TOPSIS METHOD IN ASSESSING INNOVATIVE POTENTIAL OF VOIVODSHIPS IN POLAND

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The article presents an assumption that the characterization of regional innovativeness requires an assessment on many levels, mainly at the regional level. For this reason in this research paper is applied the linear method of ordering objects as an instrument for assessing and comparing the level of innovativeness on the example of Polish voivodships. The aim of research is to present the TOPSIS method as an instrument for assessing and comparing the level of innovativeness of Polish voivodships. Research object: innovative potential of Poland voivodships. The results allowed identifying the level of differentiation among Polish voivodships in terms of distance of the object from the "ideal" and "undesirable", as well as making their hierarchy and arranging them in 3 groups of innovativeness. The research and its results lead to the conclusion that the proposed method is a useful tool in evaluating the regions according to their innovativeness level.

Key words: innovational potential, linear method of ordering objects, TOPSIS method, voivodships.
JEL Codes: Q16, Q12, M10.

1. Introduction

Innovation (Latin: *innovatis* – renewal, creating something new) is defined in various ways in contemporary literature. Basically, however, economic science follows the definition promoted by J. A. Schumpeter (1998) who understood innovation to be an introduction of a new commodity or type of commodity, new production method, opening a new market, acquiring a new source of raw materials or semi-finished products, introduction of new organization of a certain industry, etc. With the development by M. E. Porter (1990), who incorporated technology improvements, better methods and ways of doing certain things, the innovative process is revealed not only through changes of product or process but also in new approaches to marketing, new forms of distribution, or new management concepts.

In its essence, the process is creative destruction which always involves changing the existing methods of operation, and the solutions thus developed are exposed to higher risks than those deriving from solutions verified in practice (Tyc, 2011). It should be pointed out here that the distinction of three stages of the innovation cycle, namely the invention, innovation and its popularization, implies that the last stage if frequently considered innovative. This is due to the assumption that if an innovation is innovative, implementation and promotion processes will be successful. This, however, requires appropriate changes of culture and creating a trend for risk and risk-taking in business activities.

Innovation discourse is expanded by the definition proposed by P. F. Drucker (2004) who pointed out that innovative activity is the intentional and organized seeking of change in the economic and social realm, and should be rather perceived as an economic or social category than the technical one. In this context, introduction of new solutions has an institutional, social (cultural) and bioethical aspect as well. Thus, innovation is a process of introducing and promoting a creative idea that refers to new unprecedented ways, methods or solutions to achieve a competitive advantage (Brilman, 2002). Assessment of the innovation process shows that its root source is the inability to achieve the intended goals using currently known and usable methods. This involves the need to seek new methods, both to realize already identified intentions and goals not yet known or revealed within the defined needs. The dynamics of the market economy causes continuous discrepancy in the economic practice between the goals and available methods. In this perspective, innovation is an expression of individual pressure on adaptation to the challenges of the socio-economic system. Anomie, which is a frequent occurrence in this process despite the formal or informal rules (Merton, 2002), can have both a positive and a negative dimension. However, in light of the currently prevailing paradigms that define innovation, only a positive effect is assumed, as a prerequisite of growth and progress.

One of the key areas of discussion concerning innovation and innovation potential is the regional policy and issues related to economic growth. Such phenomena as globalization and pressure on creating knowledge-based economy, not only corporations but states accordingly are forced to optimize the implementation of its potential, on a macro- as well as meso- and micro-scale. Therefore, the issues of innovation potential are linked to specific businesses and sectors of the economy, with the activities of state, regional and local government authorities as well as the European Union.

As a consequence, in the reality of strengthening European integration, stimulation of innovation potential of local socio-economic systems is an important instrument of the economic policy, on the international, national and regional level. In other words, supporting innovation of local systems becomes a new form of public intervention targeted through economic, social and environmental policy creators at transnational, national and regional economy operators (Brol, 2011).

