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Innovation of Enterprises in Poland by Voivodeship in the Years 2018-2022

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Abstract:

Purpose: *The aim of the article is to analyze the innovativeness of service and industrial enterprises in Poland, cross-sectionally by voivodeships, in the years 2018-2022, using the TOPSIS method.*
Design/Methodology/Approach: *The literature review focuses, in particular, on the essence of innovation, factors influencing the level of innovation and the measurement of innovation. The analysis of the innovativeness of industrial and service enterprises in Poland by voivodeships, in the years 2018-2022, was carried out based on data from Statistics Poland. Four indicators were selected for the analysis of innovativeness, including: 2 input indicators and 2 output indicators. Based on the selected indicators, synthetic measures on the input and output side were calculated using the TOPSIS method, and then rankings of the innovativeness of industrial and service enterprises by voivodeships were prepared. Research methods such as literature review, variability analysis, Spearman's rank correlation, and TOPSIS method were used in the study.*
Findings: *The innovativeness of industrial and service enterprises in Poland by voivodeship can be measured using various measures. The measures based on inputs and outputs are worth noting in this respect, with the use of which synthetic measures were calculated using the TOPSIS methodand rankings were created. Based on the analyses conducted, it was found that in the groups of industrial and service enterprises, in the period 2018-2022, the share of innovation-active enterprises was significantly higher than the share of enterprises that incurred expenditures on R&D activities. In the period under review, a slight upward trend was also noticeable in the share of enterprises incurring R&D expenditures in both groups studied. Moreover, in the group of industrial enterprises there was a higher percentage of those that were innovation-active and those that incurred expenditure on R&D activities than in the group of service enterprises. The research indicates that the largest percentage of industrial and service enterprises introduced new or improved business processes in the 2018-2022 period. In turn, a much smaller percentage of enterprises were introducing new or improved products. The share of enterprises that introduced innovative products was higher in the group of inThalassinosdustrial enterprises than in the group of service enterprises. In 2020-2022, the share of service enterprises that introduced innovative business processes was higher than the share of industrial enterprises. It is worth noting that enterprises from a given voivodeship could occupy different places in the rankings in particular years, as well as according to inputs and outputs. The study also shows that there are very large application possibilities of multidimensional comparative analyses using*

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rankings in assessing the innovativeness of enterprises. Thanks to this, it is possible, among other things, to use the results of the analyses in various spheres of management.
Practical implications: *The Polish government can use the conclusions from the regional analysis of the innovativeness of industrial and service enterprises to allocate funds for programs supporting the innovativeness of enterprises in individual voivodeships. The authorities in these individual voivodeships can determine their position in the area of innovativeness in relation to other regions based on the rankings. On the other hand, enterprise managers can find the regions (voivodeships) most supportive of the innovativeness of enterprises based on the results obtained.*
Originality: *The originality manifests itself primarily in the comprehensiveness and scope of the research undertaken, in particular in the approach to the innovativeness of industrial and service enterprises across voivodeships, from the perspective of inputs and outputs, and the preparation of rankings on this basis using the TOPSIS method.*

Keywords: *Innovations, enterprise innovation, innovation measurement, voivodeships.*

Jel codes: *O30, O31, R59.*

Paper type: *Research article.*

1. Introduction

The economic development of countries is determined by many factors. They directly concern enterprises and the regions in which they operate. Thanks to these factors, it is possible, among others, for enterprises to create new jobs, to reduce the unemployment rate or to increase the wealth of society. In Poland, the key factors in this respect are: productivity, entrepreneurship and innovation (GUS, 2023a).

Due to the fact that there is a large variation in the economic development of regions, the enterprises located within them will also not develop in the same way. Differences in the development of enterprises from the same industries in different regions are observed.

Economic development in Poland is not evenly distributed across voivodeships (regions). There is considerable variation in this respect. This is confirmed by, among others, scientific research, which indicates that the level of economic development of voivodeships in Poland in 2010-2019 varied across voivodeships. The leader in the rankings in 2010–2019 was the Mazowieckie voivodeship. The lowest level of development was recorded in the following voivodeships: Lubelskie, Podlaskie, Warmińsko-Mazurskie and Świętokrzyskie (Bożek *et al.*, 2021).

The development of Polish enterprises is primarily related to pursuing and creating competitive advantages. This is caused by growing competition in the sectors (industries) in which these enterprises operate. The life cycles of products and technologies are also shortening. The struggle of enterprises for access to key resources and intellectual capital is also significant in this aspect. Achieving a competitive advantage in a given sector (industry) is mainly possible by incurring inputs for innovations (internal creation of innovations), building a long-term innovation management strategy and investing in innovations (purchasing innovation externally) in enterprises (Romanowska, 2016; Knauff, 2012).

The activity of enterprises related to innovation is determined by various factors. Researchers indicate the determinants of the innovativeness of Polish enterprises (Sopińska *et al.,* 2016). However, the question of how and with what metrics to measure the level of innovativeness of Polish enterprises remains open. In particular, this measurement is important in the cross-section of regions (voivodeships).

In this context, the aim of the article is to analyze the innovativeness of service and industrial enterprises in Poland, cross-sectionally by voivodeship, in the years 2018-2022, using the TOPSIS method.

2. Literature Review

2.1 Innovation Definition and Process

In theory, there are different approaches to defining innovation. Many researchers use a broad perception of innovation, where innovation is most often understood as creative changes, not only in the field of technology, but also in the social system, economic structure or nature (Sopińska *et al.*, 2016).

One of the key researchers representing a broad approach to innovation was J.A. Schumpeter. According to him, innovation is understood as the introduction of a new product or products with new properties to the market. Innovation also includes the introduction of a new production method and a new technological process. Innovation is also defined as the opening of a new sales market, gaining new sources of organization of an industry or the introduction of a new organization for an industry (Schumpeter, 1960; Havlicek *et al.,* 2013; Thalassinos and Berezkinova, 2013).

