating that will be effective in the future. They are related to the organization's possession of broad knowledge and **multidimensional intelligence (organizational smartness)** (García-Piqueres, Serrano-Bedia & Pérez-Pérez, 2019; Závadská & Závadský, 2018; Mao, Liu, Zhang & Deng, 2016) in terms of how it is gathered and how it is used. The subject's **intelligence** is considered to be its ability to find itself in any situation, especially a new one. Thanks to accumulated knowledge and the ability to perceive interdependencies between facts, successive behavioral modifications more and more efficiently directing it toward desired goals. Intelligence gives subject's ability to adapt to environmental conditions or to adjust the environment to its needs, or to choose the context most suitable for satisfactory action (Awamleh & Ertugan, 2021; Sternberg & Sternberg, 2015).

In its full form, the Smart World will emerge when (see Figure 1) human beings intelligently create and use the knowledge they possess. It will also be important for people and organizations to engage so strongly and widely with the technologies of the Fourth Industrial Revolution (IR 4.0) that the two realities of physical reality (PR) and virtual reality (VR, cyberspace) seamlessly intermingle in their lives. Under such conditions, computer processing, Internet solutions and other Industry 4.0 technologies will not only be ubiquitous, but also the most effective. In addition, a widespread commitment to social and environmental issues must be recognized, and innovative technological solutions must be accompanied by a highly

developed social and environmental responsibility for the smart solutions put into practice. At the same time, humanity must be ready to pursue various forms of open, partnership-based cooperation aimed not only at profit, but also at the well-being of present and future generations.

Figure 1
Pillars of the Smart World



2.2. Importance of Technology Intelligence of Organization in the Smart World

With the requirements of the Smart World in mind, **Organizational Intelligence** becomes a central pillar for successful development in the environment. It includes a set of individual characteristics of a given organization demonstrating its ability to perceive and create in an authoritative way the knowledge resources necessary for the realization of its goals (Gogoi & Barooah, 2021; Talaoui & Kohtamäki, 2020; Bratianu & Vasilache, 2006; Albrecht, 2002). It also involves the ability to perceive, understand, interpret complex situations, events and market signals, as well as effectively act and respond to them. It involves not only an organization's ability to gather knowledge related to its business purpose, but also to interpret it, develop it, use it, share it, as well as to reflect on it, learn from it and act effectively. In order for it to perform so many functions, it must be perceived, built and exploited in a multifaceted way (*multidimensional Organizational Intelligence*). The overall construct of an Organization's Intelligence is therefore **made up of quite a number of components**. Their types depend on how they

are classified (Adamik, 2021). The most common are social, relational, organizational, business, marketing, information, financial, environmental, technological intelligence. Each of them has specific tasks to perform.

In the Smart World, **Technology Intelligence acquires special importance in the set**. It is the organizational ability to notice the importance, recognize the specificity, evaluate the usefulness, choose the right selection and implementation mechanisms of technological solutions adequate to current organizational needs (Noh, Mortara & Lee, 2023). Because of its specificity, it gives guidance on technological requirements (the so-called “right technologies”) and technical support (supporting technologies and tools) in terms of task feasibility to the other types of intelligence. This is because this type of intelligence ensures the proper integration of the technological variable into the production and business system, enabling not only proper negotiation, but also laying the groundwork for improved decision-making, especially related to the development of innovation processes. Based on it, a systematic model is created by a given entity for collecting, analyzing and disseminating information about the technological environment designed to ensure that the organization in question is constantly, and effectively, searching for new opportunities (Moradi, Salehi & Mozan, 2022; Savioz, Luggen & Tschirky, 2003; Savioz & Scacchi, 2001). Through it:

- Social Intelligence (Riggio, 1986; Kihlstrom & Cantor, 2011) – understood as the self-awareness and level of development of a given subject/individual, their social attitudes, abilities and appetite for managing social change, developed on the basis of experiences of cooperation with people, learning from successes and failures, etc. -receives additional information supply in terms of social world knowledge resources in the Smart World environment (e.g., through social media, Metaverse, web resources, *various types of browsers*);
- Relational Intelligence (Pless & Maak, 2005) – understood as the ability of an entity to engage in collaborative relationships, the ability to communicate and interact with stakeholders from different backgrounds through accurate identification of their emotions, values, interests and requirements, and critical reflection on them. It gains in the Smart World the support of such tools as, for example, instant messaging, applications, platforms (e.g. crowdfunding), recruitment, sales, or promotional services or systems, (including LinkedIn);
- Organizational Intelligence (Silber & Kearny, 2009) – understood as the ability of an organization to gather and use knowledge corresponding to its goals, especially concerning employees, organization of their work, cooperation with different locations, branches and partners, including external ones. It gains, in Smart World, the support of databases, software, applications dedicated to companies (e.g. ASANA, Trello, Jira, crowdsourcing solutions, etc.) and tools supporting organizational work, e.g. in the form of readers, sensors, locators, intranets;

- Information Intelligence (<https://www.igi-global.com/dictionary/complex-new-world-information-security/14419>) – understood as the ability to transform large amounts of complex data into relevant and useful information for better risk management and increased profitability of the organization. It is supported in the Smart World by a number of analytical, forecasting and simulation programs that enable efficient data management (e.g., EDI-class systems-automated data exchange, Tableau-type solutions).
- Business Intelligence (Fink, Yogev & Even, 2017; Shollo & Galliers, 2016) – understood as the ability to provide an overview of various activities of the company through access to current and historical information to improve and optimize decisions and performance of various areas. It gains support in Smart World through applications, infrastructure and tools dedicated to it, e.g. CRM systems, SAP, power BI servers, data repositories, competence centers.
- Data Intelligence – (<https://www.techopedia.com/definition/28799/data-intelligence>) – understood as the ability to accurately analyze data in the Smart World. It has gained support from artificial intelligence and machine learning tools (including advanced analytics; neural networks, computer speech recognition, learning algorithms to support, for example, autonomous vehicles, automated translations from audio to audio, the so-called speech-to-speech, automated intelligent advisors, and the Internet of Things) to analyze and transform huge data sets into intelligent information that can be used to improve products, services, investments or business processes.
- Technological Intelligence (<https://www.infoentrepreneurs.org/en/technological-and-strategic-intelligence/>; Tugrul, Daim, Dundar, Kocaoglu & Anderson, 2011) – understood as an entity's ability to accumulate and use scientific and technical assets (patents, publications, know-how), as well as to carry out its ongoing research activities, design and develop products and services, efficiently carry out production processes, obtain and use various raw materials and supplies, as well as other tools necessary for day-to-day operations. It gains, in the Smart World, the support of databases, information systems and platforms (accumulating information on what, who, where, with what, and based on what standards does what), as well as simulators, operational and specialized programs that allow efficient management of the company's technical resources (e.g. ERP systems).
- Technical Intelligence (Zhang et al., 2016) is understood as the ability to collect, process, analyze and use data and information on foreign equipment and materials to prevent technological surprise, assess foreign scientific and technical capabilities, and develop countermeasures designed to neutralize a competitor's strategic actions. In the Smart World it is supported by the creation of its own repositories and databases

and access to Open Data, Open Innovations, Open Resources, or various types of industry and world reports available on the Internet and on the websites of various types of reporting organizations, etc.

- Environmental Intelligence (Kraselsky & Gravatt, 1989) – understood as the ability to collect (measurements/observations), compile, use, analyze data to characterize the state of the environment in a given place or region and time (past, present, future) is gaining, in the Smart World, among other things, the support of applications, platforms and media providing weather and environmental information 24 hours a day, based on data from satellite systems, as well as collected by drones, or various types of sensors available to organizations monitoring the areas.
- Ecological Intelligence (Goleman, 2010, 2009) is understood as the ability of individuals to gather knowledge about their impact on the environment and use the information to make changes in their behavior toward more sustainable living. In the Smart World, it is supported by environmental analyses e.g. LCA, CBA, CEA, supported by sensor readings that monitor in various ways the side effects of production activities e.g. carbon footprint.
- Market Intelligence (Najm & Alfaqih, 2021; Prescott et al., 2001) is understood as the ability to gather information from an organization's environment that is relevant to the development of the market in which it operates, and thus refers to efficient monitoring of trends, competitors, suppliers and customers (current, lost and targeted). In Smart World, it gains the support of data available from online sources, news services, company websites, secondary data sources, social media, RSS feeds, etc. It thus gives decision-makers a more complete picture of a company's current performance under specific market conditions which facilitates decision-making when determining strategy and better market penetration and development.
- Competitive Intelligence (Oubrich, 2011; Oubrich, Hakmaoui, Bierwolf & Haddani, 2018) is understood as the ability to effectively gather and use relevant information about competitors, current or potential, including analyzing their strategies and competitive advantages, products or processes. In the Smart World, it gains support from, among other things, open-source corporate or competitive intelligence services (Hastedt & Guerrier, 2010).
- Strategic Intelligence (Levine, Bernard & Nagel, 2017) is understood as the ability to collect, process, analyze and disseminate data necessary to shape policy and strategic, long-term plans at the national and international levels. In the Smart World, it gains support not only from dedicated software or platforms, but also from open source intelligence services, publicly available industry analysis, or reports on economic, technological, environmental or social trends monitored by world-class consulting firms or government organizations. It is also supported by

the results of active use of the aforementioned types of intelligence in the organization.

Taken together, the above construct provides a platform of intelligent support for the processes of knowledge accumulation, decision-making and, consequently, intelligent, the so-called smart strategic management of enterprises in the Smart World. Graphically, the phenomenon is visualized in Figure 2.

Figure 2

Using Technology Intelligence to support strategic management in the Smart World

MULTIDIMENSIONAL ORGANIZATION INTELLIGENCE IN THE SMART WORLD		Pillar of the Smart World	Area of Influence	
Technology intelligence	Social Intelligence	1,3,4,5	knowledge resources of the individual	Strategic Intelligence Policy formulation, strategic planning, organizational strategy building, organizational development management
	Relational Intelligence	1,4	relational capital, cooperation	
	Organizational Intelligence	4,5	human resource management	
	Information Intelligence	5	organization management	
	Business Intelligence	5	data management	
	Data Intelligence	5	optimization of business decisions	
	Technological Intelligence	2,5	business process management	
	Technical Intelligence	2,5	technical resource management, investment, development	
	Environmental Intelligence	3,5	R&D, prevention of technical surprise	
	Ecological Intelligence	3,4,5	environmental risk management, relations with the environment	
	Market Intelligence	5,4	environmental impact management, relations with the environment, CSR	
	Competitive Intelligence	5,4	knowledge of market development	
	SMART STRATEGIC MANAGEMENT			
STRATEGIC MANAGEMENT IN THE SMART WORLD				

The organization's Technology Intelligence strengthens the accuracy of its response to all the requirements of the Smart World (5 Pillars of Smart World). It supports the development of the knowledge of individual employees (Pillar 1), their teams, the entire organization and its network of cooperating partners (Pillar 4). Besides, it allows the organization to build its technological capabilities (Pillar 2) in a conscious, prudent (Pillar 5), socially and environmentally responsible (Pillar 3) manner.

2.3. Importance of Technology Intelligence for Strategic Management in the Smart World

Since a Game Changer, by definition, is a newly introduced element or factor that significantly changes an existing situation or activity it seems that the answer should not be in doubt. In a Smart World environment, technologies change so frequently and strongly, so surprisingly changing the conditions and rules of operation, that greater awareness in this regard is the key to success. Nowadays, the apt and timely selection and smooth implementation of the right technology into organizational operations can do a lot. Research indicates that it affects:

- The technological maturity of the organization (Noh, Mortara & Lee, 2023), i.e. the experience acquired in the technological field, the patterns, values and attitudes outlined and adopted, and consequently the way in which the organization uses its financial, relational, technological and knowledge-based resources. It results from the smooth integration into one system and coordinated development of all the above interdependent resources. It is accompanied by continuous change, rapid response, quality improvement, responsibility for employees and the environment, and comprehensive customer orientation. At the same time, it is based on three main, properly selected underlying factors: 1) the right organizational and management structures, 2) the right employees empowered and equipped with the right knowledge, and 3) the right, flexible production technologies (Nogalski & Niewiadomski, 2019).
- The pace and extent of an organization's technological transformation, i.e., the degree to which the organization adapts to the new so-called digital landscape, which is a condition for survival in the Smart World (Albukhitan, 2020). This transformation is related not only to the focus on technology and machinery, but also to the ability to transform the materials, activities and processes used into digital versions so that they can form the basis for the transformation of the entire business model. "Proper" technological transformation, in fact, is the application of technology to digital transformation in order to radically increase efficiency in every area of the organization (Aybeka, 2017). Applied aptly, ICT technologies then increase the efficiency of operations and provide new sources of value through the synergies created as a result

of integrating digital technologies with individual business processes, which means more than just supporting business processes.

- Organizational culture of enterprises and values held in the organizations – the results of the research indicate that the choice of technology determines the development of other features of organizational culture and values dominant in companies. The biggest influence on the features of the organizational culture of companies is “IT systems integration”. Thanks to it, one can see positive changes in the approach to task completion and deadlines. One can also see an increased focus on company performance, as well as an attitude toward cooperation and internal and external dialogue. Further down an increase in the openness of employees to innovative solutions and an increase in attitudes toward creativity was an effect of implementing the technology. The technology is least conducive to fault tolerance and risk-taking propensity. Other technologies of the Industry 4.0 era that significantly shape the parameters of organizational culture are IT networks, business process automation, mobile technologies, machine-to-machine communication, and cyber security (Pol, 2022).
- Competitive advantage – aptly chosen technology is one of the primary sources of competitive advantage for companies (Torrkeli & Tuominen, 2002), as it determines the structure and quality of the processes that a given enterprise uses to transform inputs into higher-value objects (Madureira, Popovic & Castelli, 2021; Christensen & Raynor, 2003). Its importance is growing due to the Smart World’s deepening globalization, rapid technological progress and the increasing importance of intellectual capital. Under such conditions, the ability to combine different types of resources and skills, both internal and external (including technological), and create unique and competitive combinations from them is growing. This is increasingly achieved through the conscious use of (global business and technological structures that go beyond the boundaries of a single company and tap into the potential of companies around the world. It increases the chances of building a competitive advantage and long-term market success (Najm & Alfaqih, 2021; Ferrier & Wiltbank, 2010). Research indicates that the accumulated resources of established knowledge and a high level of activity in the area of new technology development have the strongest impact on the ability to increase the pace of building competitive advantage and increase its effectiveness, to a slightly lesser extent on the scale (scope) of impact, and least on cost intensity. This is because they help to make decisions through more efficient, acquisition, analysis, dissemination and flow of information, and consequently change business processes.

The above analysis raises two research questions: RQ1). Can Technology Intelligence be seen as a key-factor (Game-Changer) in smart strategic management? RQ2). Are organisations able to efficiently use Technology Intelligence in their business praxis?