The focus on supporting innovative processes targeted at economies at various management levels is represented in multiple European Union documents, such as: the Lisbon Strategy, the Competitiveness and Innovation Framework Programme, and the EU's regional policy. The actions taken are often co-financed by the EU and cover both direct support for enterprises, business environment institutions, academic

bodies, as well as systematic support for the potential of the research & development sector, and its ability to create innovation, as well as to stimulate the capacity of economic operators to absorb innovative changes. This approach to European Union policy is represented in the proceedings of the European Committee which in its regional policy assumption focuses on the processes of mitigating regional changes and tends more and more strongly to perceive regional development policy as an active strategy to support innovative activity. The purpose of such proceeding is to evaluate the local innovative potential and to use it in economic growth processes in response to the requirements of contemporary economic growth theories in which socio-economic growth depends o such factors as academic and technical progress.

The analysis has demonstrated that competition-dependent growth on each level of the economy is based on the innovative potential of that economy. In this context, special attention should be drawn to inclusion of this factor in planning documents, from strategic to operational level. It is common knowledge that innovative development requires specific interaction between enterprises located in the same region that form clusters and between enterprises (which create innovation on one hand and represent the demand for such innovation on the other) and institutions which are by default responsible for creating and supplying innovation (Brol, 2011). This creates special pressure on cooperation between business organizations and science, represented by universities, research and development centers, or institutions managing growth. Knowledge growth occurring in this way fosters its propagation and increased innovation potential of regions. It should be emphasized there that the constructs used on organizational level can be constitutive or regulatory in nature, ensuring the ability to handle processes and setting their advancement and applicable rules. Institutional (social) innovations, however, encounter higher application difficulties than inventiveness in the field of manufacturing techniques, as they involve a change of rules of social interaction (Tyc, 2011). This is typically due to the need to overcome cultural limitations. In practical terms, these innovative social arrangements most frequently involve new operating methods, realized as legal, financial and organizational instruments.

The presented innovation conditions imply that in order to determine the value of innovation at all levels of the economy (micro, meso and macro), all levels of analysis need to be considered and the goal of study must be specified. On national level where most public strategies are implemented that are decisive for innovation processes, specific knowledge of trends, qualities of education systems and political institutions, etc. is required (Markowska, 2007). Still, the regional level is the area that requires attention from innovation researchers. This is the level at which the information environment and interactions between its elements are observed to have a major effect on innovative processes. To a certain extent, it is the product of geographic concentration of system components which facilitates information and knowledge sharing.

The aim of this research is to present the TOPSIS method as an instrument for assessing and comparing the level of innovativeness on the example of Polish voivodships.

2. Scope, object and methodology of analysis

The object of this paper is to attempt at presenting the TOPSIS method (The Technique for Order of Preference by Similarity to Ideal Solution) as a useful instrument for evaluation and comparison of the level of innovative potential of voivodships in Poland.

The aim of this paper was realized through evaluation and comparison of the level of innovation in the voivodships of Poland using a synthetic measure estimated with one of the model methods of linear structuring of objects TOPSIS (Hwang, 1981).

In the proposed method, the synthetic measure is defined using the distance of the tested objects from the model objects, i. e. pattern and anti-pattern. In this way, a complex phenomenon can be defined with a single number, so-called synthetic variable, the tested objects can be structured and groups of similar objects can be distinguished.

The analysis uses the data of the Central Statistical Office (GUS, 2013) for 2012. Criteria were selected on the basis of their substantive usefulness for evaluating the studied phenomenon and variability. Innovation potential of voivodships in Poland can be expressed using the following variables:

X_1 – gross domestic expenditure on research & development in gross domestic product [%],

X_2 – gross domestic expenditure on research & development in the corporate sector in gross domestic product [%],

X_3 – gross domestic expenditure on research & development per capita [PLN],

X_4 – total entities active in the field of research per 100 thousand entities of the national economy,

X_5 – percentage of entities active in the field of research in enterprises within the overall number of these entities [%],

X_6 – proportion of expenditures of the corporate sector in total expenditures on research and development [%],

X_7 – personnel employed in research and development per 1000 vocationally active persons,

X_8 – gross domestic expenditure per employee,

X_9 – specialists in physics, mathematics, technical and natural sciences and healthcare as a proportion of total vocationally active population [%],