On the other hand, innovation in the narrow sense can be defined as the first commercial introduction and use of a product, process, system or device (Freeman, 1982; Tyagi *et al.,* 2023; Thalassinos, 2014).

Regardless of whether innovation is defined in a broad or narrow sense, its implementation in the enterprise should always result in an increase in efficiency at

the operational and/or strategic level. For this to occur, certain conditions for innovation must be met.

Innovation is not accidental, it requires a conscious effort, a new combination of several factors, such as: idea, knowledge, capabilities, skills and resources (Fagerberg, 2006). Innovation is not a single activity, but a process of interrelated sub-processes (Myers and Marquis, 1969). These sub-processes are divided into three main stages: invention, development, and implementation (Garud *et al.*, 2015).

Currently, the innovation process is very complex, rarely linear, in a sequence of elements of the "technology push" model (R&D, manufacturing, marketing, user) or "market pull" (marketing, R&D, manufacturing, user) (Trott, 2017). The innovation process cannot be effective without the appropriate exchange of information, both inside the company (e.g., marketing, production, research and development employees, management staff) and outside (e.g., customers, suppliers, competitors, scientific discoveries).

Thanks to interactions, it is possible to exchange thoughts, ideas and experiences that make up the "know how" of the company. It is necessary to build formal and informal information exchange channels constituting a structure, a network of cooperation, within which there is a continuous process of creating the "new", in which the entrepreneur plays key role. The innovation process is therefore cyclical, in which the main nodes are: market transitions, scientific exploration, technological research, product development, entrepreneurship (Berkhout *et al.*, 2010, Trott, 2017), and the mutual interaction of its various elements is continuous, variable and multidirectional, and therefore it cannot be left unattended and requires management (Dodgson, 2023). Success is not possible without skillful management.

In an increasingly complex environment, with growing knowledge resources, increased competition and a huge variety of consumer requirements, specialization in action is a necessity. In such conditions, the innovation process (from idea to realization through to implementation) requires processing more and more input data, consumes more and more diverse resources, which ultimately translates into the need to commit more and more money. For this reason, innovation is inextricably linked to cooperation, not only within an organization, but also between organizations. As Trott notes, innovations have become a team game, not only of people but also of organizations (Trott, 2017).

In a sense, enterprise innovation means the continuous search for and practical use of scientific research results, business ideas or inventions. This is related to the continuous improvement of existing solutions and the creation of new ones that can be implemented in the operations of enterprises. This directly affects the competitive position of enterprises and the development of the regions in which they are located (Dolińska, 2010). In this context, innovation can be understood as the ability to constantly seek, implement and disseminate innovations (Golińska – Pieszyńska,

2011). These innovations may concern products, processes, organizational solutions or marketing (GUS, 2020; 2023b).

For many years, researchers have been trying to determine the factors influencing innovation, located in the organization or its environment, in order to be able to influence it in a way that allows obtaining the appropriate effects. Factors shaping innovation include, long-term orientation, public expenditures on education, democracy level, the inflows of foreign direct investment, entrepreneurial activity (López-Cabarcos *et al.*, 2021), R&D investment, human capital, social freedom, globalization, country affluence (Ding, 2022), trust (Bischoff *et al.*, 2023), innovative spirit (Yin *et al.*, 2023), authentic leadership (Huang, 2017).

Taking into account the specificity of Polish enterprises, many researchers indicate various factors influencing their level of innovativeness. External and internal factors are distinguished. Among the external determinants, attention should be paid to (Romanowska, 2016):

- direct impact factors such as: tax breaks, preferential loans, financing of innovative enterprise projects,
- indirect impact factors which include: education, science, research and implementation facilities, the tax system, law, the credit system, the efficiency of local and central government administration, freedom of economic activity,
- sectoral factors, such as: intensity of competition in the sector, importance of technological change, internationalization of the sector.

The level of innovation in Polish enterprises is also influenced by internal factors. The key factors in this respect include the creativity of employees and top management, the work of their own research and development facilities, leadership style, organizational culture, teamwork and the quality of resources (Radomska, 2015).

2.2 Measuring Innovation

Measuring innovation is important because it enables striving to achieve the intended results, efficient allocation of resources, increasing productivity, directing efforts to the right areas (Pokala, 2023), tracking changes, and measuring inputs and effects.

Björk, Frishammar and Sundström (2023) have developed 9 lessons to help enterprises create and improve their innovation measurement system. In short, they contain the following guidelines (Björk *et al.*, 2023):

1. the starting point for creating an innovation measurement system should be the development strategy;

2. the measurement system should take into account the role of partners in innovation processes;
3. clearly define who is responsible for the measurement and results;
4. participants in the innovation process should understand mutual relations, interdependencies and jointly agree on the scope of their duties and responsibilities;
5. measuring innovation should enable not only planning, implementation and evaluation, but also learning from experience and identifying new opportunities;
6. too much concentration on measures that are familiar and easy, but not necessarily useful, should be avoided, and one should strive to measure what is really important;
7. the number of metrics should not be too large, but should be known and understood, and also manageable;
8. measures of innovation should be selected in such a way as to be able to assess the whole, not just individual stages or elements;
9. interdependencies between measures should be clear and understandable, and contradictions should be eliminated.

The measurement of innovation in the economy should provide information that may be useful in the development and implementation of policy actions, verification, testing and improvement of the theory of innovation, and helpful to enterprises and other institutions in developing their own innovation strategies (Arundel *et al.*, 1998).

Innovation measures can be divided into the following groups: inputs, processes, outputs (Anthony *et al.*, 2008; Davila *et al.*, 2012).

Examples of input measures include: expenditures on R&D activity, expenditures on innovation activity, acquisition of technology, expenditures associated with the launch of new or changed products.