3. Research Methods and Results

In order to empirically verify the suggestions noticed in the literature of the issue, an original research process was designed. It was decided to answer the questions based on qualitative desk research of the subject and empirical quantitative research. Qualitative research was an introduction to quantitative research. They allowed us to indicate the scope of knowledge and activities that are a manifestation of high Technology Intelligence (element of the central pillar of the Smart World-Organizational Intelligence). They focused on identifying key trends and technologies for the development of organizations in the Smart World and determining which of them already constitute our technological reality (new normal) and which will become such in the near future (reactive zone). The purpose of the quantitative research was to test in practice whether respondents had Technology Intelligence and used it to identify and assess the usefulness of the technology trends around them, whether they were more likely to implement new technologies that accompanied the trends thanks to the support of technology intelligence, and whether they perceived the impact and importance of the technologies for the development of their organization.

3.1. Qualitative Research

Supporting qualitative research were the findings of Infuture Institute, which, through a wide range of applied foresight methods (expert interviews, panel discussions, the Delphi method, etc.) based on long-term cooperation with experts (market leaders, inventors, representatives of key institutions, founders of startups, both from Poland and the World) has been systematically preparing future scenarios of the so-called “Trend Maps” since 2018 (Infuture Institute, 2022). Their maps are a comprehensive analysis of the most relevant megatrends. They are presented in three time perspectives: new normal (currently leading trends), reactive zone (short-term perspective, trend needs up to 5 years to become a leading trend), innovation zone (medium-term perspective, trend needs 5 to 20 years to become a leading trend). The research undertaken consisted of two stages. The spheres of technological megatrends included in two maps were selected for further analysis: 1) “2020 Trend Map” and 2) “2022 Trend Map”.

The results diagnosed on the first map were the reference point (see Table 1) for the Technology Intelligence assessments of 107 companies operating in Lithuania and Poland surveyed in 2021/2022 (see quantitative research). As a result, 21 technological trends were identified that organizations with developed Technology Intelligence should be aware of.

Table 1
List and description of technological trends

Trend	Technological trends 2020
IMPLEMENTING AI	Implementation of artificial intelligence to solutions based on big data and neural networks implemented in many areas of life. Currently, they are at the initial stage of development.
5G	The new generation of fifth generation mobile technology (5G) has a chance to change and accelerate the development of many areas, including transport, internet of things, telemedicine and smart cities.
DIGITAL HEALTH	The trend indicating the development of digital solutions in the field of broadly understood health based on, inter alia, technologies such as VR, AR, AI or IoT.
SEAMLESS TECH	Seamless Tech is a trend in which technology becomes almost imperceptible to people, while being part of everyday life.
SMART LIVING	As part of this trend, solutions based mainly on new technologies support everyday human life to make it easier.
DATA IS THE NEW BLACK	A trend that speaks of the growing role of data. Basing on the analysis and interpretation of data, i.e., The “data-driven approach” is currently one of the most important elements of digital transformation.
IMMERSIVE ART	This is a trend that speaks of an increasingly common combination of art and technology, it creates solutions that fully engage the recipient.
MAKE TECH HUMAN	Make Tech Human, a trend indicating the increasing role of technology in the service of people.
HUMAN TECH BOND	In this trend, technology acts as an intermediary between people. Thanks, among others, to the development of haptic technologies, devices will allow us to feel the physical presence of another human being.
BABY TECH	Technologies (including IoT, VR, AI) are already entering virtually every area of our lives. Currently, they support parents in their care for the upbringing and health of their children.
HUMAN+	The Human + trend concerns the development of areas and solutions related to improving the human body with the help of technology, so as to overcome human limitations.
AI FOR HUMANITY	The AI for Humanity trend concerns those solutions where humanity is a priority. Artificial intelligence can be used in any field: from medicine, through sport, education, to culture and art.

Table 1 – cont.

Trend	Technological trends 2020
ETHICAL TECH	The dynamic development of artificial intelligence (including the choices made by AI on a racist basis and chauvinistic) makes more and more talk about the need to create a code according to which artificial intelligence would develop and function.
MIRROR WORLD	The constantly developed technologies in the area of XR (Extended Reality) are heading towards a world where everything has its counterpart and representation in the digital world.
QUANTUM COMPUTING	Quantum computers are at an early stage of development. However, we already know today that this development redefines concepts such as efficiency, speed and data security.
BCI (BRAIN-COMPUTER INTERFACE)	Advanced research is underway to create an interface that would allow communication between the brain and an external device. Such a solution can completely change the way we communicate and our relationship with technology in the future.
PRIVACY	In the world of fake news (including the growing amount of data, traces of our activities and online behavior), the fight for privacy is becoming an important challenge today.
SELF-DRIVING CARS	There is more and more talk about the impact of autonomous cars on many areas of our lives, including the functioning of cities and maintaining security. Certainly, their appearance on the market will revolutionize many industries.
VOICE TECHNOLOGY	The use of voice assistants or chatbots in communication is already implemented in the industry, including in the FMCG industry, but the development of the technology will extend to all areas of our lives.
VIRTUAL ASSISTANTS	The trend indicates the growing role of virtual assistants (including Siri, Alexa, Google Assistant), who are becoming an integral part of human life, facilitating everyday functioning.
DEEPFAKES (MALICIOUS USAGE OF AI)	Today, artificial intelligence allows for image and voice processing that creates a false message, very close to the authentic one. Such activities are increasingly used to manipulate or discredit public figures.

To identify which technological trends will be shaping the modern world and which technologies therefore will play a special role in the development of contemporary companies, the research was continued on the “Trend Map 2022”. In the map showing 54 megatrends, the technological sphere was named “Mirror World”. It contains 18 megatrends. An effort was made to determine what the trends mean and what technologies they are related to. The findings in this area seem important for strategists planning

to intelligently shape the company's management processes in the right direction and with the support of the most up-to-date technological solutions (They develop and use the organizational Technology Intelligence). In 2022, 6 technological trends that have entered the mainstream and are already generating the so-called "new reality" were spotted, 7 qualified for the short-term perspective and 5 for the long-term. Details are shown in Table 2.

Table 2
Technologies as a response to Smart World megatrends

Mirror World (2022)		
Trend Specificity		
Trend	New Reality (New Normal)	Supporting Technologies
Digital Inequalities	The trend points to inequalities related to web access and digital exclusion. Globally, still about 40% of the population does not have access to the Internet. The development of the metaverse, which the major bigtechs are currently working on, could become a factor that exacerbates digital inequality. (Support: digital transformation, digitization, virtualization, technological maturity)	5G, 6G, FG, edge computing, portable data centers, quantum computers AI, NFT (non-fungible tokens), IoT (internet of senses), BCI (brain computer interface), neurotechnologies, natural interfaces (BCI, voice, touch), digital therapeutics, blockchain, facial recognition,
Privacy	The trend points to the growing amount of data and traces of our online activities and behaviors, and the growing struggle for privacy. We are threatened not only by the theft of sensitive personal data, but also by the loss of privacy in other forms (e.g., data from homes, cars and even clothing). Cyber security is becoming a challenge.	
Accumulation of technology power	A trend recognizing that big-tech companies are referred to as the fifth power and have an increasing influence on legislation, economics, innovation. With access to user data, they influence not only global processes, but also the behavior of societies and the choices of individuals (Perceived increase in importance of: personalization, machine learning, AR, geolocation)	
Invisible technologies	This is a trend in which technology, while embedded in people's daily lives, becomes almost invisible to them (IoT; 5G; Facial recognition technologies, Bots, voice technologies, virtual assistants, machine learning, AR, AI, geolocation. (Effect: the need to incorporate new technological solutions into more products, services or processes to satisfy growing customer demands).	

Table 2 – cont.

Mirror World (2022)			
Trend Specificity			
Trend	New Reality (New Normal)	Supporting Technologies	
The war of influence	A trend signaling an increasingly complicated relationship between the two powers, the US and China, they influence the rest of the world. Economic tensions, ideological tensions and competition for influence and patents are becoming more serious. (Increasing importance of: technological leadership, technological transformation, dependence on technology from outside companies)	<i>control technologies, haptic technologies, AR, VR, MR, smart textiles, soft robotics, microfluidics, passthrough technologies, pancake optics, wearables, EMG input technologies, Avatars, digital humans, emotion recognition technologies, IoT, (internet of things)</i>	
Hactivism	A trend recognizing that moving into the online world is causing hacking activity to increase, involving, among other things, hacking into networks or databases to expose information about, among other things, human rights abuses. (Emphasis on cybersecurity development)		
Short-term perspective (1–5 years) (Reactive zone)			
Remote On	People and their activities are moving to the digital world. It is becoming a standard that all our activities can be and are remote: medicine, work, meetings, shopping, entertainment, etc.		
Psychological wellbeing	A trend whose premise is to achieve the so-called mental wellbeing in society. It includes all activities related to the mental health category conducted both online and offline. It addresses issues such as digital wellbeing and digital detox.		
Robo-tized life	It's a trend that refers to the use of automation and robots increasingly in various areas of socio-economic life, from industry to elderly care assistance and education, etc.		
Algorithmization of life	The trend recognizes that progressive algorithmization is turning humans into products. The systems used and the tools used build individualized catalogs of knowledge, needs or motivations and behaviors. The choices an Internet user makes are overwhelmingly based on the recommendations of algorithms.		
ReCity	The trend recognizes that urban services, transportation, workplaces or shared spaces are undergoing a transformation. The challenge is to reorganize cities to maintain a high quality of life for residents while ensuring their safety		
Multi-sensory	The trend signals that society has begun to feel a greater need for physical experiences. Along with the need to interact with each other in the digital world, the need to experience the world with all the senses is becoming more apparent (the lockdown and Pandemic effect).		

Table 2 – cont.

Mirror World (2022)			
Trend Specificity			
Trend	New Reality (New Normal)	Supporting Technologies	
A-Commerce	The A-Commerce (Anywhere Commerce) trend refers to the ubiquitous availability and ability to purchase a product or service at any time. Unlimited access to products and services is changing the habits of certain groups of consumers, while forcing companies to change their sales model.		
Medium-term perspective (5–20 years) (Innovative zone)			
Smart living	A trend referring to the use of technology in building independence from larger systems. Efforts to manage resources more intelligently, including water or energy, are evident.		
Gigacity	The trend recognizing the importance of deploying fifth-generation (and, in the future, sixth-generation) mobile technologies, which are characterized by zero latency and much higher network capacity. New generations of mobile technology will become drivers of development in many areas of human life.		
Meta-economics	The trend recognizes that economic development is increasingly linked to the introduction of the concept of meta-economy. Meta-economics refers to both the development of the economy inside the digital world (owning, selling, ownership, costs, unlimited growth, new currencies, blockchain, NFT) and economic changes in the physical world as a result of the introduction and spread of new technologies related to the construction of the metaverse.		
Denaterialization	The trend signals that the intensive shift to the digital world in all aspects of life is causing the physical world to disappear (e.g., cash, physical stores, people in offices, etc.), as well as changing our approach to product value, ownership, purchase or use.		
Decentralization	The trend that sees the need to return to the early days of the Internet – more openness, freedom for all users, and a move away from the management of the world by a few major technology companies, which is growing with the development of technologies such as blockchain, the Internet of Things, the spread of the metaverse concept and the development of the Internet towards web 3.0, as well as the expectations of younger generations.		

Source: own compilation based on Infuture Institute, Trend Map 2022, <https://infuture.institute/mapa-trendow/#opcje>, retrieved 29.12.2022 and results of expert research.

Companies with developed Technology Intelligence should be familiar with the above areas and should be making efficient use of the new technologies that accompany current technology trends (especially New Reality technologies). Their plans should also include investment in the implementation of technology solutions related to the emerging megatrends (Short-term perspective) and supporting technologies (Table 2 column 3).

3.2. Quantitative Research

In order to identify the symptoms and assess the ability to use Technology Intelligence of modern organizations, a study of their knowledge regarding trends and technological requirements of the Smart World surrounding them was undertaken. The ability to identify them and assess their impact on the activities of the company and the industry was taken as a symptom of Technology Intelligence. This allowed the adoption of two hypotheses in the research: H1- Technology Intelligence helps organizations understand ideas and assess the importance of technology trends surrounding them. H2- Technological Intelligence accelerates the processes of implementing Smart World requirements in organizations (especially technological, but not only).

The original CAWI type survey form based on list of technological trends 2020 (Table 1) was prepared for the research. The survey form was tested in a pilot study ($n = 10$ companies). The survey was addressed to representatives of more than $N = 600$ enterprises operating in Poland and/or Lithuania interested in the research “Do you know technological trends of the Smart World”. Respondents were managers of the surveyed companies. The data was collected in the period from December 2021 to February 2022. In the end, a total of $n = 107$ respondents ($n_{PL} = 50$ and $n_L = 57$; $n_{production} = 27$ and $n_{service \& trade} = 80$) filled the form. A basic 5-point Likert scale was used to assess each surveyed technological trend. Details are presented in the two tables below.

In the first step of survey research attempts were made to determine whether the respondents are able to assess how strongly individual technological trends affect the activities of their enterprises (especially building a competitive advantage) and the industry in which they operate, and whether their answers are consistent with the diagnosis “2020 Trend Map”. This approach allowed the authors to determine the level of Technology Intelligence of the respondents in terms of their knowledge and ability to assess the technology trends surrounding them. The convergence of the respondents’ answers and the results of the positioning of each trend by the experts who prepared the “2020 Trend Map” was taken as a manifestation of their knowledge and the maturity of their Technology Intelligence. The greater the convergence, the more Technology Intelligence the respondents show in a given area/trend. (chance to positive verification H1).

Table 3
Grading scale in the survey questionnaire

Level of implementation of the trend (and technologies typical for trend) in enterprise (IMPL)	Impact of trend implementation on the possibility of shaping a competitive advantage of company in the era of Industry 4.0 (IMPACT)	Maturity level of the trend in our industry (MAT)
1 very low, we do not implement and do not think about it, we are absolutely not ready	1 no impact, implementation of this trend will not translate into the possibility of shaping a competitive advantage	1 We do not see this trend or the opportunities for its development and the possibility of entering the mainstream
2 low, we are not implementing it yet, but we are thinking about it	2 low impact, implementation will allow us to gain an easy-to-eliminate very short-term market advantage	2 foresight level, long-term perspective, the trend takes over 20 years to enter the mainstream
3 moderate, we think about it and started to prepare to implement the trend	3 mediocre influence, implementation will allow us to gain a short-term advantage	3 innovation level, medium-term perspective, the trend needs 5 to 20 years to enter the mainstream
4 high, we are currently implementing the trend	4 high impact, implementation will allow us to gain a medium-term advantage	4 reactive level, short-term perspective, the trend takes 1 to 5 years to enter the mainstream
5 very high, we implement and believe that we are one of the leaders	5 very high impact, implementation will allow us to gain a long-term advantage	5 new normal level, currently the leading trend in the mainstream

In the second survey research step, an attempt was made to determine whether the diagnosed opinions of the respondents in the area of IMPACT of technological trend on company are reflected in the implementation of technologies typical of the trends in the surveyed enterprises (IMPL). It was assumed that the greater the convergence of the indicated IMPACT level with the IMPL level, the greater the Technology Intelligence maturity of the respondents in implementation the Smart World requirements (possible positive H2 verification).