X_{10} – patents issued for domestic inventions according to the principal author's domicile, per 1 million inhabitants,

X_{11} – proprietary rights granted for domestic utility models according to the principal applicant's domicile, per 1 million inhabitants,

X_{12} – industrial enterprises that have made expenses on innovation [%],

X_{13} – enterprises from the services sector that have made expenses on innovation [%],

X_{14}– expenditures on innovation per 1 innovative industrial enterprise [million PLN],

X_{15}– expenditures on innovation per 1 innovative enterprise in the services sector [million PLN],

X_{16}– proportion of sales generated by industrial enterprises on sales of new or significantly improved products in total sales [million PLN],

X_{17}– proportion of sales generated by enterprises in the services sector on sales of new or significantly improved products in total sales.

The variables taken for the analysis are stimulants, meaning that their high values are desirable in the perspective of evaluating the object, while low values are undesirable.

3. Research findings

All variables in the tested object group meet the basic variable selection criterion for description of a complex occurrence: $V(X_j) > 0,1$, where $V(X_j)$ coefficient of variation of j th diagnostic feature (Table).

Table. Values of diagnostic features for Poland and their numerical characteristics

Feature	Poland	Numerical characteristics					
		Maximum value	Minimum value	Median	Arithmetic average	Standard deviation	Coefficient of variation
X_1	0.89	1.61	0.23	0.63	0.68	0.40	0.59
X_2	0.33	0.74	0.07	0.19	0.27	0.19	0.70
X_3	372.00	923.00	65.00	289.50	282.94	210.81	0.75
X_4	7.10	13.10	3.40	5.80	6.04	2.39	0.40
X_5	37.20	72.60	16.60	38.10	38.71	16.11	0.42
X_6	32.30	65.40	14.50	29.30	29.82	12.55	0.42
X_7	5.20	10.30	0.80	3.60	4.30	2.26	0.52
X_8	158.20	220.90	54.30	139.65	138.39	43.94	0.32
X_9	6.10	8.40	3.90	4.85	5.49	1.37	0.25
X_9	48.00	97.80	9.80	45.00	42.53	23.23	0.55
X_{10}	13.35	20.78	1.96	13.24	12.00	4.93	0.41
X_{11}	12.90	19.26	9.62	12.85	13.27	2.43	0.18
X_{12}	9.83	13.03	4.09	8.24	8.53	2.80	0.33
X_{13}	5.50	11.25	1.32	4.61	4.96	2.36	0.48
X_{14}	6.40	14.52	0.29	2.50	2.87	3.26	1.14
X_{15}	9.20	36.30	3.10	6.35	8.34	7.53	0.90
X_{16}	3.10	10.80	0.10	1.15	1.79	2.56	1.43
X_{17}	0.89	1.61	0.23	0.63	0.68	0.40	0.59

The following were executed sequentially in order to determine a synthetic measure of innovation for every voivodship:

– standardization of diagnostic features using the standardization formula:

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{S_j}, \qquad S_j \neq 0, \quad i = 1, \; 2, ..., n, \quad j = 1, \; 2, ..., m \qquad (1)$$

where: x_{ij} – the value of jth feature for ith voivodship; $\bar{x}_j$, S_j stand for arithmetic average and standard deviation of j th feature, respectively; z_{ij} – standardized value of j th feature for ith voivodship, such that:

$$z_{ij} \in \left\langle \frac{\min\limits_i x_{ij} - \bar{x}_j}{S_j} ; \frac{\max\limits_i x_{ij} - \bar{x}_j}{S_j} \right\rangle \qquad (2)$$

– determination of pattern and anti-patters, respectively:

$$z^+ = \begin{bmatrix} z_1^+ & z_2^+ & \cdots & z_n^+ \end{bmatrix} \qquad (3)$$

and

$$z^- = \begin{bmatrix} z_1^+ & z_2^+ & \cdots & z_n^+ \end{bmatrix} \qquad (4)$$

as model objects, so that: $z_j^+ := \max\limits_i \{ z_{ij} \}; \; z_j^- := \min\limits_i \{ z_{ij} \}$

– estimation of distance of every tested voivodship from the defined ideal solution and anti-ideal solution in accordance with the following formula:

$$d_i^+ = \sqrt{\sum_{j=1}^{m} (z_{ij} - z_j^+)^2} \qquad (5)$$

and

$$d_i^- = \sqrt{\sum_{j=1}^{m} (z_{ij} - z_j^-)^2} \qquad (6)$$

– determination of synthetic measure of innovation for every voivodship according to the following formula:

$$Q_i = \frac{d_i^-}{d_i^- + d_i^+} \qquad (7)$$

where Q_i – value of synthetic measure of innovation for i th voivodship.