Output measures may include, the following: increase in profits, share of revenues from innovation in total revenues, decrease in costs, the number of new and/or improved products, processes.

In Poland, Statistics Poland, in accordance with the methodology set out in the Oslo Manual, adopted a certain catalog of measures by means of which it is possible to measure the innovativeness of enterprises. According to this approach, the following are distinguished (GUS 2020; OECD 2018):

- indicators of the occurrence and characteristics of innovations (for example: the share of enterprises with one or more types of product innovation, the share of enterprises with at least one innovation of any type, or the share of enterprises conducting sustainable innovation activities);

- indicators of innovation-based capital activities (for example: total expenditure on knowledge-based capital activities incurred for innovation purposes, number of innovation projects or share of enterprises planning to increase (reduce) their innovation expenditure in the current period);
- indicators of probable or actual innovation potential (for example: share of enterprises using various types of intellectual property rights, share of enterprises using advanced supporting or emerging technologies, or share of enterprises using advanced digital tools and methods);
- indicators of knowledge and innovation flows (for example: the share of enterprises that have cooperated with other parties in the field of innovation activities, the share of enterprises conducting licensing activities or the share of enterprises reporting barriers in contacts with other parties in the process of generating or exchanging knowledge);
- indicators of external factors influencing innovation (for example: the share of enterprises selling products on international markets, the share of enterprises that received public funding for the development or use of innovations, or the share of enterprises reporting selected items as barriers to innovation);
- indicators of innovation goals and effects (for example: share of turnover from product innovations and product innovations new to the market, number of new products – median and average, or share of enterprises achieving a given goal thanks to their innovation activities).

Measuring innovation is difficult, owing to its nature. The innovation process is a complex activity, often involving the entire organization, the essence of which is to create novelties, based on knowledge, experience and cooperation. Hence, many innovative activities are immeasurable or not directly measurable. Moreover, when measuring complex activities, indicators can provide simplified and summary information that will reflect a certain range of them, but are unable to capture the essence of the phenomenon (Arundel *et al.*, 1998). However, the measurement of innovation is possible, although ambiguous, and the selection of a set of measures is made on the basis of the "best possible" (Klóska, 2018).

3. Research Design and Methodology

The study of innovation of industrial and service enterprises by voivodeships in Poland, in the years 2018-2022, was conducted based on data from Statistics Poland. Four indicators were selected for the analysis of innovation, including: 2 input indicators and 2 output indicators.

The input indicators are:

- Share of innovation-active enterprises in total enterprises (%),
- Share of enterprises which incurred expenditure on R&D activity in total enterprises (%).

The output indicators are:

- Share of enterprises that introduced new or improved products in total enterprises (%),
- Share of enterprises that introduced new or improved business processes in total enterprises (%).

The selection of indicators for the study was determined by their importance in measuring innovation and the availability of comparable data across voivodeships and industrial and service enterprises.

The selected indicators were subjected to variability analysis and Spearman's rank correlation analysis (to eliminate indicators that are too correlated).

Based on the selected indicators, synthetic measures for inputs and outputs were calculated using the TOPSIS method, and then rankings of the innovativeness of industrial and service enterprises by voivodeship were prepared.

In addition, the values of individual innovation indicators of industrial and service enterprises in 2018-2022 are presented in tables and figures to enable an appreciation of the trend of changes. However, this data is presented only at the level of Poland, and not by voivodeships, due to their excessive number.

Research methods such as literature review, variability analysis, Spearman's rank correlation, and TOPSIS method are used in the study.

4. Research Results

4.1 Industrial and Service Enterprises – Input Indicators

Innovation-active enterprises include those that introduced at least one innovation or implemented an innovation project in the period under review. The implementation of an innovation project in the period under review may not have been completed, may have been abandoned or may have ended in failure (Statistics Poland, 2022).

Expenditures on R&D as part of innovation activities includes research and development related to the development of new or improved products and business processes, performed by in-house development facilities or acquired from other units (Statistics Poland, 2022).

It is worth noting that not all enterprises that incur expenditure on innovation activities also incur expenditure on R&D activities. Research and development is one of the very important elements of the innovation process, but it is not essential.

Data on industrial and service enterprises active in innovation and those incurring expenditure on R&D are presented in Table 1 and Figure 1.

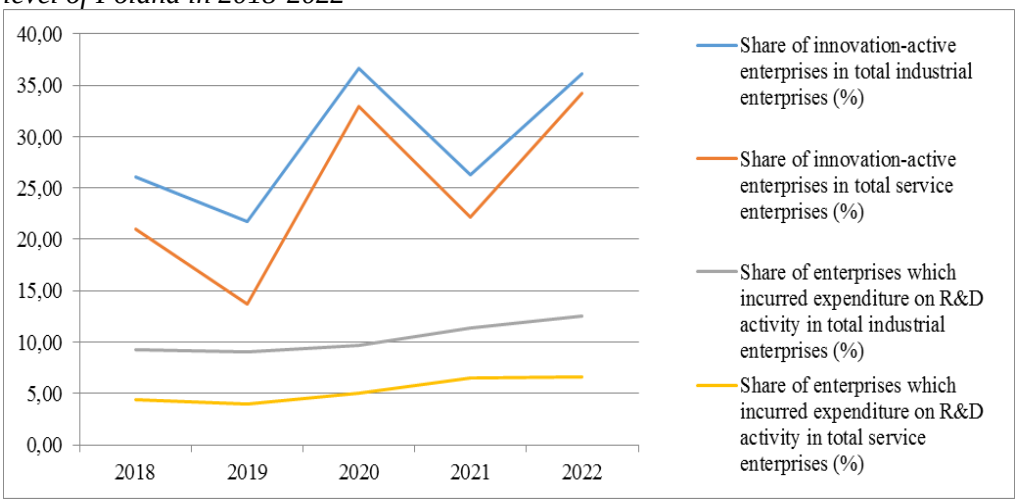
Table 1. *Values of input indicators in the industrial and service enterprises at the level of Poland in 2018-2022*