The results of the first stage of the survey research showed that respondents know, how to assess the importance of the technological trends surrounding them. In the 21 technology trends, according to the surveyed, six trends have the strongest impact on their competitive advantage: Smart living, Data is new

black, Make tech human, Privacy and 5G, Implementing AI. Of them, the Privacy trend is the most mature and widespread (MAT 3,290; IMPACT 3,028). It is the only leading trend in today's reality (mainstream). The remaining four trends will enter the mainstream in the short term (1-5 years). Another 7 trends are likely to enter the mainstream in the medium term, and 5 in the long term. Four trends have no chance of public acceptance. All trends are strongly related to new the Smart World technologies. The Deepfakes trend (IMPACT 1,785) has the least impact on the market advantage of those surveyed, in their opinion. The importance of the surveyed trends is illustrated in detail in Table 4.

Table 4

Level of impact and level of implementation of technological trends in practice surveyed companies vs. "2020Trend Map"

Trends: N/position in "2020 Trend Map"	Differences in positioning (points)	AVERAGE			Σ (IMPL_IMPACT)	PEARSON's correlation coefficient		
		IMPACT	MAT	IMPL		MAT - IMPL	MAT - IMPACT	IMPL - IMPACT
1 Smart living/5	4	3.364	3.075	2.907	6.271	0.599	0.641	0.643
2 Data is the new black/3	1	3.336	3.028	2.888	6.224	0.727	0.705	0.679
3 Make tech human/7	5	3.280	3.028	2.738	6.018	0.681	0.649	0.650
4 Privacy/1	3	3.131	3.290	3.028	6.159	0.675	0.610	0.660
5 5G/13	8	3.056	2.907	2.364	5.420	0.679	0.667	0.641
6 Implementing AI/10	4	3.047	2.598	2.206	5.253	0.735	0.702	0.585
7 Virtual assistants/2	5	2.963	2.710	2.215	5.178	0.683	0.701	0.641
8 Seamless tech/6	2	2.860	2.570	2.336	5.196	0.713	0.679	0.562
9 AI for humanity/15	6	2.757	2.449	2.093	4.850	0.783	0.740	0.632
10 Voice technology/4	6	2.589	2.449	1.935	4.524	0.652	0.665	0.564
11 Digital health/12	1	2.486	2.467	2.009	4.495	0.732	0.697	0.710
12 BCI /20	8	2.477	1.813	1.551	4.028	0.675	0.563	0.390

Table 4 – cont.

	Trends: N/position in “2020 Trend Map”	Differences in positioning (points)	AVERAGE			Σ (IMPL_IMPACT)	PEARSON’S correlation coefficient		
			IMPACT	MAT	IMPL		MAT- IMPL	MAT - IMPACT	IMPL - IMPACT
13	Human tech bond/14	1	2.449	2.243	1.925	4.374	0.802	0.701	0.652
14	Immersive art./8	4	2.411	2.280	2.150	4.561	0.777	0.849	0.817
15	Quantum computing/21	6	2.393	2.000	1.589	3.982	0.610	0.702	0.495
16	Human+/16	0	2.374	2.234	1.944	4.318	0.766	0.664	0.695
17	Mirror world/11	6	2.336	2.234	2.009	4.345	0.821	0.778	0.772
18	Baby tech/7	11	2.318	2.159	1.879	4.197	0.737	0.808	0.704
19	Ethical tech/17	2	2.168	2.000	1.729	3.897	0.763	0.727	0.707
20	Self-driving cars/20	0	2.000	1.953	1.589	3.589	0.662	0.665	0.684
21	Deepfakes/ 18	3	1.785	1.804	1.486	3.271	0.617	0.663	0.648

IMPLEMENTATION & IMPACT LEVEL VALUES RANGE:

- value > 3 → high or very high = strong impact on the possibility of shaping a competitive advantage
- value 2 ÷ 3 → mediocre impact on the possibility of shaping a competitive advantage
- value < 2 → low impact on the possibility of shaping a competitive advantage

MATURITY LEVEL VALUES RANGE:

- value > 3.25 = currently the leading trend in the mainstream, NEW NORMAL
- value 3.00 ÷ 3.24 = short-term perspective, the trend takes 1 to 5 years to enter the mainstream, REACTIVE ZONE
- value 2.5 ÷ 2.99 = medium-term perspective (5 to 20 years to enter the mainstream), INNOVATIVE ZONE
- value 2.2 ÷ 2.49 = long-term perspective (over 20 years to enter the mainstream) FORESIGHT ZONE
- value < 2.19 = trend most likely will not be developed in the future (lack of even long-term perspective) NO FUTURE ZONE

The results of the survey thus confirmed that the companies surveyed have some knowledge of the importance of the technological trends surrounding them (level of IMPACT). The respondents had an opinion on the trends indicated for evaluation and were able to roughly assess the strength of their impact on their companies. When comparing the results of the “2020 Trend Map” with those of the respondents, there is a convergence

of assessments. The Top 10 of the “2020Trend Map” included quite all the trends indicated by the respondents as having the strongest impact on their companies. Some of them differed only slightly in their ranking position. Ten trends were slightly over-rated and 11 under-rated (see Table 2 in column 2). Only in the assessment of the 6 technological trends studied did the difference between the positioning of the experts who prepared the “Trend Map 2020” and the results of the respondents exceed 5 points. (see Table 2 in column 3). Summarizing this part of the research results, it seems that the respondents generally have a certain level of Technology Intelligence (it varies individually), which helps organizations understand ideas and assess the importance of the technology trends surrounding them. It allows us to confirm hypothesis H1.

Unfortunately, the ability of respondents to implement technological solutions (IMPL) that are related to current trends is somewhat weaker. Although they have knowledge about the importance of technological trends, for the most part, respondents are only just thinking about and preparing for the implementation of technological solutions related to the trends of the Smart World era (for 12 trends $2 < \text{IMPL} < 3$). They do not even think about implementing solutions typical of 9 new technological trends yet ($1 < \text{IMPL} < 2$). This is true even for trends indicated as a leading trend in the mainstream (especially PRIVACY) and short-term perspective trend. There may be many reasons for the discrepancy between respondents’ reported level of knowledge of the technology trends surveyed (IMPACT, Table 4, column 4) and their reported level of practical implementation (IMPL, Table 4, column 6) of the new technology solutions associated with them. For example, the organizations surveyed may not be technologically, financially, organizationally or humanly prepared to implement new technologies. In such a case, organizational Technology Intelligence will signal new technological opportunities, but will not be able to significantly accelerate the implementation of Smart World requirements due to the lack of appropriate organizational resources. It needs to be supported by other organizational resources. If the surveyed organizations had such support at an appropriate level, verification of H2 could be positive. The current situation of the surveyed organizations (enterprises from Poland and Lithuania) does not allow a clearly positive verification of H2.

4. Discussion

A review of the literature on the subject revealed that no similar multifaceted research has been carried out. More often, the topics of Smart World, Organizational Intelligence, Technology Intelligence and Strategic Management have been explored separately. For the reason, the present review of the definition, interrelations, classification, operationalization and meaning of Technology Intelligence and the research results supporting it can be one

of the first steps towards a deeper understanding of the specificity, conditions, development and conscious use of the opportunities inherent in Technology Intelligence of organizations operating in the Smart World. The analyses carried out have clearly shown that the development of an organization in the Smart World environment depends on the development and correct use of specific factors (the Pillars of the Smart World), and their significant support is Technology Intelligence. It offers great opportunities, significantly accelerates and improves the quality of many organizational processes, including intelligent strategic management. Unfortunately, it does not drive itself, but is one of the central elements of the entire system of activities. In order to achieve its full potential, it must be supported by intelligently selected resource potential developed in the individual pillars of the Smart World (intelligent human factor / Smart Human, commitment to Technologies 4.0 / Smart Technologies, social and environmental commitment, openness to broad cooperation / Smart Cooperation, multidimensional organizational intelligence / Organizational Smartness). Technology Intelligence cannot function effectively without their support. It is confirmed by our research and research by Awamleh and Ertugan (2021), Rumelt (2022), Najm and Alfaqih (2021), Adamik (2021).

One of the forms of Technology Intelligence development is the systematic observation and interpretation of the organization's environment, especially the Smart World technological trends emerging there and the new technologies accompanying them. The knowledge collected this way suggests the development of which technologies to implement in a given organization in the near future. The empirical research showed how such observations can be conducted and what they bring to the decision-making processes of Smart World organizations (e.g. technologies of "New reality" and "Short-term perspective zone"). In order to maintain and build their competitive advantage in the Smart World, intelligent organizations should conduct such analyzes and monitoring their environment systematically (Rumelt, 2022).

Comparing the results of the 2020 and 2022 "Trend Maps" analyses (deepening the answer to RQ1 and supporting the verification of H1), while not easy, due to some changes in the naming and classification of trends by the Infuture Institute, nevertheless provides opportunities for some interesting insights. The finding of the study clearly show:

- Firstly, with each passing year, more and more technology trends are entering the mainstream and becoming a reality for today's organizations (2020-1 trend; 2022-6 trends). Technologies are increasingly determining socio-economic development. This phenomenon is also recognized by Albukhitan (2020) and team: De Sousa, Jabbour, Jabbour, Foropon, Godinho and Filho (2018).
- Secondly, not only is interest in new technologies maintained, but map after map emphasizes their growing impact on humanity and the working and living environment they create (higher and higher positions

in subsequent rankings). This is confirmed by the results of studies e.g. Adamik, Nowicki and Puksas (2022) and Zhang, Robinson, Porter, Zhu, Zhang and Lu (2016). It means a growing awareness of the opportunities but also of the dangers of the growing power of technology in the Smart World. It is also perceived by Agostini and Filippini (2019).

- Thirdly, the trends that have already entered the mainstream provide hints for smart organizations about current technology requirements and indicate areas of most urgent change, e.g. product or process changes (e.g. digital transformation, digitalization, virtualization, technology maturity, personalization of products and services, development of the use of IoT, machine learning, AI, AR, geolocation, cyber security, etc.). Similar observations are also made by, Adamik, Ghinea, Ghinea and Nowicki (2022), Agostini and Filippini (2019). The trends that qualified for further time horizons should become a source of inspiration for strategic decisions related to the “right” orientation of the next years of their development, i.e. smart strategic management. It is confirmed by, e.g. Christensen, McDonald, Altman and Palmer (2018). It is related, among other things, to decisions to choose: 1) the “right” domain of activity, 2) strategic resources on the development and exploitation of which the company intends to bet (including especially technological ones), 3) the plane and spheres within which it intends to build its competitive advantage, and 4) the level and forms of commitment to the principles of social, environmental responsibility and sustainable development of activities.

5. Conclusions

It seems that the research carried out has provided answers to two research questions posed in the research process: RQ1). Can Technology Intelligence be seen as a key-factor (Game-Changer) in smart strategic management? RQ2). Are organizations able to efficiently use Technology Intelligence in their business praxis? In the author’s opinion an organization’s Technology Intelligence deserves to be called the Game-Changer of smart strategic management processes, due to the fact that technology is increasingly changing the organization’s approach to many decisions and market activities. Technological Intelligence related to the skillful selection of technology and its effective practical use in various areas of the organization is the key to effective management in the Smart World (one of the pillar of the Smart World). As far as the practice of companies’ activities is concerned, the research results allow us to say that the surveyed companies already have a certain potential of Technology Intelligence (mainly knowledge about the technological environment), but they still lack certain resources and competences to use their Technology Intelligence effectively in practice. They are mainly limited by financial

and human resources. New technological solutions are certainly costly and require a high and specific level of employee competence. Unfortunately, not all organizations have sufficiently developed capabilities in the area. Not only do they lack the resources, but they also have problems with the processes of gathering them and the associated decision-making processes, e.g. selecting the right technologies, assessing the profitability and risks of implementing new technologies, preparing the implementation process and its acceptance by employees or customers (Daña, Caputo & Ráček, 2020).

Moreover, the conducted empirical research allowed us to positively verify H1-Technology Intelligence and helps organizations understand ideas and assess the importance of technology trends surrounding them. Unfortunately, the research did not allow us to clearly positively verify H2-Technological Intelligence accelerates the processes of implementing Smart World requirements in organizations (especially technological, but not only). Although Technology Intelligence provides support for so many organizational processes, it is itself a variable dependent on the support of many other variables.

Further research is recommended in the area of understanding the needs and capabilities of the organization's Technology Intelligence and ways to support and develop it (e.g. What competencies are needed to master Technological Intelligence in different types of companies? Who and how in the company should be responsible for continuous monitoring of the technological environment?). One of the form of such support is, of course, the continuous supply of information to the organization in the form of thematic trend maps, but it is not enough. Off course, tracking and analyzing the above trends make it easier to understand and respond to the environment in which today's businesses will thrive. The "supporting technologies" e.g. signaled in Table 2 (including 5G, 6G, FG, AI, AR, VR, MR, BCI, facial recognition, haptic technologies and, above all, IoT or Io senses) make it possible to collect and analyze data more accurately and, ultimately, to build strategies more precisely, including human resources, investment, production, logistics, marketing, change and development strategies for companies. Other sources of important information can also be: 1) Dervent Patent Databases, 2) Web of Science with inspiring articles, 3) Technology Reports from consulting companies, 4) Endnote. web with lists of patents, 5) IHS Engineering Workbench, CAS Sci Finder and Thomson Innovation with basis of patents, articles, news and deep-web documents. But smart organizations need more, it is also worth accelerating research into the creation of a clear tool (algorithm, software, application or consulting platform) that will allow strategists to quickly assess suitability of the selected technology for the needs of a given company. The results of the type of analysis would greatly enhance the Technology Intelligence of any organization. Thanks to it, the knowledge and Technology Intelligence of the organization will have a chance to be translated faster and more

accurately into practical implementations of new Smart World technologies and competitive advantage of companies (Feng, Sun, Chen & Gao, 2020; Dalenogare, Benitez, Ayala & Frank, 2018). Despite the fact that the research conducted had its limitations (e.g. a limited research sample, difficulties in defining and understanding by the respondents the names of the technological trends diagnosed by the Infuture Institute, changes in the names of the technological trends in the subsequent maps, “Trend Map 2020” and “Trend Map 2022”), the author believes that they make a certain contribution to the knowledge of the Technology Intelligence of modern companies.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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Economic Complexity, Institutions, and Property Rights

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Abstract

Objectives/Background: Property rights play a fundamental role in economics through rights to asset and resource owners, thereby enhancing their economic efficiency. The study investigates the relationship between property rights and economic complexity across countries classified by income levels, including high, middle, and low-income nations.

Methods: The study utilized Robust Least Square (RLS) to obtain results from a secondary data set.

Results: Our analysis reveals a positive relation between economic complexity and property rights across all income groups. It is suggested to have potential developmental paths for countries based on their income status such as those of low income and middle income groups. More specifically, it is proposed that low-income countries could benefit from the institutional improvements observed in high middle-income countries group. Whereas, high middle-income countries may find help in modeling their institutions after those of high-income countries. The approaches may help sustain and enhance institutions and foster an environment conducive to economic complexity.

