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Innovative Potential of the European Union's Member States in 2017

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Prof. dr. hab. M. Proniewski[1] , dr J. B. Zielińska[2]

Abstract:

Purpose: *The aim of this paper is to evaluate the innovative potential of the European Union's countries in 2017.*
Design/Methodology/Approach: *The authors have proposed their methodology of measuring the innovative potential of the EU Member States. Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) was used to rank and evaluate countries' ability to innovate with respect to internal sources of innovativeness.*
Findings: *The analysis confirms moderate innovative capacity of the EU countries. The classification of countries on the account of their innovative potential in 2017 reveals some similarities to ranking of Global Innovation Index (Input Sub-Index).*
Practical Implications: *The paper proves that the most innovative countries in the light of the European Innovation Scoreboard display the highest ability to innovate. Therefore, internal resources of financial and human character were found to influence the overall level of innovativeness of member states. European countries should benefit from developing their innovative potential in terms of national resources.*
Originality/Value: *Most researchers adopt input and output approach to innovativeness because it represents a sophisticated phenomenon. Due to shortage of studies measuring solely the innovative potential of economies, the paper will contribute to the development of literature.*

Keywords: *Innovative potential, R&D, human capital, European Union, TOPSIS.*

JEL codes: *O39, O57, C38.*

Paper type: *Research article.*

[1]*Professor, Faculty of Economics and Management, University of Bialystok, Poland,* *m.proniewski@uwb.edu.pl*
[2]*PhD, Faculty of Economics and Management, University of Bialystok, Poland,* *j.zielinska@uwb.edu.pl*

1. Introduction

The recent EU enlargements have led to deepening its differentiation in terms of economic, political and social sphere. Despite the benefits of countries' participation in the processes of economic integration as well as the implementation of European funds within cohesion policy, more efforts must be taken in order to reduce the economic disparities between member states and strengthen the competitive position of the European Union in the world economy. EU has proved to be a successful economic project, but lately it has undergone serious problems – the deepest economic downturn since its inception, refugee crisis and political instability connected with Brexit (Kundera, 2019). Innovations are still considered worldwide to be a crucial driver of economic growth, hence countries continuously improve innovation policy in order to intensify innovative activities in public and private sector (Kijek, 2019).

Recent studies mostly combine input and output approach to measuring country's innovativeness which displays the economy's capability of transforming resources into innovative activities. Sparse researches propose empirical approach to measure innovative potential of the economies, therefore the authors decided to create own methodology with the use of the TOPSIS method. The chosen topic is of great concern because spatial diversity of innovativeness among member states contributes to the moderate level of innovativeness of the whole European Union. Many researchers have outlined weaker competitive ability of the EU in the global economy in relation to China or United States of America which can be illustrated by lower share of high-tech exports in global trade. Recently, development of high-tech industries is seen as a crucial factor of country's economic growth and development as well as its global competitiveness. The importance of innovations increases with the level of country's economic development. The authors strive to answer three main research questions:

- *Which member states of the European Union have presented higher ability to innovate in 2017?*
- *Which determinants of innovative capacity have contributed to higher positions of countries in the ranking?*
- *Does classification of innovative potential correspond to ranking of the innovativeness presented in the Global Innovation Index Reports?*

The structure of the paper is as follows. Firstly, the concept of innovativeness and innovative potential is discussed briefly and research approach is being presented. Secondly, EU countries are classified on innovative capacity through the application of the TOPSIS method. Authors' classification is compared with commonly approved ranking of GII. Thirdly, determinants of innovative capacity are evaluated and conclusions are drawn.

2. National Innovative Capacity and Sources of Innovativeness

Innovation and innovativeness are concepts widely discussed in recent economy, since Schumpeter (1939) has given economic importance to the idea of innovation and its role in the process of economic development (Paiva and Lourenço, 2015). Innovation in a broad sense (presented in Oslo Manual) can be seen as a novelty introduced on the market or an implementation of new or significantly improved goods or services, processes and solutions in terms of marketing, organization, workplace and external relations (Gault, 2018). Narrow view of an innovation focuses on first commercial application of a new product, process or invention (Wieprow, 2016). Innovativeness in turn constitutes company's ability to introduce new solutions into the market.