Input indicators	**2018**	**2019**	**2020**	**2021**	**2022**
Share of innovation-active enterprises in total industrial enterprises (%)*	26.10	21.70	36.70	26.30	36.10
Share of innovation-active enterprises in total service enterprises (%)*	21.00	13.70	33.00	22.20	34.20
Share of enterprises which incurred expenditure on R&D activity in total industrial enterprises (%)	9.30	9.00	9.70	11.40	12.50
Share of enterprises which incurred expenditure on R&D activity in total service enterprises (%)	4.40	4.00	5.00	6.50	6.60

Note: *Data for 2018 refers to enterprises which were innovation-active in 2016-2018; data for 2019 refers to enterprises which were innovation-active in 2017-20219; data for 2020 refers to enterprises which were innovation-active in 2018-2020; data for 2021 refers to enterprises which were innovation-active in 2019-2021; data for 2022 refers to enterprises which were innovation-active in 2020-2022.*

Source: *Own study based on data from Statistics Poland.*

Figure 1. *Values of input indicators in the industrial and service enterprises at the level of Poland in 2018-2022*



Source: *Own study based on data from Statistics Poland.*

The data in Table 1 and Figure 1 demonstrate that the share of innovation-active enterprises is higher in industrial enterprises than in service enterprises, although these differences decrease over the years 2018-2022.

In 2019, the difference in the share of innovation-active enterprises between industrial and service enterprises was 8% (industrial 21.70%, service 13.70%), while in 2022 it was only about 2% (industrial 36.10%, service 34.20%). Despite the

fluctuations, a clear upward trend can be seen in the share of innovation-active enterprises among both industrial and service enterprises.

In both groups of surveyed enterprises, the share of those that incurred expenditures on R&D activities is definitely smaller than that of those that are innovation active. In the years 2018-2022, a stable, albeit small, growing trend can be observed in the share of enterprises incurring expenditures on R&D. Interestingly, the difference between the share of industrial and service enterprises incurring expenditures on R&D in the years 2018-2022 remains at a similar level, amounting to approximately 5% - 6%.

4.2 Industrial and Service Enterprises – Outputs Indicators

Enterprise that introduced at least one business innovation in the period under review is considered innovative enterprise. A business innovation is a new or improved product or business process (or a combination of them) that differs significantly from previous ones and that has been introduced to the market or put into use by the enterprise. A product should be understood as a product or service, or a combination of them. On the other hand, business processes include all the basic activities of the company related to the production of products and all activities of an auxiliary and supporting nature (OECD, 2018).

Table 2 and Figure 2 contain data on business innovations introduced by industrial and service enterprises in 2018-2022.

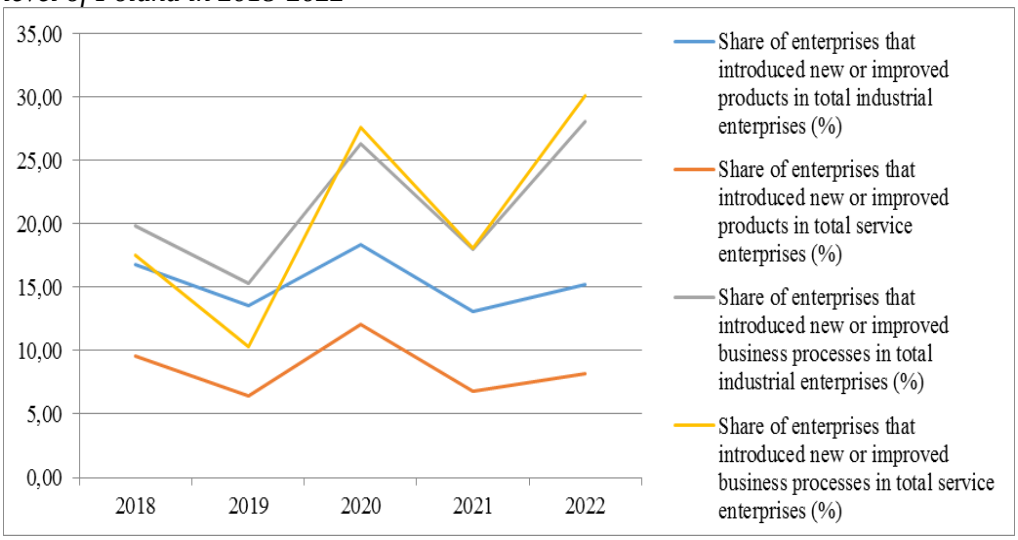
Table 2. *Values of output indicators in the industrial and service enterprises at the level of Poland in 2018-2022*

Output indicators	**2018**	**2019**	**2020**	**2021**	**2022**
Share of enterprises that introduced new or improved products in total industrial enterprises (%)*	16.80	13.60	18.40	13.10	15.20
Share of enterprises that introduced new or improved products in total service enterprises (%)*	9.60	6.40	12.10	6.80	8.20
Share of enterprises that introduced new or improved business processes in total industrial enterprises (%)*	19.90	15.30	26.30	18.00	28.10
Share of enterprises that introduced new or improved business processes in total service enterprises (%)*	17.50	10.30	27.60	18.10	30.10

Note: *Data for 2018 refers to enterprises that introduced innovations in 2016-2018; data for 2019 refers to enterprises that introduced innovations in 2017-20219; data for 2020 refers to enterprises that introduced innovations in 2018-2020; data for 2021 refers to enterprises that introduced innovations in 2019-2021; data for 2022 refers to enterprises that introduced innovations in 2020-2022.*

Source: *Own study based on data from Statistics Poland.*

Figure 2. *Values of output indicators in the industrial and service enterprises at the level of Poland in 2018-2022*



Source: *Own study based on data from Statistics Poland.*

The largest percentage of enterprises, both service and industrial, introduced new or improved business processes, while significantly fewer introduced new or improved products.