Conclusion: This research contributes valuable insights into the interplay between economic complexity and property rights across diverse income contexts, offering potential strategies for policymakers to enhance property rights and drive inclusive economic development.

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Keywords: Property rights, Institutions, Robust Least Square, Economic Theory.

JEL: O10, O25, O44, O50

Złożoność gospodarcza, instytucje i prawa własności

Streszczenie

Cele: prawa własności odgrywają fundamentalną rolę w ekonomii poprzez prawa właścicieli aktywów i zasobów, zwiększając tym samym ich efektywność ekonomiczną. W badaniu poddano analizie związek między prawami własności a złożonością gospodarczą w krajach sklasyfikowanych według poziomu dochodów, w tym w krajach o wysokich, średnich i niskich dochodach.

Metody: w badaniu wykorzystano metodę Robust Least Square (RLS) w celu uzyskania wyników ze zbioru danych wtórnych.

Wyniki: analiza ujawnia pozytywny związek między złożonością gospodarczą a prawami własności we wszystkich grupach dochodowych. Sugeruje się, że istnieją potencjalne ścieżki rozwoju dla krajów w oparciu o ich status dochodowy, jak te z grup o niskich i średnich dochodach. Zaproponowano, aby kraje o niskich dochodach mogły skorzystać z ulepszeń instytucjonalnych zaobserwowanych w grupie krajów o średnim dochodzie. Natomiast kraje o średnim dochodzie mogą znaleźć pomoc w modelowaniu swoich instytucji na wzór krajów o wysokim dochodzie. Podejścia te mogą pomóc w utrzymaniu i wzmocnieniu instytucji oraz wspierać środowiska sprzyjające złożoności gospodarczej.

Wnioski: badania wnoszą cenny wkład w interakcję między złożonością gospodarczą a prawami własności w różnych kontekstach dochodowych, oferując potencjalne strategie dla decydentów politycznych w celu wzmocnienia praw własności i stymulowania rozwoju gospodarczego sprzyjającego włączeniu społecznemu.

Słowa kluczowe: prawa własności, instytucje, Robust Least Square, teoria ekonomii.

1. Introduction

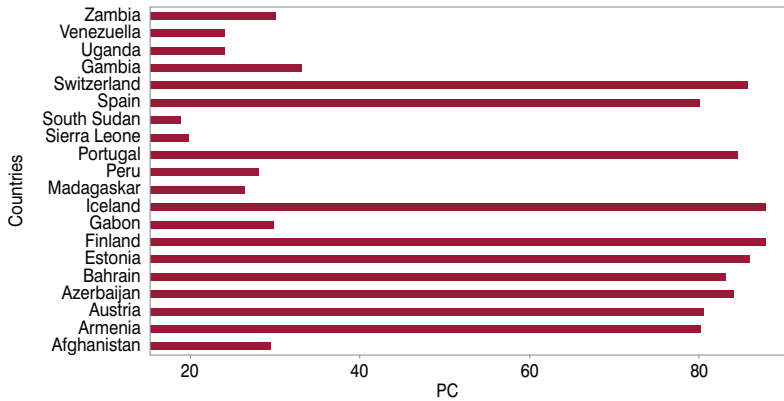
Property rights are the owner's exclusive legal right to use tangible and intangible goods or assets for income earnings or consumption purposes. They may include the use of rights, which allow an owner to utilize their assets, and transfer rights, which permit an owner to transfer the assets to another group or individual (Acemoglu & Robinson, 2008; Acosta & Suresh, 2016; Arabiyat, Mdanat, Haffar, Ghoneim & Arabiyat, 2019; Aslam, 2020; Ayres, 1951, 1967; Coase, 1984; Commons, 1931, 1936; Davidson & Chismar, 2007; Ghouse, Aslam & Bhatti, 2022; Javadov, Rustamov, Aliyev, Bahmanov & Yarmammadli, 2022; Menger, 1996; Mitchell, 1935; North, 1989, 1991, 2000, 2016; Platteau, 2015; Przeworski & Curvale, 2006; Valeriani & Peluso, 2011; Veblen, 2005; von Hayek, 1970, 1971, 1976; Williamson, 1985, 1998, 2000, 2007). Property rights grant an owner exclusive legal use of their goods or assets (Besley & Ghatak, 2008). Institutional Economics relies greatly on the importance of property rights, they act as a legal right, granted to an individual or group, allowing them exclusive use of tangible and intangible goods or assets in a lawful manner (Aslam, 2020; Aslam & Farooq, 2019; Aslam, Naveed & Shabbir, 2021; Aslam, Sultana & Yasin, 2017). The rights are protected by law (which adds to their worth) and enable owners to utilize

their assets for income or consumption purposes, and may also allow for the transfer of the assets to others (Aslam, Ghouse & Khan, 2023). In true essence, property rights grant groups the legal rights to use their assets in a manner they see fit as per the laws of the country (Black's Law Dictionary). Property rights have become a part of human history from Abrahamic law to the modern universal declaration of human rights (Aaron et al., 2008). The study of economics highlights that property rights refer to the intricate network of legal frameworks governing the ownership and mobilization of economic resources, which can be privately or publicly owned by individuals, government entities, associations, or collectives (Farooq, Hamid, Aslam & Shabbir, 2019; Ghouse et al., 2022; Qamar, Ashraf, Ghouse & Aslam, 2020). The rights grant individuals the self-sufficiency or independence to utilize their resources for income generation and to transfer them from one form to another within the purview of relevant laws and regulations. The multifaceted nature of property rights and their intricate legal and economic interplay underscores the significance of the topic in the economic domain. Property rights have been defined by Alchian and Demsetz (1973), in such a way that they mean exclusive rights of individuals to use and exchange their own resources for further production and for further earnings. Gwartney, Lawson and Hall (2012) proposed a comprehensive Property Rights Index comprising of nine critical factors that influence property rights. The factors include: (i) the degree of autonomy of the judiciary system from political pressures, (ii) the effectiveness of courts, (iii) the protection of property rights, (iv) the degree of military intervention in the rule of law, (v) the integrity of the legal system, (vi) the legitimacy of property deals, (vii) the administrative costs associated with authentic property deals, (viii) the authenticity of the police, and (viii) the business damage caused by criminal activities. The Property Rights Index (which is a composite of above mentioned 9 factors) offers a comprehensive understanding of the various dimensions that affect property rights, thereby providing crucial insights to policymakers.

Efficient property rights serve as a catalyst for stimulating business, innovation environment, trade, and investment, thereby enhancing market efficiency and productivity. The Global Economy survey shows the property right index value. The index depicts ranking of countries on the property rights and is measured on a scale of 0 to 100, where a value of 0 or close to 0 implies the prevalence of inefficient property rights, while a value of 100 or close to 100 signifies the existence of efficient property rights in countries. The violation of property rights is commonly referred to as property crime as is punished with legal prosecutions, which is defined by the National Institute of Justice (NIJ) as the theft or embezzlement of property without the use of force or threats against the victims (Aslam, 2020).

Figure 1

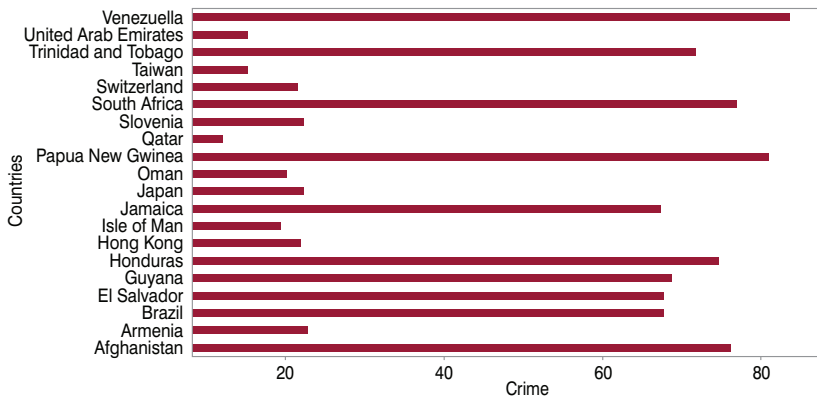
Top countries with highest property crime and lowest property crime scores



Source: Developed by the authors after collection of data from the Global Economy, 2022.

Figure 2

Top countries with highest total crime and lowest total crime rate



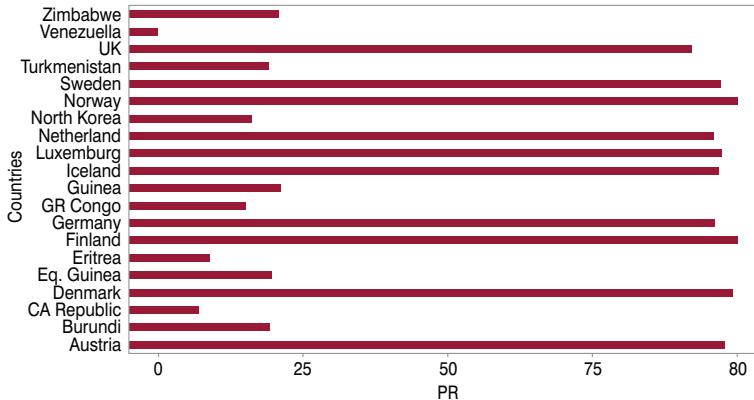
Source: Developed by the authors after collection of data from the Global Economy, 2022.

The use of private property rights is highly encouraged in the field of economics, they formally allow owners to exclude others from using tangible or intangible resources to increase their value (Besley & Ghatak, 2008). However, it is quite understandable that property rights may vary across countries or regions, with high-income countries group typically having higher property rights index values than low-income countries due to their more efficient institutional structures. Here, the key is that institutional structure plays a vital role in deciding the property rights and their firmness. Efficient institutions such as those in open access economics

provide protection to citizens and further create a smooth environment for interaction (North, 1990). Whereas, institutions are humanly self-devised constraints with an enforcing mechanism to ensure smooth interactions as indicated by Acemoglu and Robinson (2006).

Figure 3

Top countries with highest property rights and lowest property rights



Source: Developed by the authors after collection of data from the Global Economy, 2022.

In a nutshell, the above discussion focusses on efficient institutions, particularly through one of its major element i.e. property rights. Property rights are interlinked with different elements of institutions and play a significant role in promoting economic growth and achieving sustainable economic development. Efficient institutional structure (open access social order) reduces transaction costs and accelerates the implementation of property rights. The inclusive growth facilitated by efficient institutions leads to economic freedom and positive impact on property rights (Aslam & Farooq, 2019; Aslam et al., 2021; Aslam & Shabbir, 2019). Therefore, countries (like those of the developing world) should focus on developing efficient institutions and safeguarding property rights for achieving sustainable and inclusive economic growth. Economic complexity can also play a crucial role in property rights. Diversity of a country's economy, as well as the technical and technological progress towards its productive sector, are important factors that contribute to economic growth and development. Countries with high economic complexity tend to have highly skilled labor force, leading to low unemployment and increased employment opportunities. It can help reduce property crimes, as people are less likely to engage in criminal activities when they have access to legitimate and profitable means of earning a living. Therefore, promoting economic complexity can be an effective strategy to enhance property rights and achieve sustainable inclusive economic growth.

The study aims at investigating the factors that determine property rights in low, middle, and high-income countries groups, with a focus on economic complexity and institutional frameworks. Additionally, the study aims at providing policy implications based on empirical findings to enhance property rights across all income categories. The second part of the study presents a review of the relevant literature. The third section provides a description of the data and methodology employed in the study. The fourth section presents empirical findings and an analysis of them, while the fifth section discusses the conclusions and policy implications drawn from the study.

2. Literature Review

In recent years, the term “institutional economics” has been used to describe various economic approaches and schools of thought, leading to a broader interpretation. Initially, “institutional economics” or “American institutional economics” referred to the economic tradition associated with Veblen (2005), Commons (1931, 1936), Mitchell (1935), and Ayres (1951, 1967). However, a more recent development is the recognition of “new institutional economics” which stems primarily from the transactions cost approach of scholars like Coase (1998, 1984, 2005), Williamson (1985, 1998, 2000, 2007) and North (1989, 1991, 2000, 2016). Adding to the complexity, the label “new institutional economics” is often extended to encompass game theoretic approaches to the evolution of social conventions and, at times, Austrian approaches to institutions and institutional change rooted in the works of Menger (1996) and von Hayek (1970, 1971, 1976). Furthermore, some scholars are merging elements from the “old” institutional economics into the “new”, blurring the boundaries.

The paper aims at focusing on the original sense of institutional economics, tracing it back to its emergence as a distinct movement in American economics. The term “institutional economics” was first introduced to the economics profession’s attention by Hamilton in a paper presented at the American Economic Association conference in 1919. Institutionalism gained prominence in American economics during the interwar period. In addition to the historical perspective, it is essential to note that property rights have played a significant role in the development of institutional economics. Scholars such as Veblen (2005) and Commons (1931, 1936), who were central figures in the “old” institutional economics, emphasized the importance of property rights as a fundamental aspect of an economic and a social organization. Their work laid the groundwork for understanding how property rights, both formal and informal, shape economic behavior and institutions. The term “institutional economics” has evolved over time, encompassing various approaches and interpretations. Property rights have remained a central theme within institutional economics, and their study

has contributed significantly to our understanding of economic behavior and institutions. The paper seeks to provide a historical perspective on institutional economics while recognizing the enduring importance of property rights within the field.

Previous studies have established a nonlinear relationship between property rights and economic growth. Hudson and Minea (2013) argue that the relationship depends on the initial levels of GDP per capita and property rights. Samuel, Iroham and Caleb (2011) found a negative relationship between property rights and economic growth in Sub-Saharan Africa due to the prevalence of imitative and adaptive innovations. The importance of strong property rights in the countries forms the benefit of domestic firms. Valeriani and Peluso (2011) have investigated the impact of institutions on economic growth by using the panel data of 181 countries from 1950 to 2009 as a sample. They found that institutions in developed countries are more effective than the institutions of developing countries leading for higher economic growth.

Several studies have investigated the relationship between property rights and economic growth. Chauffour and Maur (2011) found that institutions play a significant role in achieving sustainable economic growth and that economic growth can be sustainable for some countries while unsustainable for others due to differences in civil and political liberties and economic freedom. Jacoby, Li and Rozelle (2002) found a positive relationship between property rights and land investment in Chinese villages. Meanwhile, Mahmoudinia, Salimi Soderjani and Pourshahabi (2011) found that economic freedom can directly and indirectly accelerate economic growth by providing incentives to businesses to use their resources efficiently, promoting productive effort, and improving the effectiveness of resource use, thereby making economic growth more sustainable.