Innovativeness can be also analysed on the macroeconomic level. The economists perceive economy's innovativeness in perspective of innovative potential and innovative position. Innovative potential expresses country's ex ante ability to create and implement innovations in terms of resources needed to generate innovative solutions. Meanwhile, innovative performance demonstrates ex post effects of innovation activities in the economy in particular time. Innovativeness happens to be evaluated as national innovative capacity which combines elements of ability to innovate and innovative performance (Weresa, 2014). Furman, Porter and Stern perceive national innovative capacity not just through the achieved level of innovative output, but as country's long term ability to produce and commercialize flow of innovative technology. Authors appoint innovation infrastructure, industrial clusters' environment for innovation and strong linkages as the basic sources of capacity to innovate (Furman, Porter and Stern, 2002).

The literature confirms that sources of innovativeness can have internal or external character. External determinants of innovativeness refer to the transfer, diffusion, imitation or adaptation of innovations created in other countries, and internal factors display country's ability to mobilize national resources for innovative activities. The level of economy's innovativeness results from combination of exogenous and endogenous factors, but internal sources of innovation constitute not only the stimuli to innovativeness. Internal factors display the national environment's ability to absorb innovations which in turn affects the form, scope and strength of external factors' influence (Weresa, 2014). This can be evidenced by the process of internationalization and globalization of the R&D activities of multinational companies (MNC). Until the mid-1980s, industrialized countries have mostly participated in the process of corporate R&D globalization, though they represented attractive locations for innovation activities. In 1990s strategic R&D units started being located in developing countries due to their abundance of highly trained human resources, visibly lower wages of R&D personnel in comparison to industrialized countries as well as appropriate infrastructure (Reddy, 2011). This confirms the substantial role of countries' innovative potential in attracting technology transfer through external sources.

3. Measuring Innovative Potential of the EU Countries: Methodology

Measuring innovativeness remains still of particular interest beyond scientists. The view of innovativeness applied in the European Innovation Survey (EIS) as well as in the Global Innovation Index (GII) refers to the Furman, Porter and Stern's perspective of national innovative capacity. GII measure innovativeness in a broad perspective in terms of innovation input and innovation output. The sub-index of innovation input represents complex combination of indices concerning institutional framework (political, regulatory and business environment), quality of human capital and research, infrastructure (general and ICT), market and business sophistication. Sub-index of innovation output takes into account the measures of knowlegde creation and diffusion as well as the effects of innovative activities like trademarks, designs and patents (GII 2011, pp. 8-14). In this paper, authors perceive innovative potential, ability to innovate and innovative capacity as synonyms. To evaluate the innovative potential of the European Union's countries the set of ten diagnostic variables will be used, which are presented in Table 1.

Table 1. *Diagnostic variables applied in the research (Eurostat, 15.07.2019)*

Description of variable	**Average in EU in 2017**	**Standard deviation in 2017**	**Median in 2017**
New doctorate graduates aged 25-34 (per 1000 population)	1,71	0,79	1,69
Population aged 25-34 having completed tertiary education (%)	41,2	8,4	42,6
Population aged 25-64 involved in lifelong learning (%)	11,3	7,8	9,4
Employment in technology and knowledge-intensive sectors (% of total employment)	4,3	1,3	4,1
Full-time equivalent researchers in business sector (% of total R&D employment)	60,6	11,9	61,2
R&D expenditure in the public sector (% of GDP)	0,57	0,25	0,56
Venture capital (% of GDP)	0,09	0,08	0,07
R&D expenditure in the business sector (% of GDP)	0,99	0,66	0,71
Non-R&D innovation expenditures (% of turnover)*	0,78	0,45	0,71
Enterprises providing training to develop or upgrade ICT skills of their personnel (%)	21,5	8,5	23,0

Note: ** data for 2016.*

Expenditures on R&D, quality of human resources and environment favoring the creation of innovations constitute the main inputs to innovativeness (Golejewska, 2014; NBP, 2016:23). In the literature, many different approaches to defining and measuring country's inputs to innovativeness can be found. The view of innovative potential applied in this research is based on the classification presented by Weresa (2014) which entails allocations on R&D, allocations on innovations and human capital as main internal inputs to economy's innovativeness. The authors concentrated on few variables describing innovative potential in order to reveal countries' innovative advantages which can activate external sources of innovativeness. The choice of measures describing ability to innovate was based on their availability and comparability. The selection of variables was made after studies of the methodology used for calculating SII and GII. Data was extracted from the Statistical Office of the European Union. Majority of variables used in the research process come from the same time of analysis (2017), only in case of one measure the data regard 2016 (instead of 2017) due to lack of more recent data.