In the analyzed period, the shares of enterprises introducing innovations are unstable, alternately decreasing in one year and increasing in the next. The greatest variability can be observed in enterprises from the service sector introducing business processes, which is also visible in Figure 2. Despite significant fluctuations in the shares of enterprises introducing innovative business processes, a clear upward trend can be observed, both among industrial and service enterprises.

In service enterprises, the largest share is that of those that introduced new or improved business processes, the minimum value is in 2019 and amounted to 10.30%, and the maximum is 30.10% and occurred in 2022.

The situation is similar in industrial enterprises, i.e. the largest percentage of enterprises introduced new or improved business processes, the minimum value is in 2019 and amounts to 15.30%, and the maximum is 28.10% and occurs in 2022.

The share of industrial enterprises introducing innovative products ranges between 13.10% (minimum in 2021) and 18.40% (maximum in 2020). In the group of service enterprises, these values are 6.40% (minimum in 2019) and 12.10% (maximum in 2020), respectively. Interestingly, the trend of changes in the percentage of enterprises introducing innovative products is slightly downward, in contrast to the

introduction of innovative business processes, where a clear upward trend is observed.

4.3 Enterprise Innovation Rankings by Voivodeship

The TOPSIS method enables linear ordering of the objects of analysis and their evaluation by means of a synthetic measure. The synthetic measure reflects the distance of the analysis object from two reference points, i.e. the ideal reference point (Positive Ideal Solution) and the anti-ideal reference point (Negative Ideal Solution). The synthetic measure takes values from 0 to 1, and the higher its value, the better the given analysis object should be evaluated (Bąk 2016; Effatpanah *et al.*, 2022). The calculation of the synthetic measure value in the TOPSIS method is performed according to specific rules, which have been described in many pieces of literature (Hwang and Yoon, 1981; Effatpanah *et al.*, 2022; Pardede *et al. 2023,* Konuk, 2018, Acar and Sariyer, 2021; Bąk, 2016).

In the study, the TOPSIS method is used to prepare a ranking of the innovativeness of industrial and service enterprises by voivodeships in Poland in the years 2018-2022. In this context, the calculation of synthetic measures of objects (enterprises in the cross-section of voivodeships) is carried out in the following stages:

Stage 1: Preparation of decision matrices:

$$X = [x_{ij}]_{nxm}; i = 1,2, \dots n; j = 1,2, \dots, m \quad (1)$$

where n = 16 (number of voivodeships in Poland), m = 2 (number of input or output indicators).

Input indicators are:

- Share of innovation-active enterprises in total enterprises (%),
- Share of enterprises which incurred expenditure on R&D activity in total enterprises (%).

Output indicators are:

- Share of enterprises that introduced new or improved products in total enterprises (%),
- Share of enterprises that introduced new or improved business processes in total enterprises (%).

Decision matrices are prepared separately for industrial and service enterprises, inputs and outputs, and 5 years covered by the analysis. A total of 20 decision matrices are prepared.

Stage 2: Preparation of normalized decision matrices:

$$R = [r_{ij}]_{nxm} \tag{2}$$

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \tag{3}$$

Stage 3: Calculation of weighted normalized decision matrices:

$$V = [v_{ij}]_{nxm} \tag{4}$$

$$v_{ij} = w_j * r_{ij} \tag{5}$$

w_j – weight of *j* criterion, $\sum_{j=1}^{m} w_j = 1$

It is assumed that all the meters have the same weights, so each input and output indicators are assigned a weight of 0.5.

Stage 4: Determining the coordinates of the ideal reference point and anti-ideal reference point:

$$v_j^+ = \begin{cases} max_i \{v_{ij}\} \; for \; stimulants \\ min_i \{v_{ij}\} \; for \; destimulants \end{cases} \tag{6}$$

$$v_j^- = \begin{cases} min_i \{v_{ij}\} \; for \; stimulants \\ max_i \{v_{ij}\} \; for \; destimulants \end{cases} \tag{7}$$

All input and output indicators are considered as stimulants (the higher their value, the better).

Stage 5: Calculating the Euclidean distance from the ideal reference point and anti-ideal reference point:

$$D_i^+ = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^+)^2} \tag{8}$$

$$D_i^- = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^-)^2} \tag{9}$$

Stage 6: Calculation of the synthetic measure for each object:

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{10}$$

$$0 \leq D_i \leq 1$$

Stage 7: Preparation of rankings of industrial and service enterprises by voivodeships (separately for each year covered by the study), by arranging them according to decreasing values of the synthetic measure (C_i).

A total of 20 rankings are prepared, the results of which are presented in Tables 3 through 8.

Based on the data contained in Tables 3 through 5, it is possible to assess the level of innovation of industrial enterprises, by voivodeship, in the years 2018-2022, for both inputs and outputs.