In the context of property rights, literature is extensive and diverse. It has been argued that property rights have a significant impact on the economic fabric of a country. Bonadies (2016) has emphasized the importance of property rights in the development of exports, which can be achieved through the proper use of endowments and power exchange within the productive structure of the economy of a country. Costinot and Komunjer (2007) found that quality of contract enforcement is a very important factor influencing production technologies, it can in turn enhance labor productivity. Moreover, Varian (2006, p. 323) suggests that a country's property rights framework can limit production possibilities, meaning the set of all combinations of inputs and outputs that comprise a technologically feasible way to produce. Furthermore, Berkowitz, Moenius and Pistor (2006) elaborate that countries with efficient institutional structures tend to export more complex products while importing goods from industries with less complex products.

Institutions, comprising formal rules and informal norms, and enforcement mechanisms such as organizations governing societies and economies, hold immense significance, too. Efficient institutions exhibit characteristics such as

clear, enforceable rules, transparency, accountability, and effective governance structures. Upholding the rule of law, protecting property rights, and ensuring fair contract enforcement are central to their functionality. Furthermore, low corruption levels, accessible justice systems, and the ability to safeguard property rights are essential. Measuring institutional efficiency relies on indices such as the Corruption Perceptions Index, Ease of Doing Business Index, Rule of Law Index, and Human Development Index, which collectively contribute to economic development, social justice, and political stability. Policymakers prioritize improving institutional efficiency to enhance citizens' quality of life.

Based on the literature reviewed in the section, it can be inferred that the existing research has focused on analyzing the impact of property rights on various socio-economic indicators. However, the reverse relationship of how socio-economic indicators can affect property rights within the institutional framework of justice and governance has not been extensively studied. The research aims at bridging the gap by exploring the determinants of property rights in low, middle, and high-income countries in the context of economic complexity and institutions. The study will provide novel insights into the complex relationship between property rights, justice, governance, and socio-economic indicators, making it a unique contribution to the existing literature on the same subject.

3. Data Description and Methodology

The section of the study provides a comprehensive description of the data used and the methodology employed for empirical findings. The study employed secondary longitudinal (panel data) for empirical inferences, which is considered more informative than time series and cross-sectional data. The study utilized the data of three sets of countries, i.e. lower income, middle income, and higher income, for the years spanning from 2012 to 2020. The sample size of the study is limited to the availability of the data. The study utilized Robust Least Square (RLS) to obtain the results.

Property rights are defined as the exclusive rights of individuals to use and exchange their own resources for further production and earnings, as described by Alchian and Demsetz (1973). Gwartney et al. (2012) presented the Property Rights Index comprising nine factors, including autonomy of the judiciary system from political stress, courts affinity, property rights safeguard, intrusion of the military in the rule of law, legal system rectitude, legitimate prosecution of deal, administrative costs for the deal of authentic property, authenticity of police, and the business damage of crime.

The World Global Economy has defined the property crime rate as including all those consciously and cold-bloodedly committed offenses that cause the loss of property of others. Institutions are self-construct restraints (informal norms and formal rules) that generate politically, economically, and socially effortless and creamy communications. The focus of the research

is the index of justice and governance made by Principle Component Analysis (PCA). This technique enables the transformation of the most correlated variables into a single uncorrelated variable with the help of orthogonal transformation. The used index has also been used by Madni and Khan (2019) as an explanatory variable.

The Economic Complexity Index is a barometer of the productive structure of an economy. This signal is a combination of the diversity of the economy, which means that the country produces various products, and the ubiquity of the product, which means that the product is made by a few countries. The Economic Complexity Index also elucidates the technical know-how embodied in the labor force of the country, as proposed by Hidalgo and Hausmann (2009). The Economic Complexity Index has also been used by Madni and Khan (2019) as an explanatory variable for their study.

The Economic Misery Index is a consolidation of annual inflation and annual unemployment discovered by Okun (1970). The indicator has also been used by Madni and Khan (2019) as an independent variable for their study. According to the World Bank, the total number of people occupying an area is called a population (Nolan III, 2004). This variable has also been used by Madni and Khan (2019) as an independent variable for their study.

4. Theoretical Framework

The concept of property rights and its relationship with economic efficiency has been a subject of debate for several decades. It all began with the groundbreaking work of Coase (1960), which was later expanded upon by Alchian and Demsetz (1973), Barzel, Haller and Wood (1989), Eggertsson, Eggertsson and Eggertsson (1990). They all contributed significantly to the understanding of property rights. In the early stages, Demsetz (1967) introduced the concept of property rights as it relates to economic efficiency, emphasizing three fundamental principles: (i) universality, (ii) exclusivity, and (iii) transferability. However, the early concept was later criticized by Libecap (1989) and North (1990), they argued that institutional evolution (property rights), economic and political organizations, play a more significant role in economic efficiency.

North's (1990) institutional evolution theory focused on the persistence and change of institutions, emphasizing how institutional progression can alter economic stagnation. The idea is so well accepted that the Nobel prize was given on the same subject. Hart (1995) further expanded upon North's ideas, highlighting the importance of control and contractual incompleteness in understanding economic arrangements and institutions. Hart's work focused on the financial formation of firms, ownership, boundaries, and the economic ramification of contractual incompleteness.

The study recognizes the transaction cost theory introduced by North (1990), it suggests that transaction costs can be reduced or even eliminated (in some contexts) in an efficient institutional framework. Transaction costs come in three types: (i) search cost, (ii) measurement cost, and (iii) enforcement cost. This means that efficient institutions can cause increased confidence of resource owners (property rights) to mobilize resources, leading to increased economic efficiency. However, efficient mobilization of resources requires a productive structure that utilizes skills and technical know-how, known as economic complexity. Therefore, both institutions and economic complexity have a positive relationship with property rights, which is the dependent variable in the study. The main focusing variables are economic complexity and institutions, while urban population, property crime rate, and economic misery index serve as control variables for the study.

$$PopR_{it} = \beta_{1i} + \beta_2 EcC_{it} - \beta_3 EMsy_{it} + \beta_4 INST_{it} - \beta_5 LPoP_{it} - \beta_6 PC + w \dots \quad (1)$$

Note that in the equation, $PopR$ = Property Rights, EcC = Economic Complexity, $EMsy$ = Economic Misery, $INST$ = Institutional index comprised on Governance and Justice, $LPoP$ = Log of Urban Population and PC = Property Crime.

Property rights refer to the legal rights to possess, use, and dispose of property, including both physical assets (like land and buildings) and intellectual property (patents and copyrights). Strong property rights are essential for economic development and investment, as they provide security and encourage individuals and businesses to invest in and protect their assets (Aslam et al., 2023). There is a positive relationship expected between $PopR$ and property rights. As property rights strengthen (i.e., when individuals and businesses have clear and enforceable rights over their property), it is likely to lead to increased economic development, investment, and overall prosperity. Therefore, an increase in $PopR$ is expected to have a positive effect on property rights.

Economic complexity measures the diversity and sophistication of a country's economy. A higher economic complexity suggests that a nation has a more developed and diversified economy with advanced industries and a broader range of products and services. There is a positive relationship expected between EcC_{it} and property rights. When a country has a more complex and diversified economy, it often indicates a higher level of economic development and a greater need for strong property rights to protect various assets and investments. Thus, an increase in EcC_{it} is likely to be associated with higher property rights.

Economic misery represents economic hardships and difficulties faced by individuals and households within a country. It may include factors like high inflation, unemployment, poverty rates, and economic instability. There is a negative relationship expected between $EMsy$ and property

rights. Economic misery is often associated with a lack of economic stability and security, which can lead to weaker property rights. In countries with high economic misery, property rights may be less protected and secure, negatively affecting *PopR*.

The institutional index combines measures of governance and justice from the six indicators of institutions of *ICRG* websites (control of corruption, rule of law and order, government effectiveness, voice accountability and political stability). It assesses the quality of a country's institutions, including the effectiveness of its government, rule of law, and overall governance. There is a positive relationship expected between *INST* and property rights. Strong institutions and effective governance are crucial for upholding property rights. When institutions are well-functioning and provide a fair and transparent legal system, property rights are more likely to be protected and upheld. Therefore, an increase in *INST* is expected to have a positive impact on *PopR*.

LPOP represents the logarithm of the urban population, which indicates the degree of urbanization within a country. The relationship between *LPOP* and property rights may vary. In some cases, higher urbanization may be associated with stronger property rights, as urban areas often have better infrastructure and governance. However, in rapidly urbanizing areas, property rights issues can arise due to land disputes and inadequate legal protections. Therefore, the relationship between *LPOP* and *PopR* may not have a clear direction and would depend on specific contexts. Property crime represents criminal activities such as theft, burglary, and vandalism that target individuals' property. There is a negative relationship expected between *PC* and property rights. Higher levels of property crime are likely to be associated with weaker property rights, as a higher prevalence of property crime can undermine individuals' confidence in the security of their property. Strengthening property rights can be a way to reduce property crime and enhance security. The benefit of using Robust least squares is that it uses a weighting scheme to down-weight the influence of outliers, allowing more accurate estimates of regression coefficients.

5. Empirical Findings and Their Description

The data's stationarity was assessed using the Levin, Lin and Chu test, it determines if the null hypothesis should be rejected or accepted (Ghouse, Khan & Rehman, 2018). If rejected, it indicates the data is stationary, while if accepted, it implies the data is non-stationary (See appendix for details).

The concept of economic complexity, as proposed by Hidalgo and Hausmann (2009), refers to the combination of total knowledge and technical know-how embodied in the labor force. They argue that if labor force has high skills and technical knowledge, they have a higher chance of employment. Furthermore, employed individuals are less likely to engage in

theft or property crime. Consistent with this view, Madni and Khan (2019) have shown that economic complexity has a negative relationship with crime rate. The positive relationship between economic complexity and property rights in high-income countries can be attributed to the advanced economic and legal systems in place. The countries typically have intricate economies with well-defined property rights, fostering innovation and investment. In middle-income nations, strong positive association suggests that as their economies develop and diversify, property rights become more crucial, making them a priority for policymakers. Low-income countries also show a positive relationship, though weaker, indicating that even in less developed contexts, economic complexity plays a role in shaping property rights by encouraging formalization of property ownership.

Table 1
Empirical Results of Robust Least Square for Income Groups

	(1)	(2)	(3)
VARIABLES	High Income	Middle Income	Low Income
Economic Complexity	1.470*** (0.516)	11.49*** (1.673)	4.274*** (0.785)
Economic Misery	-0.684*** (0.158)	0.0853 (0.0670)	-0.157** (0.0700)
Institutional Index	5.217*** (0.761)	5.227*** (0.778)	1.230* (0.704)
Log of Population	-0.939*** (0.318)	-5.921*** (0.916)	5.805*** (1.013)
Property Crime	-0.132* (0.0684)	0.0409 (0.0645)	0.0186 (0.0402)
C	109.6*** (9.301)	143.1*** (16.90)	4.579 (8.876)
Observations	90	90	90
R-squared	0.912	0.635	0.471

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Economic misery, defined as the combination of unemployment and inflation rates by Okun (1970), has also been shown to have a significant impact on property rights. Torruam and Abur (2014) and Madni and Khan

(2019) have predicted that economic misery has a positive relationship with crime rate. The negative relationship between economic misery and property rights in high-income countries may be due to a more established social safety net, which provides some protection even in economically challenging times. In middle-income countries, the weak positive relationship suggests that economic misery may not significantly affect property rights, as the countries often exhibit mixed economic conditions. In low-income countries, the negative relationship is consistent with the idea that economic distress hampers property rights by reducing the resources available for enforcement and protection.

The institutional index measures the efficiency of institutional structures in protecting property rights. The strong positive relationship between the institutional index and property rights in high and middle-income countries indicates that robust institutions, such as effective legal systems and governance structures, are essential for protecting property rights. In the countries, institutions play a pivotal role in safeguarding individuals' assets and fostering a conducive environment for businesses and investment. The weaker but still positive relationship in low-income countries suggests that while institutions are important, other factors may limit their impact, such as resource constraints and political instability. Thus, the results of the study are consistent with previous findings (Madni & Khan, 2019; Khan, Ahmed, Nawaz & Zaman, 2015).

The negative relationship between the log of population and property rights in high-income countries may stem from the established property rights systems that can accommodate demands of a larger population. In middle-income countries, the stronger negative association could reflect challenges of managing property rights in rapidly growing populations, leading to more complex legal and administrative structures. The positive relationship of low-income countries suggests that, as their populations grow, there is a greater need for property rights to facilitate economic development and investment. Neumayer (2003) and Madni and Khan (2019) have also shown that high population increases the crime rate, and the snatching of property rights is also a crime. Therefore, the results of the study are consistent with previous findings.

Finally, the impact of property crime on property rights has been analyzed in the study. The negative relationship between property crime and property rights in high-income countries is logical, as the nations typically have effective law enforcement systems to combat property crime. Middle and low-income countries exhibit positive but weaker relationships, which could be indicative of the challenges they face in managing and reducing property crimes. This result emphasizes the need for property rights protection to be closely aligned with crime prevention efforts in the income groups. This finding is in line with previous research that has shown a positive relationship between crime and property theft (Madni & Khan, 2019).

In conclusion, the study provides evidence on the significant impact of economic factors on property rights. Economic complexity, economic misery, institutional index, log of population, and property crime all have an impact on property rights, and the findings are consistent with previous research. The results can inform policymakers and stakeholders in designing and implementing policies to protect property rights in different economic contexts.

6. Conclusion and Policy Implications

The study examines the impact of economic complexity, economic misery, institutional index, population, and property crime on property rights in three income groups such as low, high middle, and high-income countries. In high-income countries, strong property rights are linked to economic complexity. The reason behind is their advanced legal systems, they may support innovation and investment. Economic misery has a weaker influence, owing to established safety nets. A strong institutional structure plays a pivotal role in preserving property rights in high and middle-income nations. Population size negatively affects property rights in high-income countries, while low-income nations have positive effects. It indicates the importance of property rights for development. Property crime affects high-income countries negatively, showcasing for alignment with crime prevention and policies. The findings highlight the need for structured and solution driven policies, which aim at protecting property rights and spur economic growth across different income groups. The study suggests that policies should focus on improving skills and knowledge of labor force, reducing economic misery, and improving institutional efficiency to enhance property rights.

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Declaration of Conflicting Interests

The authors declare that there is no conflict of interest related to the research paper. The study was conducted without any financial or personal relationships that could be perceived as potentially influencing the research or its outcomes.

Declaration

The authors used the AI tool ChatGPT to help check grammar (only) in the preparation of this article.

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Appendix

Table A1.

Levin, Lin, Chu Stationarity Result for Low-Income Countries

Variables	S. Values	P. Values	Levels
Property Rights	-2.23816	0.0126	*
Economic Complexity	-2.12545	0.0231	*
Economic Misery	-2.53959	0.0055	**
Institutional Index	-8.75182	0.0000	***
Log of Population	-20.1548	0.0000	***
Property Crime	-5.21342	0.0000	***

Note: ***, **, * indicate stationarity at the level, at 5% level, and at 10% level of significance.

Table A2.