In the assumed course of proceeding, the value of synthetic measure (Q_i) close to unity shows that the distance from the pattern identified for the given voivodship is negligible and therefore, the distance from the anti–pattern is relatively high.

Within ordered set of voivodeships according to synthetic measure topological classification was made using formulas proposed by K. Kukuła (1993):

- group I (high level): $Q_i \in \left(\dfrac{1}{3}\left(\min_i Q_i + 2\max_i Q_i \right), \ \max_i Q_i \right]$,

- group II (high level): $Q_i \in \left(\dfrac{1}{3}\left(2\min_i Q_i + \max_i Q_i \right), \ \dfrac{1}{3}\left(\min_i Q_i + 2\max_i Q_i \right) \right]$,

- group III (high level): $Q_i \in \left[\min_i Q_i, \ \dfrac{1}{3}\left(2\min_i Q_i + \max_i Q_i \right) \right)$.

The results obtained through calculation shows that voivodships in Poland are characterized by high diversity of the distance from the "ideal" as well as the "undesirable" object (Fig. 1).
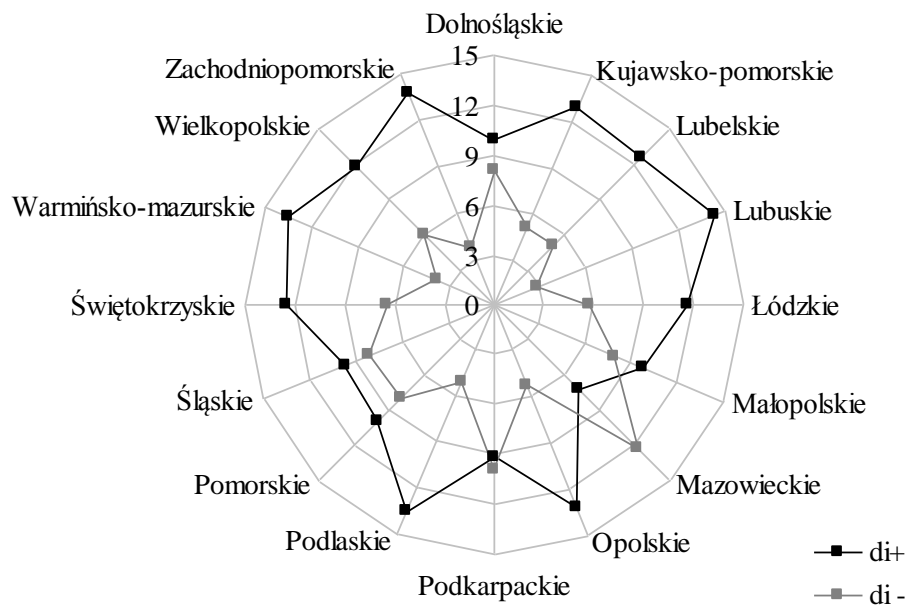