Table 3. *Innovation rankings of industrial enterprises by voivodeships, according to inputs, in 2018-2022*

VOIVODESHIPS	2018		2019		2020		2021		2022	
	Ci	Rank	Ci	Rank	Ci	Rank	Ci	Rank	Ci	Rank
DOLNOŚLĄSKIE	0.3930	8	0.6423	5	0.6392	4	0.4781	10	0.7577	4
KUJAWSKO-POMORSKIE	0.4174	7	0.4321	8	0.1883	14	0.4868	9	0.6708	7
LUBELSKIE	0.6276	3	0.3814	12	0.4609	8	0.6268	5	0.7909	1
LUBUSKIE	0.2735	14	0.3113	13	0.0125	16	0.1142	15	0.4627	12
ŁÓDZKIE	0.2802	13	0.4077	10	0.4169	9	0.4229	12	0.5364	10
MAŁOPOLSKIE	0.4480	6	0.4892	6	0.7915	3	0.6703	3	0.5731	8
MAZOWIECKIE	0.7049	2	0.6717	4	0.5834	6	0.9008	2	0.7902	2
OPOLSKIE	0.5175	4	0.6897	3	0.1109	15	0.4909	8	0.5696	9
PODKARPACKIE	1.0000	1	0.8847	2	0.9218	1	0.9798	1	0.7283	5
PODLASKIE	0.3058	12	1.0000	1	0.8742	2	0.6309	4	0.7665	3
POMORSKIE	0.3767	10	0.4228	9	0.6009	5	0.5077	7	0.7114	6
ŚLĄSKIE	0.4842	5	0.4487	7	0.4638	7	0.4677	11	0.5250	11
ŚWIĘTOKRZYSKIE	0.3902	9	0.3005	15	0.2059	13	0.5744	6	0.1311	16
WARMIŃSKO-MAZURSKIE	0.2259	15	0.3008	14	0.3087	11	0.3374	13	0.2346	14
WIELKOPOLSKIE	0.3165	11	0.4031	11	0.3856	10	0.2713	14	0.3940	13
ZACHODNIOPOMORSKIE	0.0811	16	0.0000	16	0.2904	12	0.0000	16	0.1452	15

Source: *Own study based on data from Statistics Poland.*

Table 4. *Innovation rankings of industrial enterprises by voivodeships, according to outputs, in 2018-2022*

VOIVODESHIPS	2018		2019		2020		2021		2022	
	Ci	Rank	Ci	Rank	Ci	Rank	Ci	Rank	Ci	Rank
DOLNOŚLĄSKIE	0.2684	11	0.3907	8	0.5240	8	0.4537	7	0.6312	4
KUJAWSKO-POMORSKIE	0.4145	8	0.2614	13	0.1621	14	0.3025	12	0.5995	6
LUBELSKIE	1.0000	1	0.3808	10	0.7740	2	0.4286	9	0.4969	10
LUBUSKIE	0.4468	7	0.1776	15	0.1443	15	0.2372	15	0.3312	14
ŁÓDZKIE	0.2642	13	0.4715	6	0.4803	9	0.2564	14	0.6155	5

MAŁOPOLSKIE	0.3790	9	0.5382	5	0.7372	4	0.5509	3	0.3833	13
MAZOWIECKIE	0.7655	3	0.6224	2	0.5805	7	0.4735	5	0.5928	7
OPOLSKIE	0.4732	6	0.5833	4	0.3856	12	0.4202	10	0.5696	9
PODKARPACKIE	0.9427	2	1.0000	1	0.7613	3	0.8717	1	0.8822	1
PODLASKIE	0.2238	14	0.6151	3	0.7893	1	0.6379	2	0.8192	2
POMORSKIE	0.6648	4	0.2068	14	0.4313	11	0.4654	6	0.6970	3
ŚLĄSKIE	0.5916	5	0.3636	11	0.6223	6	0.4430	8	0.5902	8
ŚWIĘTOKRZYSKIE	0.2171	16	0.2980	12	0.0649	16	0.2661	13	0.0739	16
WARMIŃSKO-MAZURSKIE	0.2658	12	0.3904	9	0.3254	13	0.5006	4	0.4061	12
WIELKOPOLSKIE	0.2205	15	0.4185	7	0.6707	5	0.3094	11	0.4214	11
ZACHODNIOPOMORSKIE	0.2709	10	0.0000	16	0.4623	10	0.0532	16	0.2343	15

Source: *Own study based on data from Statistics Poland.*

Table 5. *Summary of innovation rankings of industrial enterprises by voivodeships, according to inputs and outputs*, in 2018-2022*

VOIVODESHIPS	**2018**		**2019**		**2020**		**2021**		**2022**	
	IN	**OUT**	**IN**	**OUT**	**IN**	**OUT**	**IN**	**OUT**	**IN**	**OUT**
DOLNOŚLĄSKIE	8	11	5	8	4	8	10	7	4	4
KUJAWSKO-POMORSKIE	7	8	8	13	14	14	9	12	7	6
LUBELSKIE	3	1	12	10	8	2	5	9	1	10
LUBUSKIE	14	7	13	15	16	15	15	15	12	14
ŁÓDZKIE	13	13	10	6	9	9	12	14	10	5
MAŁOPOLSKIE	6	9	6	5	3	4	3	3	8	13
MAZOWIECKIE	2	3	4	2	6	7	2	5	2	7
OPOLSKIE	4	6	3	4	15	12	8	10	9	9
PODKARPACKIE	1	2	2	1	1	3	1	1	5	1
PODLASKIE	12	14	1	3	2	1	4	2	3	2
POMORSKIE	10	4	9	14	5	11	7	6	6	3
ŚLĄSKIE	5	5	7	11	7	6	11	8	11	8
ŚWIĘTOKRZYSKIE	9	16	15	12	13	16	6	13	16	16
WARMIŃSKO-MAZURSKIE	15	12	14	9	11	13	13	4	14	12
WIELKOPOLSKIE	11	15	11	7	10	5	14	11	13	11
ZACHODNIOPOMORSKIE	16	10	16	16	12	10	16	16	15	15

Note: ** IN – ranking for inputs (marked in blue), OUT – ranking for outputs (marked in green).*

Source: *Own study based on data from Statistics Poland.*

In attempting to discern certain general trends, it can be noticed that the top positions in almost all the years analyzed, both in terms of inputs and outputs, are occupied by, among others, industrial enterprises from the Podkarpackie and Mazowieckie voivodeships. However, the last places in the ranking are often occupied by, among others, enterprises from the Zachodniopomorskie and Lubuskie voivodeships.