Levin, Lin, Chu Stationarity Result for Middle-Income Countries

Variables	S. Values	P. Values	Levels
Property Rights	-4.14784	0.0000	***
Economic Complexity	-1.99589	0.0230	*
Economic Misery	-2.79238	0.0026	**
Institutional Index	-5.48911	0.0000	***
Log of Population	-4.82941	0.0000	*
Property Crime	-1.65835	0.0486	***

Note: ***, **, * indicate stationarity at the level, at 5% level, and at 10% level of significance.

Table A3.

Levin, Lin, Chu Stationarity Result for High-Income Countries

Variables	S. Values	P. Values	Levels
Property Rights	-9.37580	0.0000	***
Economic Complexity	-3.62514	0.0000	*
Economic Misery	-2.55780	0.0053	**
Institutional Index	-4.98687	0.0000	***
Log of Population	-2.9392	0.0016	**
Property Crime	-4.21530	0.0000	***

Note: ***, **, * indicate stationarity at the level, at 5% level, and at 10% level of significance.

Robust Least Square (RLS) has been used for empirical findings after the checking of stationarity of data. Property rights are the regress and while economic complexity, economic misery, institutional index, log of population and property crime rate are the regressors for the study.

Social Media Utilization of Public Benefit Organizations During the COVID-19 Pandemic

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Abstract

Purpose: The main purpose of the research was twofold. First, it was to assess the impact of the COVID-19 pandemic on the publishing activity of Polish public benefit organizations on Facebook. Second, to determine the impact of content published in a crisis situation on the public reaction.

Design/methodology/approach: During the investigation, the financial reports of public benefit organizations were analyzed. Further the basic parameters of the organization's Facebook profile and the content published on Facebook were analyzed (1025 organizations were covered by the research). From the reports, financial data of organizations has been collected. Both in 2020 and in 2021, posts of the same organizations were analyzed.

Findings: The Covid-19 pandemic did not have a significant impact on the publishing activity of the surveyed organizations. Although interest in the Facebook profile of organizations during the Covid-19 pandemic increased, the results indicate that Facebook's potential in the crisis stage was only used to a small extent.

Research limitations/implications: The research is limited to one social networking site – Facebook. It would also be worth scrutinizing other social media sites (e.g. by comparative analysis).

Originality/value: The paper fills a research gap regarding the behavior of non-profit organizations concerning the utilization of social media during the crisis consisting in losing direct contact with the public and the inability to operate in an offline environment (due to the lockdown). It shows what opportunities exist in such situations in social media and how the managers of non-profit organizations could use them for the benefit of the organizations they handle.

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Keywords: social media, COVID-19, non-profit organization.

JEL: L31, M15, M30

Wpływ pandemii COVID-19 na wykorzystanie serwisów mediów społecznościowych przez organizacje pożytku publicznego

Streszczenie

Cel: główny cel badań miał dwójaki charakter. Po pierwsze, była to ocena wpływu pandemii COVID-19 na aktywność publikacyjną polskich organizacji pożytku publicznego w serwisie społecznościowym Facebook. Po drugie, ustalenie wpływu publikowanych w kryzysowej sytuacji treści na reakcję odbiorcy.

Metodyka: w trakcie badania przeanalizowano sprawozdania finansowe i merytoryczne organizacji pożytku publicznego. Następnie poddano analizie podstawowe parametry profilu organizacji oraz treści publikowane na Facebooku (badaniem objęto 1025 organizacji). Z utworzonej bazy danych zebrano dane finansowe organizacji. Posty tych samych organizacji pożytku publicznego przeanalizowano zarówno w 2020 r., jak i w 2021 roku.

Wyniki: pandemia Covid-19 nie miała istotnego wpływu na działalność publikacyjną badanych organizacji. Choć zainteresowanie profilem organizacji na Facebooku w czasie pandemii COVID-19 wzrosło, to wyniki wskazują, że potencjał Facebooka w fazie kryzysu został wykorzystany tylko w niewielkim stopniu.

Ograniczenia/implikacje badawcze: badanie ograniczono do jednego serwisu społecznościowego – Facebook. Wskazaniem byłoby przyjrzenie się innym portalom społecznościowym (np. poprzez analizę porównawczą).

Oryginalność/wartość: artykuł wypełnia lukę teoretyczną dotyczącą zachowań organizacji non-profit dotyczących wykorzystania mediów społecznościowych w czasie kryzysu polegającego na utracie bezpośredniego kontaktu z ich publicznością i niemożności działania w środowisku offline (lockdownu z powodu COVID-19). Artykuł ukazuje, jakie możliwości istnieją w takich sytuacjach w mediach społecznościowych i jak menedżerowie organizacji non-profit mogą je wykorzystać z korzyścią dla obsługiwanych przez siebie organizacji.

Słowa kluczowe: media społecznościowe, COVID-19, organizacja non-profit.

1. Introduction

In the last couple of years due to the perpetual lockdown threat caused by the COVID-19 pandemic, the running mechanisms of both for-profit and non-profit organization have changed dramatically. It was especially onerous for the latter ones. For most of them, the practice of raising funds through charity outdoor events like concerts, football matches, retreats for the disabled and street collections almost completely came to a halt, which badly impeded the building of social relations and public engagement. Non-profit organizations are therefore very complex institutions with financial arrangements and rich governance systems (Coupric, 2012). “The lockdown certainly took place through the mechanisms, reducing the social complexity and the possibilities of individuals to have an experience and actively take part” (Stanzani, 2020, p. 922). On the other hand, the world is becoming more and more digitalized. “New applications, new services, new platforms,

new data and new devices have become a crowded playground for all kinds of companies that want to tap the emerging opportunities” (Zott & Amit, 2017, p. 19). For profit-oriented companies, a digitalized world should be perceived as a unique place for the development of mutually beneficial long-term relationships with clients and other stakeholders and in consequence might be a deciding factor in achieving a competitive advantage (Domazet et al., 2010; Day & Bulte, 2002; Siggelkow & Terwiesch, 2019; Karlsen, 2008; Hazra et al., 2017; Chakrabarty, 2020). The same philosophy applies to non-profit organizations (Balsler & McClusky, 2005; Pickard, 2007; Van Huijstee & Glasbergen, 2008; den Hond, 2010; Burchell & Cook 2013; Smillie et al., 2013; Zaharrudin & Zakaria, 2022). The decision to press the “donate” button on the website or social media platform of the non-profit organization is nothing more than the decision to “add to cart” a product on the website of a profit-oriented organization. A large number of non-profit organizations have already reshaped their current business models, and many will do so. The models will be focused primarily on Internet utilization not only as the main source of mission accomplishment, but also as part of the daily routine. Social media will play a key role in the process as it provides non-profit organizations with unique opportunities to engage with their audience, mobilize support, and amplify their efforts. Their role will also be relevant in crisis scenarios and such was undoubtedly the outbreak of the COVID-19 pandemic. To date, there have been very few studies analyzing the impact of the pandemic outbreak on the utilization of social media by non-profit organizations especially in Central European countries. The article aims at partially filling the gap.

The structure of the paper is as follows: first, the theoretical background is established. It is divided into four parts. The first part describes the notion of a specific form of non-profit organization that is a Public Benefit Organization (PBO). The second part discusses the importance of social media in the operating of non-profit organizations (with particular emphasis on Facebook). The third part analyzes the theory of social media utilization in non-profit organizations. Afterwards, scientifically backed hypotheses are developed. Then the research methodology is laid out, involving methods, the selection of a research sample, and a method of coding and data analysis. Finally results are presented, followed by discussion part. At the end, conclusions are provided with an emphasis on how our work impacts the existing practice.

2. Theoretical Background

2.1. Public Benefit Organizations as Specific Kind of Non-profit Organizations

One of the specific entities that can be distinguished within the Polish landscape of non-profit organizations are public benefit organizations (PBOs). They are important Polish non-profit organizations constituting approximately 10% of all registered non-profit organizations in Poland. To get the status of a PSO organization, a number of conditions must be met, from which according to the “Polish Act of 24 April, 2003 on public benefit and voluntary work” the most important are:

- they perform public benefit work to the benefit of the entire society or of a specific group of individuals provided that such group can be distinguished from the society due to difficult living conditions or financial situation (activity for the benefit of the community as a whole should be understood as such activity of an organization that is directed to a certain broad group of recipients, distinguished due to various criteria, e.g. ethnic, religious, geographical criteria);
- they may pursue business activity solely as an activity auxiliary to public benefit work;
- the entire income of the organization (the excess of revenues over costs) is allocated to public benefit work;
- they have a statutory collegial audit or supervision body, separate from the management body and not reporting thereto in matters related to internal audit or supervision (Ministry of Labor and Social Policy, 2018).

According to the data contained in the National Court Register (NCR), at the end of 2021, there were over 9,082 registered entities with a PBO status (the actual number is slightly smaller due to the fact that in a given year some organizations ceased their activities).

Possessing PBO status involves the possibility of using certain privileges. One of the most important is the right to receive 1% of personal income tax. With the introduction of the PBO organization into the Polish tax system, individual taxpayers obtained the right to transfer 1% of their income tax to a specific public benefit organization indicated by them. In 2021, such a decision was made by 15 million 337 thousand taxpayers, 3.7% more than in 2020. In total, in 2022, public benefit organizations received exactly PLN 1 billion 114 million from the source. The average amount donated to the organizations by an individual taxpayer amounted to PLN 70 (Ministry of Finance, 2022).

2.2. Social Media and Non-profit Organizations

“The power of social media to engage with user communities is a key benefit for organizations that use the tools” (Given et al., 2013, p. 1). Many non-profit organizations use social media as a main communication channel with the public and stakeholders (Wang & Yang, 2020). Regardless of the COVID-19 issues, “social media nowadays play an important role in the further development of civil society and the enhancing of people’s awareness of their social responsibilities” (Akatay et al., 2017, p. 64). The issues related to COVID-19 and possible future epidemic diseases will probably increase the intensity of the utilization of the kinds of tools. For non-profit organizations, the use of social media is of particular significance, because they usually do not have sufficient monetary and human resources for large-scale campaigns or mass media advertisements. “Therefore, they use social media functions that enable them to communicate with many individuals quickly and cheaply” (Kim, 2022, p. 2). So, “the non-profit organizations can operate close to the community, and they are gaining many benefits from information shared on social media such as Facebook” (Masdar et al., 2022, p. 168). Other social media like Twitter (Neu et al., 2020; Kim, 2022; Zhang et al., 2022) or Instagram (Cobos, 2022; Bernardi & Alhamdan, 2022; Najafizadeh et al., 2022) are important as well. Nevertheless, as compared to Facebook, they are used much less frequently. “The Facebook application has become a standard for non-profit organizations to express their activities. It allows them to convince donors for fundraising purposes” (Masdar et al., 2022, p. 167).

Social media seems to be a particularly useful tool in building relationships between non-profit organizations and various stakeholder groups (Chen, 2016; Armstrong & Butcher, 2018; Saraite-Sariene et al., 2021). The reasons for the potential are: faster and easier information delivery, dissemination of information and knowledge, connectivity and network creation, efficiency and transparency gains, transformation of people’s lives and lastly decentralization and empowerment (McNamara, 2003; Yamamichi, 2011; Sheombar, 2015). Previous studies on the utilization of social media in the public relations activities of non-profit organizations focused primarily on identifying the organizational role of social media based on the opinion of public relations practitioners (e.g. Wright & Hinson, 2017; Russmann & Lane, 2020), the extent of its applications and an attempt to find an answer to the question of what attributes of an NGO influenced the greater utilization of the services (e.g. Nah & Saxton, 2013). Subsequently, the research concerned an analysis of static elements of an organization’s profile on a social media service (e.g. Bortree & Seltzer, 2009; Lane, 2018; Smith et al., 2018), and then the content and its impact on the level of public engagement (e.g. Saxton & Waters, 2014; Guo & Saxton, 2014; Huang et al., 2016; Van Wissen & Wonneberger, 2017; Bellucci & Manetti, 2017; Hellsten et al., 2019, Tao et al., 2021; Oliński & Szamrowski, 2021). The research

also brought up the role of social media in crisis management, although the most common studies focused on the significance of the communication channels in minimizing the negative image caused by the activities of the organization itself. The outbreak of the COVID-19 pandemic did not have its origin in the activities of the organization itself, it was an independent occurrence, although it had a significant impact on the way it operates. There are only a few studies on the impact of a crisis situation arising independently of a non-profit organization. In the context of COVID-19, they mainly concerned motivations that influenced attitudes toward online donations related to the COVID-19 response (Bin-Nashwan & Al-Daihani, 2021) showing the participation of non-profit organizations in information policy concerning the COVID-19 pandemic (Diab, 2021; Chen et al., 2022). With few exceptions, there are no studies scrutinizing the impact of the COVID-19 pandemic on the publishing activity of non-profit organizations in social media, as well as its influence on the public engagement level expressed in the case of Facebook by the number of likes, shares and comments (e.g. Banker & Park, 2020). Therefore the research gap in this respect is clearly visible and the following paper is an attempt to fulfill it, thus providing a stimulus for other researchers to conduct similar research.

2.3. Theory of Social Media Utilization in Non-profit Organizations

There are no ground rules of conduct that will guarantee success for an organization in every situation. This is especially true in various crisis conditions (COVID-19 can be a good example here). Therefore, in explaining the adaptability of organizations to crisis conditions, the contingency theory is a helpful approach to studying organizational behavior. It elucidates how factors like technology, culture, and the external environment influence the design and functioning of organizations (Islam & Hu, 2012). Thus, the contingency theory paradigm postulates that organizational outcomes are the consequences of a match between two or more factors, like publishing activities and audience reaction (Van de Ven, Drazin, 1985). Besides utilization of social media in non-profit organization has made significant theoretical contributions to various aspects of management. The contributions have expanded the understanding of management practices, communication dynamics, organizational behavior, and stakeholder interactions. Some key theoretical contributions of social media in management include:

- Communication and information flow: social media have reshaped communication patterns within organizations and between organizations and their stakeholders. They have facilitated faster and more direct communication, breaking down hierarchical barriers and enabling open dialogue. Theoretical models have been developed to study the impact of social media on information sharing, knowledge dissemination, and decision-making processes in non-profit organizations (Guo & Saxton, 2020; Jung et al., 2014);

- Customer Relationship Management (CRM): social media have revolutionized how non-profit units interact with their audience. Theoretical contributions in CRM have emerged, focusing on understanding customer engagement, sentiment analysis, and the role of social media in building and maintaining customer relationships (Go & You, 2016; Hussain et al., 2014);
- Network Theory and Social Capital: Social media platforms operate based on networks, leading to the emergence of a network theory and its application in management research. Social media has also been linked to the concept of social capital, investigating how it influences non-profit organizational success and resource acquisition (Xu & Saxton, 2019; You & Hon, 2019);
- Social Media Marketing and Branding: Social media has introduced new dimensions to marketing and branding strategies. Theoretical contributions have explored the role of social media in non-profit units brand building, consumer behavior, and the impact of influencer marketing (Bernritter et al., 2016; Asencio & Sun, 2015);
- Crisis Management: As discussed earlier, social media have transformed crisis management practices. Theoretical models have been developed to understand the dynamics of crisis communication on social media and the effects of them on a non-profit organization's reputation (Luna, & Pennock, 2018; Brengarth & Mujkic, 2016);
- Organizational Resilience: Social media's impact on organizational resilience, which refers to an non-profit organization's ability to adapt and recover from crises, has also been a subject of theoretical exploration (Herrero & Kraemer, 2022; Singh et al., 2022).