For the purpose of classifying the European Union's Member States on their innovative potential, the TOPSIS method was used. TOPSIS is a Technique for Order Preference by Similarity to the Ideal Solution which bases on selecting the closet and the furthest alternative from the ideal solution. It can be best applied, when problems are well defined and measurable (Roszkowska, 2011).

Firstly, after the selection of criterions characterizing the research area, authors decide whether they constitute stimulants or destimulants to particular phenomenon. In this study all variables are treated as stimulants because the growth of their value should increase the innovative potential of a given country (Roszko-Wójtowicz and Białek, 2017). Secondly, values representing positive and negative solutions must be appointed and normalization of variables according to two procedures must be conducted:

$$\text{for stimulants: } n_{ij} = \frac{x_{ik} - \min_i\{x_{ik}\}}{\max_i\{x_{ik}\} - \min_i\{x_{ik}\}}; \quad (1)$$

$$\text{for destimulants : } n_{ij} = \frac{\max_i\{x_{ik}\} - x_{ik}}{\max_i\{x_{ik}\} - \min_i\{x_{ik}\}}; \quad (2)$$

where:

$\min_i\{x_{ik}\}$ - minimal value of k index

$\max_i\{x_{ik}\}$ - maximal value of k index

Thirdly, the weighted normalized decision matrix is created by multiplying normalized values by the criteria weights.

$$v_{ik} = w_k * n_{ij} \text{ for } i = 1, 2, 3 \ldots m \text{ ; } j = 1, 2, 3 \ldots n \text{ ,} \quad (3)$$

where the w_k is the weight of k-th index or criterion and $\sum_{i=1}^{n} w_k = 1$.

After calculations, the positive-ideal and the negative-ideal solutions must be appointed according to the formula:

$$v_k^+ = \max_i\{x_{ik}\}, v_k^- = \min_i\{x_{ik}\} \quad (4)$$

The distance of each alternative to the positive-ideal and the negative-ideal solution is computed using n-dimensional Euclidean metric:

$$\mathrm{d}_i^+ = \sqrt{\sum_{k=1}^{m}(\mathrm{v}_{ik} - \mathrm{v}_k^+)^2} \text{ and } \mathrm{d}_i^- = \sqrt{\sum_{k=1}^{m}(\mathrm{v}_{ik} - \mathrm{v}_k^-)^2} \quad (5)$$

and synthetic measure is being calculated with the use of formula:

$$q_i = \frac{d_i^-}{d_i^- + d_i^+}, \text{ where } 0 \le q_i \le 1, i = 1, 2, 3 \ldots n. \quad (6)$$

Eventually, objects are ranked according to their relative closeness to the ideal solution by the value of q_i. The higher the q_i index, the higher innovative potential of a given country (Roszkowska, 2009; Roszkowska, 2011; Iwacewicz-Orłowska and Sokołowska, 2018).

4. Results and Discussion

Table 2 presents the European Union's Member States' rating on the account of their innovative potential in 2017 according to TOPSIS method in comparison to GII 2017. For the purpose of analysis, the authors have divided the EU countries into classes basing on values of average ($\bar{q}_t$) and standard deviation (s_{qt}) calculated from synthetic measures (Roszkowska and Lašakevič, 2017)[3].

The classification evidences that high degree of diversity in the context of innovative capacity constitutes one of the major problems of the European Union. According to the results of authors, three countries stand out because of the highest value of the synthetic measure. In 2017 the highest ability to innovate in terms of internal resources of the economy was presented by Sweden, Finland and Denmark. The validity of this observation can be evidenced by the results of the GII Report. The second class (upper-middle) includes the following member states: Estonia, Austria, Germany, France, United Kingdom, Ireland, Netherlands, Belgium, Slovenia, Lithuania and Luxembourg (range from 0,445-0,580). Estonia is undoubtly an achiver in this group. Portugal, Spain, Czech Republic, Cyprus, Greece, Hungary,

[3]*With the use of the formula - class I (upper level):* $q_{it} \ge \bar{q}_t + s_{qt}$ *; class II (upper-middle level):* $\bar{q}_t + s_{qt} > q_{it} \ge \bar{q}_t$ *; class III (lower-middle level):* $\bar{q}_t > q_{it} \ge \bar{q}_t - s_{qt}$ *; class IV (low level):* $q_{it} < \bar{q}_t - s_{qt}$ *.*

Poland, Latvia, Slovakia, Malta and Croatia create the class of countries showing lower than medium capacity to innovate. The last class of member states is formed by: Bulgaria, Italy, Romania. Relatively smaller number of countries represent the weakest innovative potential. It should be noticed that in 2017 there were three member states with the smallest internal capacity to innovate. It proves positive effects of the ongoing process of improving innovativeness' in the European Union.