Based on the data contained in Tables 6 through 8, the level of innovation of service enterprises can be assessed, by voivodeship, in the years 2018-2022, for both inputs and outputs.

Table 6. *Innovation rankings of service enterprises by voivodeships, according to inputs, in 2018-2022*

VOIVODESHIPS	2018		2019		2020		2021		2022	
	Ci	Rank	Ci	Rank	Ci	Rank	Ci	Rank	Ci	Rank
DOLNOŚLĄSKIE	0.5617	5	0.7920	4	0.4722	7	0.9053	1	0.6256	4
KUJAWSKO-POMORSKIE	0.5717	4	0.2119	12	0.7646	2	0.2988	10	0.3067	11
LUBELSKIE	0.5026	6	0.1221	14	0.5080	6	0.2286	12	0.1397	14
LUBUSKIE	0.1113	15	0.0670	16	0.0205	16	0.1998	14	0.0628	15
ŁÓDZKIE	0.1081	16	0.6279	5	0.3771	11	0.5965	6	0.4214	8
MAŁOPOLSKIE	0.7650	2	0.9462	1	0.8180	1	0.8096	3	0.5206	7
MAZOWIECKIE	1.0000	1	0.8085	3	0.7386	3	0.8483	2	0.5893	6
OPOLSKIE	0.3505	11	0.3527	10	0.3637	12	0.0884	15	0.3244	9
PODKARPACKIE	0.3954	9	0.5982	7	0.4190	9	0.7208	4	0.9245	1
PODLASKIE	0.3860	10	0.1047	15	0.3908	10	0.6983	5	0.3174	10
POMORSKIE	0.7545	3	0.8838	2	0.6244	5	0.5333	9	0.6005	5
ŚLĄSKIE	0.4678	7	0.5148	9	0.4230	8	0.5472	8	0.7056	3
ŚWIĘTOKRZYSKIE	0.1245	13	0.1669	13	0.2208	13	0.0291	16	0.2784	12
WARMIŃSKO-MAZURSKIE	0.1155	14	0.6178	6	0.6972	4	0.5738	7	0.0421	16
WIELKOPOLSKIE	0.3238	12	0.5148	8	0.2054	15	0.2960	11	0.2423	13
ZACHODNIOPOMORSKIE	0.4253	8	0.2137	11	0.2105	14	0.2114	13	0.7787	2

Source: *Own study based on data from Statistics Poland.*

Table 7. *Innovation rankings of service enterprises by voivodeships, according to outputs, in 2018-2022*

VOIVODESHIPS	2018		2019		2020		2021		2022	
	Ci	Rank	Ci	Rank	Ci	Rank	Ci	Rank	Ci	Rank
DOLNOŚLĄSKIE	0.8772	2	0.7420	4	0.4008	10	0.7041	3	0.5521	6
KUJAWSKO-POMORSKIE	0.5942	5	0.3912	11	0.3621	11	0.2400	12	0.3159	11
LUBELSKIE	0.3203	11	0.2296	12	0.4051	9	0.3731	10	0.4276	8
LUBUSKIE	0.2229	13	0.2284	13	0.0000	16	0.1989	13	0.1412	16
ŁÓDZKIE	0.1312	14	0.5495	8	0.5365	5	0.5828	4	0.1434	15
MAŁOPOLSKIE	0.6038	4	0.9734	1	0.7113	4	0.4506	9	0.3375	10
MAZOWIECKIE	0.9080	1	0.8708	2	0.9409	1	0.7381	2	0.5788	5
OPOLSKIE	0.4131	10	0.1888	14	0.3450	12	0.1200	14	0.3427	9
PODKARPACKIE	0.2801	12	0.6881	6	0.3035	13	0.5131	5	1.0000	1
PODLASKIE	0.4800	7	0.0000	16	0.4240	8	0.4932	7	0.2826	12
POMORSKIE	0.6719	3	0.7459	3	0.7264	3	0.4757	8	0.4736	7
ŚLĄSKIE	0.4361	9	0.5408	9	0.4343	7	0.5073	6	0.5857	4
ŚWIĘTOKRZYSKIE	0.0190	16	0.1789	15	0.2921	14	0.0811	16	0.6311	3
WARMIŃSKO-MAZURSKIE	0.0930	15	0.7162	5	0.7967	2	0.8934	1	0.1476	14
WIELKOPOLSKIE	0.4497	8	0.6557	7	0.2865	15	0.3290	11	0.2723	13
ZACHODNIOPOMORSKIE	0.4909	6	0.4220	10	0.4930	6	0.0876	15	0.6846	2

Source: *Own study based on data from Statistics Poland.*

Table 8. *Summary of innovation rankings of service enterprises by voivodeships, according to inputs and outputs*, in 2018-2022*

VOIVODESHIPS	2018		2019		2020		2021		2022	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
DOLNOŚLĄSKIE	5	2	4	4	7	10	1	3	4	6

KUJAWSKO-POMORSKIE	4	5	12	11	2	11	10	12	11	11
LUBELSKIE	6	11	14	12	6	9	12	10	14	8
LUBUSKIE	15	13	16	13	16	16	14	13	15	16
ŁÓDZKIE	16	14	5	8	11	5	6	4	8	15
MAŁOPOLSKIE	2	4	1	1	1	4	3	9	7	10
MAZOWIECKIE	1	1	3	2	3	1	2	2	6	5
OPOLSKIE	11	10	10	14	12	12	15	14	9	9
PODKARPACKIE	9	12	7	6	9	13	4	5	1	1
PODLASKIE	10	7	15	16	10	8	5	7	10	12
POMORSKIE	3	3	2	3	5	3	9	8	5	7
ŚLĄSKIE	7	9	9	9	8	7	8	6	3	4
ŚWIĘTOKRZYSKIE	13	16	13	15	13	14	16	16	12	3
WARMIŃSKO-MAZURSKIE	14	15	6	5	4	2	7	1	16	14
WIELKOPOLSKIE	12	8	8	7	15	15	11	11	13	13
ZACHODNIOPOMORSKIE	8	6	11	10	14	6	13	15	2	2

Note: ** IN – ranking for inputs (marked in blue), OUT – ranking for outputs (marked in green).*
Source: *Own study based on data from Statistics Poland.*

In the case of service enterprises, the top positions in almost all the years analyzed, both for inputs and outputs, are occupied by, among other, enterprises from the Mazowieckie (although there is a significant drop in the rankings in 2022), Małopolskie and Dolnośląskie voivodeships. On the other hand, the last places in the ranking are often occupied by, among others, enterprises from the Lubuskie, Świętokrzyskie and Wielkopolskie voivodeships.