Overall, social media have expanded the theoretical landscape in management studies, influencing various domains and providing new avenues for research and understanding. As technology and social media continue to evolve, management theories will continue to adapt and incorporate these advancements to improve organizational practices and outcomes.

The study contributes to the following crisis communication theory – the Social-Mediated Crisis Communication Model (SMCC). It emphasizes the role of social media in managing and responding to crises. The model points out effective ways of content distribution in social media environment (Liu et al., 2012).

2.4. Hypotheses Development

The main purpose of the research was twofold. First, it was to assess the impact of the COVID-19 pandemic on the publishing activity of Polish public benefit organizations on Facebook. Second, to determine the impact of content published in a crisis situation on the public reaction. Due to the significant prevalence of Facebook in relation to other social media used by PBOs, the research focused entirely on the medium.

The lack of physical interaction with the recipient of organizational messages means that the role of social media in crisis situations seems particularly important. As described in the Introduction section, the subject of the research was a specific group of non-profit organizations, i.e. only those with the status of a public benefit organization. Their unique feature, which is the possibility of getting 1% of personal income tax, means that organizations of this type should pay special attention to the group of their stakeholders with the status of individuals. This group is usually very dispersed, which means that for a public benefit organization the process of continuous communication and sharing with the surrounding values and ideas becomes of special importance. In the process of communicating professed values and ideas, organizations should use as many communication channels as possible. Since the activity of many organizations has moved to cyberspace during the pandemic, one should also expect greater publishing activity among PBOs. As noted by Peter Raeymaeckers and Stijn Van Puyvelde, as a result of Covid-19, “non-profit organizations experimented with alternative ways of staying in touch with their target groups” (2021, p. 1309). Research results have also indicated that the size of the organization is an important contingency factor improving an organization’s general information technology capacity (Finn et al., 2006; Hackler & Saxton, 2007; Oliński & Szamrowski, 2020). The use of IT technology including social media only seems to be cost-free. It requires not only equipment but, above all, experienced employees. “The ties of an internet network model are treated as costless” (Urry, 2004, p. 116), but other researchers have emphasized that non-profit organizations are particularly affected by the limited availability of spare resources. Smaller organizations have an especially limited capacity, which causes differences in IT adaptation between small and large entities (Baird et al., 2012). Moreover, as it grows in size, the organization becomes more visible, attracting more attention from outside stakeholders such as the media and the public, and even the state or local government (Nah & Saxton, 2013). This, in turn, on the basis of feedback, forces the organization to be more active in content dissemination to meet audience concerns. We thus posit the following hypothesis:

H1. Publishing activity of non-profit organizations during the pandemic increased, and the scale of the increase was determined by the size of the organization, measured by the total annual revenue.

The importance of social media should be particularly evident in crisis management. As noted in section 1.1, the outbreak of the COVID-19 pandemic limited the functioning of the entire socio-economic sphere, causing economies to close for months and creating general difficulties in relocating. The role of online channels in the activities of both commercial and non-commercial organizations has clearly increased, representing the

main channel enabling organizational messages to reach stakeholders. The lockdown meant that it was not possible to organize mass sports or cultural events, concerts, public endowment collections, trips for the beneficiaries of the statutory activity of the organization etc. We thus posit the following hypothesis:

H2. Operating under the conditions of the COVID-19 pandemic, rendered an increased stakeholders interest in the Facebook profile of non-profit organizations.

From the beginning of their existence, non-profit organizations have played the role of binding individuals around a specific social problem. In practice, therefore, they act on behalf of individuals or organizations. Moreover, they represent and mobilize them to collective action around common goals (Bimber et al., 2005; Bimber, 2017). Prior research included the analysis of post function which led to the identification of those that had the greatest impact on the total engagement measured by the number of likes, shares and comments (e.g. Cho et al., 2014; Guo & Saxton, 2018). “It simply involved counting the number of reactions to prove the effectiveness of specific social media strategies” (Ihm, 2022, p. 103). Under the current conditions, it would be interesting to check whether, regardless of the type of post, COVID-19 and the associated lockdown resulted in a higher level of response from the public. The necessity of staying at home and spending more time in front of the computer should contribute to the phenomenon. We thus posit the following hypothesis:

H3. Facebook posts during the COVID-19 pandemic were characterized by a higher level of response from the public, as compared to the period before its appearance.

3. Research Methodology

3.1. Research Sample

The process of selecting the research sample consisted of several stages. The first step was to identify the public benefit organizations that were entitled to receive 1% of personal income tax for 2020. All of the data was gathered from the National Freedom Institute website. The database contained 8,833 organizations that were the subject of further research (as of December 8, 2021). Having the status of a PBO means the necessity to conduct accurate reporting overt to the public, which allowed access to data relevant from the research point of view. During the research, 241 organizations were excluded from the analysis because they did not include their annual financial statement in the database, or because they started

the process of shutting down. Thus, 8592 organizations were covered by further research. From the database, among the others, the following data was collected: total revenue, revenue from gratuities and paid public benefit activities, revenue from business activities, revenue from 1% of personal income tax and sources of income broken down into private and public.

The second stage of the research process focused on determining the utilization scale of social media in the daily activities of Polish Public Benefit Organizations. First, all the organizations were checked in terms of running their own website. The level of the organization's involvement in the utilization of social media was analyzed through the organizational website, but also with the employment of google.pl search engine, because some organizations only used social media services in their activities without using the organizational website at all. Facebook was the most popular social media service embraced by Polish non-profit organizations and it was the only subject matter of further research. It was pulled into activities of over 60% of all Polish public benefit organizations (N = 5184). The second in line, YouTube was used by only 8% of Polish non-profit organizations.

Public benefit organizations were clustered into four groups depending on the amount of total revenue in 2020 (Tab. 1).

Table 1
Public benefit organizations by size

Number of the cluster	Size of the organization	Number of organizations	Total annual revenue
I	Micro	1927	below PLN 100 thousand
II	Small	2073	from PLN 100 thousand to under PLN 1 million
III	Medium	1047	from PLN 100,000 to less than PLN 1 million
IV	Large	136	revenue of PLN 10 million and more

The size of the minimum sample for a finite population (for a confidence level of 0.95 and a maximum error of 0.05) amounted to 1025 entities (320 from cluster I, 324 from II cluster, 281 from cluster III and 100 from cluster IV). The selection of the non-profit organizations from each of the layers was performed using the Research Randomizer algorithm.

To analyze social media users' behaviors the netnography method was used in the third stage of the research. Netnography is a qualitative research method that involves the study of online communities, interactions, and behaviors on the internet. It is a combination of "net" (from internet) and "ethnography" (a traditional research method used in anthropology

to study cultures and societies). Netnography focuses on observing and understanding the behavior, attitudes, and social interactions of individuals within virtual communities, social media platforms, forums, blogs, and other online spaces.

The post database consisted of content that organizations published on Facebook throughout February 2020 and 2021. The choice of the month of February was not accidental. February 2020 was the last full month before the COVID-19 pandemic in Poland. The activity of Polish non-profit organizations was not inhibited in any way at that time. In turn, February 2021 was the time of the lockdown, which was associated with significant restrictions in their daily activities. The restriction process was gradual and began in March 2020, with only minor interruptions until the end of May 2021. From the public benefit organizations point of view, the most important barriers during the time included: a practical ban on public gatherings, remote education in primary and secondary schools as well as university education (with some exceptions), significant impediments in the running of the entire economy, including the tourism industry, collective accommodation, numerous difficulties or the inability to organize sports and recreational events, numerous difficulties in the organization of events of cultural importance, widespread social fear of movement and the associated risk of contracting the COVID-19 virus.

The analysis included the basic parameters of the organization's Facebook profile, i.e. the number of followers, the frequency of publication on Facebook for the two periods analyzed, and the public reaction to the content published by the organization (the public reaction was measured by the number of likes, shares and comments on a single post). Including the parameters in the analysis made it possible to verify the research hypotheses set.

Both in 2020 and in 2021, posts of the same organizations were analyzed. As a result, we gathered reliable information concerning the utilization scale of the Facebook social networking site, both before and during the COVID-19 pandemic. It was especially important because most of all socio-economic activity moved to the online environment due to an almost complete lockdown. In the case, the role of social media in maintaining social relationships should be particularly important. At the same time, the adoption of the month of February 2021 for the analysis, and not e.g. April 2020, where many types of restrictions were introduced, gave the entities much more time to switch activities related to building relationships from the offline environment to online milieu. Thereby, it was possible to gather valuable information on how Polish non-profit organizations deal with a crisis situation, having almost 12 months at their disposal to adapt to it.

3.2. Data Coding and Analysis Scheme

The collected data was exported from a Microsoft Excel spreadsheet to the Statistical Package for the Social Sciences (SPSS), version 27, where it was checked for correctness and completeness. Then, the SPSS program was used to carry out a statistical analysis for the data we gathered. The following statistical procedures were used: analysis based on standard parameters and the study of the dependence of selected variables (Kruskal-Wallis tests, non-parametric median tests). The classic p value < 0.05 was assumed as the significance level in the analyses. P scores ranging from 0.05 to 0.1 were considered to be close to statistical significance (statistical trend level). The following variables were included in the analysis: selected characteristics of the organization, i.e. the basic features of the organization's Facebook profile, i.e. the number of followers before and during the lockdown, publication frequency on Facebook before and during the Covid-19 pandemic, public reaction to content measured by the number of likes, shares and comments before and during the lockdown, and the level of annual revenue of non-profit organizations.

Due to the lack of possibility to compare the organizational use of the Facebook social network before and during the COVID-19 pandemic, 22 organizations (2.15%) were excluded from further research. The reason for it was twofold. Firstly, in 2021, they lost the status of a public benefit organization and did not publish their financial statements in the database, or they set up a new Facebook profile, eliminating the previous one. The two factors made it impossible to conduct a comparative analysis, hence exclusion from the study. This group included three entities from Cluster II, thirteen entities from Cluster III and six entities from Cluster IV.

4. Research Results

4.1. Publishing Frequency Activity of Public Benefit Organizations

The public benefit organizations published 12,790 posts on their Facebook profile in February 2020 (before the outbreak of the COVID-19 pandemic in Poland). On average, it was 12.48 posts per entity. The COVID-19 pandemic did not have a significant impact on the publishing activity of the surveyed organizations. In February 2021, they published a total of 12,850, which is practically the same as in the same month of the previous year. On average, each organization posted 12.54 posts over a period of 28 pandemic days.

Additionally, the organizations were divided into four clusters, taking the total annual revenue as the parameter for the division. The results make it possible to easily identify the leading trend. As the level of the annual total revenue of the organization decreased, the frequency of publication also decreased. Such results were observed both before and during the pandemic, i.e. in February 2020 and February 2021. On average, in February

2020, within the largest organizational cluster a single post was published with a frequency of 23 hours and 31 minutes, within the medium-sized organizational cluster the frequency was every 1 day 15 hours and 5 minutes, for small organizations it was every 2 days 15 hours and 10 minutes, and within the micro-organizational cluster it was every 5 days 2 hours and 11 minutes.

In February 2021, the publication frequency, as compared to 2020, for the largest and smallest entities was slightly higher, by 2.1 and 0.8%, respectively. In the cluster of medium-sized entities, the difference was greater and amounted to 5.3% in favor of the pandemic year 2021. Explicitly different results were observed among the smallest entities, where publishing frequency activity decreased by as much as 18.5%, as compared to 2020. Less than 33% of the largest entities increased their publication frequency in February 2021, and 4% of organizations maintained it at exactly the same level. The remaining 63% of organizations with an annual total revenue greater than PLN 10 million decreased their publishing activity on their Facebook profile. Ultimately, the 37% of entities whose publishing frequency was higher during the pandemic resulted in a 2% increase in the overall publishing activity in the cluster, as compared to the pre-pandemic period.

In the cluster of medium-sized entities, 40.8% of them increased their publication frequency, and 5.6% of organizations kept it at exactly the same level. Ultimately, organizations whose publishing frequency activity was greater during the pandemic resulted in a 5% increase in the overall publishing activity in the cluster, as compared to the pre-pandemic period. In the cluster of medium-sized entities, several spectacular increases were observed. For example, there were 400 or even 700 percent surges, but they were small increases if we express them in absolute terms, e.g. from 1 to 7 posts or from 2 to 10 posts in February 2021. In the cluster of small entities, 33.7% increased their publication frequency, while in the case of 4.9% of organizations it remained at exactly the same level. In summary, the years 2020 and 2021 in terms of the publishing frequency activity of small public benefit organizations remained practically at the same level (minimal increase by 0.8%). Again, there were some very large surges in publication frequency, but except for one case, they were small in absolute terms.

Only 22.5% of the smallest organizations increased their publication frequency in February 2021, which ultimately reduced the total publishing activity in the cluster of entities by as much as 18.5%.

Due to the large variation in the publishing frequency activity of the organizations, Kruskal-Wallis tests were additionally carried out, they are resistant to extreme observations and allow an answer to the question of whether the arithmetic means actually confirm the thesis that along with the decrease in the level of total revenue, the publishing frequency activity of the organization decreases, too (table 2). Each line in the table tests the null hypotheses about whether distributions of Sample 1 and Sample

2 are the same. Asymptotic significance (two-tailed tests) are displayed. The significance level is 0.05 and the significance values for many tests were corrected by the Bonferroni method. The tests were performed for both 2020 and 2021. The results indicate that for both periods of time the size of the organization measured by the level of annual total revenue had an impact on the publication frequency. The test value for February 2020 totaled $\chi^2(3) = 130.786$, $p < 0.001$; (mean rank for cluster I = 307.51; for cluster II = 425.76; for cluster III = 505.53, and mean rank for cluster IV = 618.59). The pairwise comparison proved that the largest organizations in terms of annual total revenue were characterized by higher publishing frequency activity, as compared to the organizations from all other clusters ($p < 0.001$ for clusters I and II, and $p = 0.021$ for cluster III, significance level adjusted with the use of the Bonferroni method). The pairwise comparison also proves that the smallest entities are clearly characterized by the lowest publishing frequency activity. It is lower in comparison not only to the largest entities (cluster I), but also to entities from cluster II and III ($p < 0.001$ in each case). In turn, the largest entities were characterized by higher publishing frequency activity, as compared to all other clusters of organizations (in two cases $p < 0.001$, in one case $p = 0.004$, as compared to medium entities). Kruskal-Wallis tests also confirmed that entities from cluster III were characterized by a higher publication frequency, as compared to organizations from cluster II ($p = 0.001$). The exact same results were observed for 2021. Again, large entities were the most active in terms of frequency of publication activities, explicitly distancing themselves from the small and smallest entities, and to a slightly lesser extent the medium ones (see Table 2). The smallest ones clearly lagged behind.