Figure 1. Distances of voivodships in Poland from the pattern and anti-pattern

On the other hand, hierarchy of the voivodships in Poland by the value of Q_i (Fig. 2) as the value of synthetic measure of innovation indicates that his coefficient is almost four times higher for the highest rating voivodship (Mazowieckie) than that for the last ranking voivodship (Lubelskie).
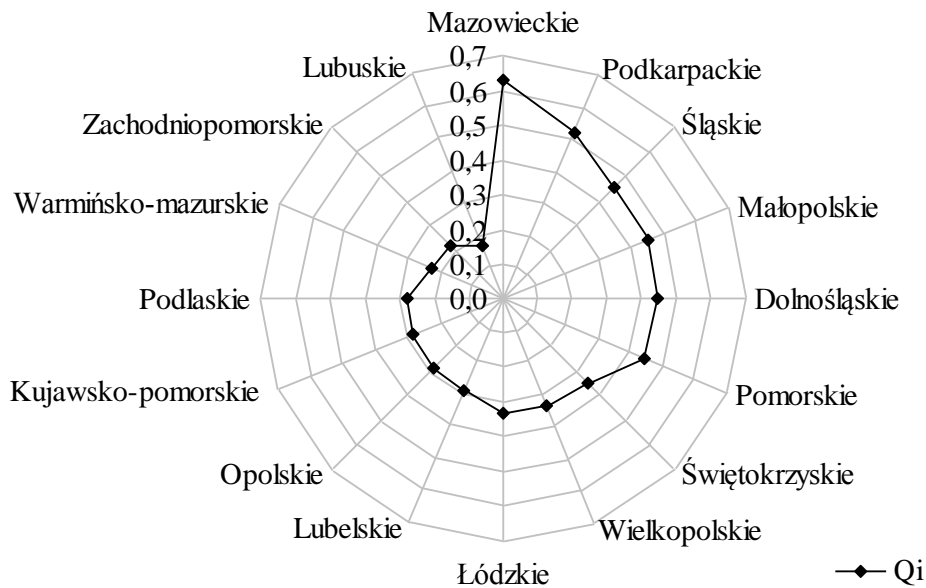
Figure 2. Ranking of voivodships in Poland by value of synthetic measure of innovation

The presented method of structuring allows for distinguishing three levels of innovation and thus concluding that voivodships in Poland are generally characterized by a medium or low level.

Only two voivodships were characterized by relatively high level of innovation: Mazowieckie and Podkarpackie.

4. Conclusions

1. Innovation potential of a region is a multifaceted phenomenon that is not measurable directly; therefore, statistical methods have to be used for measuring this value.

2. Based on the completed research and findings, one may conclude that the proposed procedure is a useful tool in objective evaluation of regions in terms of innovation potential. The TOPSIS method is a simple and transparent way to evaluate the tested phenomenon, to build the ranking and to group the tested objects.

3. Research provides grounds for identifying these voivodeships in which the level of innovation is high, fostering their growth and guaranteeing an appropriate level of competitiveness. The ability to identify regions with medium or low innovation potential is both an indication of the need for rationalization to foster development of regional policy development and facilitation of the decision-making process through pointing to investment directions to ensure reducing of regional disparities.

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TOPSIS METODO PRITAIKYMAS ĮVERTINANT INOVACIJŲ DIEGIMO POTENCIALĄ LENKIJOS VAIVADIJOSE

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Santrauka

Straipsnyje keliama hipotezė, kad ekonominis regionų išvystymas gali būti vertinamas pagal inovacijų įdiegimą. Todėl svarbu identifikuoti būdus, leidžiančius palyginti novatoriškumo laipsnį. Tyrimo tikslas – naudojant TOPSIS metodą, kaip mokslinių tyrimų įrankį, palygintas ir įvertintas inovacijų diegimo potencialas Lenkijos vaivadijose. Tyrimo objektas – inovacijų diegimo potencialas. TOPSIS metodas buvo pasiūlytas mokslininkų Hwang ir Yoon, išplėtotas ir adaptuotas šio straipsnio autorių. Tyrimo metu gauti duomenys leido nustatyti Lenkijos vaivadijų pasiskirstymą pagal nutolimą nuo „idealios" ir „nepageidaujamos" inovacijų diegimo būklės bei atlikti grupavimą pagal tris inovacijų diegimo lygmenis. Tyrimo rezultatai parodė, jog taikytas TOPSIS metodas yra tinkamas mokslinių tyrimų įrankis objektyviam regionų vertinimui ir palyginimui, atsižvelgiant į inovacijų diegimo potencialą.

Raktiniai žodžiai: inovacijų diegimo potencialas, TOPSIS metodas, vaivadijos.
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