5. Conclusions

The innovativeness of industrial and service enterprises across Polish voivodeships can be measured using various indicators. Measures based on inputs and outputs are particularly noteworthy in this respect.

For the purposes of this study, the input indicators selected are:

- Share of innovation-active enterprises in total enterprises (%),
- Share of enterprises which incurred expenditure on R&D activity in total enterprises (%).

When measuring outputs, the focus is on indicators:

- Share of enterprises that introduced new or improved products in total enterprises (%),
- Share of enterprises that introduced new or improved business processes in total enterprises (%).

The factors that influenced the choice of these specific indicators were mainly related to their importance in measuring innovation as well as limitations in the availability of Statistics Poland data on industrial and service enterprises across voivodeships.

Based on the analyses conducted, it was found that in the groups of industrial and service enterprises, in the period 2018-2022, the share of innovation-active enterprises was significantly higher than the share of enterprises that incurred expenditures on R&D activities. In the period under review, a slight upward trend was also noticeable in the share of enterprises incurring R&D expenditures in both groups studied. Moreover, in the group of industrial enterprises there was a higher percentage of those that were innovation-active and those that incurred expenditure on R&D activities than in the group of service enterprises.

The research indicates that the largest percentage of industrial and service enterprises were introducing new or improved business processes in the 2018-2022 period. In turn, a much smaller percentage of enterprises were introducing new or improved products. The share of enterprises that introduced innovative products was higher in the group of industrial enterprises than in the group of service enterprises. In 2020-2022, the share of service enterprises that introduced innovative business processes was higher than the share of industrial enterprises.

Based on selected partial measures (2 input indicators and 2 output indicators), synthetic measures for inputs and outputs were calculated. The TOPSIS method was used for this purpose. Innovation rankings of industrial and service enterprises by voivodeships in 2018-2022 were created (separately in terms of inputs and outputs; inputs and outputs were not combined into one synthetic measure).

In the period 2018-2022, industrial enterprises from the Podkarpackie and Mazowieckie voivodeships were very high in the rankings according to inputs. On the other hand, industrial enterprises from the Zachodniopomorskie, Lubuskie and Świętokrzyskie voivodeships were doing very poorly. In the rankings with respect to outputs, enterprises from the Podkarpackie and Mazowieckie voivodeships were very high, while those from the Zachodniopomorskie, Lubuskie and Świętokrzyskie voivodeships were very poorly presented. Taking into account both inputs and outputs, it can be seen that the leading places in almost all the years analyzed were occupied by industrial enterprises from the Podkarpackie and Mazowieckie voivodeships. On the other hand, the last places in the ranking were often occupied by enterprises from the Zachodniopomorskie and Lubuskie voivodeships.

Among service enterprises, in the period 2018-2022, those from the following voivodeships were very high in the rankings according to inputs: Mazowieckie, Małopolskie, Dolnośląskie and Pomorskie. Enterprises from the following voivodeships were doing very poorly, Lubuskie and Wielkopolskie. On the other hand, service enterprises from the Mazowieckie voivodeship were very high in the

rankings according to outputs, while those from the Lubuskie and Świętokrzyskie voivodeships were doing very poorly. Taking into account both inputs and outputs, the highest positions in almost all the years analyzed were occupied by, among others, service enterprises from the Mazowieckie, Małopolskie and Dolnośląskie voivodeships. On the other hand, the last places in the ranking were often occupied by, among others, enterprises from the Lubuskie, Świętokrzyskie and Wielkopolskie voivodeships.

It is worth noting that enterprises from a given voivodeship could occupy different places in the rankings in particular years, as well as according to inputs and outputs.

The study also shows that there are great opportunities to conduct multidimensional comparative analyses using rankings in assessing the innovativeness of enterprises. This makes it possible to use the results of analyses in various areas of management.

The Polish government can capitalize on the conclusions from the regional innovation analysis of industrial and service enterprises to allocate funds for innovation support programs in individual voivodeships (establishment of approprations in budgets).

The authorities of individual voivodeships can use the rankings to determine their position in the area of enterprise innovation relative to other regions – conducting so-called external benchmarking and comparing themselves to the leader.

Based on the rankings, business managers can locate regions (voivodeships) that best support enterprise innovation.

6. Limitations

The analysis of the innovativeness of industrial and service enterprises in Poland in the years 2018-2022 was conducted on the basis of only 4 indicators, including: 2 input indicators and 2 output indicators. This was determined by the availability of comparable data from Statistics Poland in the cross-section of voivodeships and industrial and service enterprises.

It should be noted, however, that other metrics can also be used to measure innovation, capturing various aspects of innovation, not only inputs and outputs.

For this reason, further exemplary lines of research on enterprise innovation may include:

- extension (supplement) of the catalog of input- and output-based indicators,
- utilizing other measures of enterprise innovation, also taking into account other aspects of innovation;

- extending strategic positioning and external benchmarking of innovation to include other aspects such as productivity and entrepreneurship,
- utilizing other methods of multidimensional comparative analysis to assess innovation.

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