Table 2
Pairwise comparison of publication frequency activity depending
on the size of the entity – February 2021

Group X-Group Y	III-IV	II-IV	I-IV	II-III	I-III	I-II
Test statistics	93.111	179.960	304.253	86.849	211.142	124.293
Standard error	33.140	32.456	32.661	21.508	21.816	20.764
Dev. test statistics	2.810	5.545	9.315	4.038	9.678	5.986
Statistical significance	0.005	<.001	0.000	<.001	0.000	<.001
Corrected statistical significance	0.030	0.000	0.000	0.000	0.000	0.000

4.2. Size of an Organization and the Number of Followers of the Facebook Profile

In the studies, the number of followers of the organization's Facebook profile was measured twice. This made it possible to execute a comparative analysis both for the period before the COVID-19 pandemic and the time when its impact on the socio-economic sphere was the greatest.

On average, in February 2020, the Facebook profile of public benefit organizations was observed by 8,820 so-called "followers". Half of the profiles were observed by less than 1011 followers (by "followers" we mean humans, although a different organization or entity may also be an observer, but the decision to observe the Facebook profile is always made by a human being). The profile of $\frac{1}{4}$ of the organizations was observed by less than 453 followers (the profile of 25% of organizations was observed by more than 2527 followers). The disproportion between the mean values, the median, and especially between the first and third percentiles is substantial. The large dispersion of the results is also confirmed by the very high value of the standard deviation ($SD = 67130.274$). The results for February 2021 indicate that the COVID-19 pandemic could have had an impact on the number of followers of Polish non-profit organizations. On average, during that period, the Facebook profile was observed by 10,126 followers, which is almost 15% more than in the period before the pandemic. The number of followers within the organizations was, similar to February 2020, highly varied. The standard deviation value reached 71454.275 followers (6.4% more than in February 2020), the median for the period amounted to 1230 followers (21.7% more than in February 2020), the 25th percentile did not exceed 574 followers (26, 7% more than in February 2020), and the 75th percentile reached 3,241 followers (28% more than in February 2020). To sum up, it can be stated that the size of the organization significantly influenced the number of followers of its Facebook profile. Along with the organizational size increase, the average number of profile followers observing and the median value also rose. For instance, in 2020 on average in the cluster of the largest entities, the Facebook profile was observed by over 50 thousand people, and in the cluster of the smallest entities by only 1055 (more than a 50-fold difference). Thus, the disparity is substantial in this respect. Slightly smaller differences were noted for the median, although they were still large. The difference between large and micro entities was over nine times in favor of the former (the median value was 5225 for large entities and 559.5 for micro entities). Similar results were observed in February 2021.

Additionally the Kruskal-Wallis test confirmed that the size of an organization measured by the level of annual total revenue had an impact on the number of followers of its Facebook profile ($\chi^2(3) = 180.409$, $p < 0.001$; (mean rank for cluster I = 286.90; for cluster II = 405.28;

III = 510.17 and IV = 655.56). The pairwise comparison showed that the largest organizations in terms of annual total revenue have a greater number of Facebook followers compared to organizations from all other groups ($p < 0.001$ for groups 2, 3 and 4, Bonferroni corrected significance level). The pairwise comparison also shows that the Facebook profiles of the smallest entities are clearly characterized by the lowest number of “followers”. It is lower, as compared not only to entities from cluster IV, but also from cluster II and III ($p < 0.001$ in each case). Differences in the average number of followers of the Facebook profile were also observed in the case of organizations from clusters II and III, in favor of the latter. The same results were obtained both for 2020 and 2021.

4.3. Impact of Content on the Public Level of Engagement

The research also took into consideration the impact of the Facebook content on the level of public engagement. The public’s response was measured by the number of likes, shares and comments for each post published by the organization at the time selected for analysis (the period before and during the COVID-19 pandemic).

The public reaction to the content was also analyzed with respect to the organization’s size measured by the level of total annual revenue. The average values for both periods are misleading (e.g. the number of likes for medium entities increased in February 2021 by over 50%, but the median decreased by 9%, from 24 to 22 likes). In the case of large and small entities, a similar situation was observed, although the increase in average values was clearly smaller, as compared to medium-sized entities. The smallest entities were the only exception, both the average and the median decreased in terms of likes. In the case of shares and comments, the median for both February 2020 and February 2021 remained practically the same, and only the average values were subject to certain fluctuations, due to extreme observations.

Kruskal-Wallis tests were carried out to verify the hypothesis regarding the influence of the size of an organization on the public response to the Facebook content. Due to extreme observations, the tests were additionally verified with the non-parametric median test. In 2020, the Kruskal-Wallis test confirmed that the number of likes, one of the types of public reaction, was influenced by the size of the examined entity ($(\chi^2(3) = 742.727, p < 0.001$; mean rank for cluster I = 3905.77; for cluster II = 4690.05; III = 6090.10; IV = 5786.69).

The pairwise comparison shows that the posts of the smallest entities are clearly characterized by the lowest number of likes, both in relation to large, medium and small entities ($p < 0.001$ in each case). The Facebook content of small entities was characterized by a smaller number of likes, as compared to medium and large entities ($p < 0.001$). The most compelling is the comparison of medium and large entities. Although the average

values indicate that the posts of large organizations are more often “liked” than the posts of medium-sized organizations (146.82 vs. 103.7), the tests indicate exactly the opposite situation. The posts of medium-sized entities were liked more often than those of large entities ($p = 0.002$, corrected by the Bonferroni method). Nonparametric median tests confirmed the Kruskal-Wallis tests ($(\chi^2(3) = 489.325, p < 0.001)$). Pairwise comparison also shows exactly the same relationships. The Kruskal-Wallis tests and non-parametric median tests were then performed for February 2021. The results were exactly the same as for 2020. No significant differences were observed between the pre-pandemic and its advanced phase.

The Kruskal-Wallis test showed that for the posts from February 2020, the size of the organization had an impact on the “shares” number ($\chi^2(3) = 430.583, p < 0.001$; mean rank for cluster I = 4407.53; II = 4745.62; III = 5851.50; IV = 5809.71). Again, posts by the smallest organizations are characterized by a smaller number of shares in comparison to posts published by medium, large and small organizations ($p < 0.001$, as compared to medium and large entities and $p = 0.002$ for small entities, significance corrected by the Bonferroni method). Posts of small entities were also shared, less frequently than posts of medium and large entities ($p < 0.001$). With regard to medium and large organizations, the average number of shares was the same. Nonparametric median tests confirmed the results of Kruskal-Wallis tests ($(\chi^2(3) = 338.200, p < 0.001)$, with one small difference. Posts of small entities were shared less often than posts of the smallest entities ($p = 0.035$). For February 2021, Kruskal-Wallis tests and non-parametric median tests were also carried out. The results were exactly the same as for 2020. In terms of the number of “shares” there were no significant differences between the pre-pandemic state and its advanced phase.

The Kruskal-Wallis test showed that for the posts from February 2020, the size of the organization had an impact on the “comments” number ($\chi^2(3) = 278.050, p < 0.001$; mean rank for cluster I = 4720.34; II = 4880.35; III = 5789.76; IV = 5491.53). The pairwise comparison produced very similar results to likes and shares. The posts of the smallest entities were commented on the least often, as compared to large and medium entities, but not small ones ($p = 0.386$). Posts of medium-sized entities were the most commented on, even when compared to large entities ($p = 0.001$). In turn, posts of small entities were commented on less often than posts of medium and large entities ($p < 0.001$ in both cases). Nonparametric median tests confirmed Kruskal-Wallis tests ($(\chi^2(3) = 226.226, p < 0.001)$, with one small difference. Posts of small entities were commented on to the same extent as posts of the smallest entities. Kruskal-Wallis tests and non-parametric median tests were then performed for February 2021. The results were exactly the same as for 2020, with one exception. Posts of the smallest entities, unlike in 2020, were commented on less often than the posts of small organizations ($p = 0.026$, corrected by the Bonferroni method).

5. Discussion

The hypothesis that the COVID-19 pandemic has had an impact on the publishing activity of non-profit organizations has only partially been positively verified. The number of posts published during the period of the “hard” lockdown remained basically at the same level as in the period just before the outbreak of the pandemic. On the one hand, someone may put forward an argument that the role of social media in the period of constricted face-to-face contact should be clearly greater, but on the other hand, the period of such drastic restrictions meant, for example, the inability to organize all kinds of charitable events and other events promoting professed values and ideals. This fact alone shows that an organization may have great difficulties with content on the social networking sites that is interesting from the public point of view. A similar situation was observed in studies of information dissemination strategies by organizations on Twitter during a crisis caused by a natural disaster (Liu et al., 2018). Moreover, the results indicate that the Facebook publication activity of Polish non-profit organizations was highly diversified. At the same time, those organizations that were active before the pandemic (at least 2 posts per day) also published a lot during the pandemic. This mainly applies to organizations related to ecology and animal protection; as well as the protection of natural heritage. This publication diversity has a number of practical implications. It also requires caution when making statistical conclusions. In the case, it is legitimate to take into account the median value when interpreting the results, and not only the arithmetic mean, which due to its stratification clearly differs from the median in terms of values. Despite statistical difficulties, the results make it relatively easy to identify a leading trend. The largest organizations in terms of total annual revenue were clearly more active on Facebook (they publish more content). As its level decreased, the publishing frequency level on the Facebook profile also diminished. Thus, the smallest entities were clearly characterized by the lowest publishing frequency activity. The largest increases in publication frequency activity during the pandemic (February 2021) were observed in the cluster of medium-sized entities, in the cluster of large entities, and especially in the case of small entities, they were clearly smaller. The worst case concerned the smallest entities, the publication frequency activity during the pandemic clearly decreased. The results indicate that the distance in this respect between medium and large entities, and small and especially the smallest entities is growing. For the latter, it means serious impediments in reaching the public with their message, which ultimately translates into a weaker financial result.

The hypothesis assuming that interest in the Facebook profile of public benefit organizations increased during the COVID-19 pandemic has been verified positively. The number of followers of the Facebook profile was

greater in all four clusters (the largest total increase concerned small entities, over 23%). However, there is one important fact one has to take into account. A person who follows a specific profile, at the time of its low or very low activity, will not simply receive notifications about the appearance of new content on it. Therefore, there is a minimal probability that this person will click the “unfollowing” button for that particular Facebook profile. The research results have proven it. Inactive profiles were followed by practically the same number of people both in February 2020 and February 2021. So if the increase in the number of followers in the analyzed sample was small and oscillated around 2–3%, hypothesis no. 2 should be rejected. The research results indicate that it was, however, clearly higher, hence the hypothesis was verified positively. The results also indicate that the size of the organization had a significant impact on the number of entities following the organization’s Facebook profile. The larger the entity, the greater this number (both in 2020 and 2021). There may be at least several reasons responsible for that. Firstly, large organizations can use both traditional forms of communication as well as the ones based in cyberspace or mobile devices in managing relationships with the public. Therefore, information about large non-governmental organizations may appear in the press, radio and television. In addition, they have a substantial enough budget to run billboard campaigns or leaflet campaigns concerning their main activities. Such activities make it easier for organizations of this size to remain in the awareness of the public as an entity, which effectively implements its mission, also attracting the people or other institutional entities to the Facebook profile. Secondly, they have access to qualified management staff or have a budget large enough to allow them to use the services of external entities in their public relations activities. The gained knowledge allows them to effectively expand the base of entities that follow their Facebook profile.

The third research hypothesis that posts during the pandemic were characterized by a higher level of engagement from their recipients should be rejected. A similar situation was observed in response to posts by non-profit organizations related to a crisis event not caused by the organization itself (Fortunato, 2018). Fortunato emphasizes that a successful crisis response doesn’t commence when a crisis first emerges. Instead, an organization must acquire essential capabilities well in advance of any potential crisis (for example the number of active followers). Therefore, in our own research, the audience’s response to content posted on the social media platform Facebook remained at a similar level as before the crisis caused by the Covid-19 pandemic. This is indicated not by the average values, which were distorted by extreme observations, but by the median values which, as compared to the pre-pandemic period, either remained at the same level (shares and comments), or slightly decreased, as in the case of likes. In addition, Facebook content was generally characterized by a low average number of likes, almost a five times lower average number of shares and

a ten times lower average number of comments (in the case of the median, the differences were even greater). The research results indicate that the majority of Facebook users of Polish non-profit organizations are passive recipients, and the pandemic did not affect their greater activity, despite such large restrictions in moving and remote types of work. A clearly greater number of likes on posts also indicates that the behavior of the recipient of the message sent by the organization may be characterized by an attitude, referred to as “slacktivism”. This notion refers to political or social activism that does not cause significant practical effects, but only contributes to the complacency of the person – the recipient of the message. The activities comprehended as “slacktivism” are usually very simple and do not require much commitment from the participants. For example, by clicking the “like” button on the Facebook profile of an organization, a recipient expresses their approval for a specific initiative, but his involvement is limited only to the action, without providing any real value to the organization. The benefit is only for the recipient of the message, complacency is what it meant to that person, and they got it in the simplest possible way. So “slacktivism” assumes that people who seemingly support the activities of an organization by performing very simple activities are not really committed and are not able to make sacrifices in order to achieve the desired results from an organizational point of view. Finally, it is worth mentioning that the size of an organization, measured by the level of total annual revenue, significantly influenced the level of audience engagement to the Facebook content. Medium and large entities clearly distanced small organizations and especially the smallest ones, in this respect. This was the case both in 2020 and 2021.

6. Conclusions

The cognitive gap that the article sought to bridge was both theoretical and practical in nature. The theoretical gap sought to explain the importance of contingency theory in crisis management through the adaptability of organizations to crisis conditions. The results indicate low adaptation of Polish public benefit organizations to the crisis situation in the area related to the utilization of Facebook. This article also comes with several managerial implications trying to answer the following question: How to cope with the altered operating conditions induced by Covid-19? One of the obvious answers seem to be: “tilize the potential of social media more intensively.” The results indicate that their potential has not been sufficiently exploited. This is all the more surprising given that at a time of such severe crisis organizations should have a well-thought-out crisis communication strategy that includes guidelines for social media use. The results of the study indicate that this was not the case. Organizations’ publication activity both before the pandemic and during the “hard” lockdown remained at

a comparable level. Besides crisis situations often evoke strong emotions in stakeholders. Managers handling social media communications must exhibit empathy and emotional intelligence in their interactions, showing concern and understanding for those affected. The results indicate, however, that the response to the content was at a comparable level both before and during the pandemic.

Nonetheless, the study encountered some limitations. Firstly, the research is limited to one social networking site – Facebook. Despite the clear Facebook prevalence in maintaining relationships with stakeholders, it would also be worth scrutinizing other social media sites (e.g. by comparative analysis). Moreover, the division into micro, small, medium and large organizations was made on the basis of only one parameter. It was the total annual revenue of the organization. Although this criterion reflects the size of the organization quite well, it could also be extended to other parameters (e.g. employment or type of non-profit activity) in the future.

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