Table 3. *Innovative potential of the EU countries in 2017 (own compilation on the basis of Eurostat, and Cornell University, INSEAD, WIPO, 2017, pp. 16-17)*

Country	**TOPSIS**		**GII Input sub-index**	
	Rank	**Value (0-1)**	**Rank**	**Value (0-100)**
Sweden	1	0,723	2	68,93
Finland	2	0,656	1	69,72
Denmark	3	0,638	3	68,68
Estonia	4	0,565	13	56,99
Austria	5	0,555	8	62,92
Germany	6	0,547	7	63,33
France	7	0,539	6	63,41
United Kingdom	8	0,532	4	68,25
Ireland	9	0,528	9	62,86
Netherlands	10	0,522	5	65,79
Belgium	11	0,512	10	59,53
Slovenia	12	0,488	17	54,40
Lithuania	13	0,463	20	51,92
Luxembourg	14	0,450	11	57,36
Portugal	15	0,426	19	53,80
Spain	16	0,426	12	57,28
Czech Republic	17	0,404	14	55,72
Cyprus	18	0,389	18	53,92
Greece	19	0,388	23	49,73
Hungary	20	0,375	25	48,36
Poland	21	0,372	22	50,20
Latvia	22	0,371	21	51,25
Slovakia	23	0,347	24	49,66
Malta	24	0,338	15	54,91
Croatia	25	0,325	26	47,96
Bulgaria	26	0,262	27	47,61
Italy	27	0,254	16	54,43
Romania	28	0,065	28	46,36

The classification according to TOPSIS method in comparison to the Global Innovation Index 2017 shows similarities mostly in the group of countries presenting the strongest (Finland, Sweden and Denmark) and the weakest (Bulgaria, Romania) innovative potential. The order of the EU member states in the middle of the Table varies significantly, especially since 10th position. Sweden, Estonia, Austria, Germany, Slovenia, Lithuania, Portugal, Greece, Hungary, Poland, Slovakia, Croatia and Bulgaria achieved better positions in the authors' ranking than in GII 2017. One can draw a conclusion that investments in R&D and human capital have contributed to building innovative potential of these economies to the higher extent than other external factors of innovativeness. Meanwhile, Finland, France, United Kingdom, Netherlands, Belgium, Luxembourg, Spain, Czech Republic, Latvia, Malta and Italy scored worse on their innovative capacity in comparison to GII 2017.

The leader among the EU member states with the respect of innovative potential – Sweden – can be distinguished because of:

- the highest share of population aged 25-64 involved in lifelong learning (30,4% against 11,3% of the average in EU-28);
- the highest share of full-time equivalent researchers in total R&D employment in business sector (81,4%, while the EU average accounts for 60,6%);
- the highest share of private funding for R&D (2,42% as a percentage of GDP, EU average – 0,99% of GDP);
- and high R&D expenditure in the public sector (0,97% of GDP, and the average in EU-28 countries was 0,57% of GDP).

Sweden represents the STI model of innovation (science, technology, innovation). The success of this country originates from the establishment of big companies internationally oriented, as well as development of strong industrial clusters in high technology sectors which are supported by good quality education and academic research. In recent times Sweden has started putting much attention to favorable conditions of conducting business, development of cooperation between science and industry and commercialization of knowledge by universities. High expenditures on R&D, access to well qualified personnel and openness to the transfer of technology through external sources jointly explain Sweden's high ability to innovate (NBP, 2016, pp. 105-106).

Finland prevail in the classification due to the highest share of enterprises providing ICT training to their personnel (38%), also good results were achieved in terms of population aged 25-64 involved in lifelong learning (27,4%) and public spending on R&D (0,94% of GDP). Denmark presented the highest scores in the field of: new doctorate graduates aged 25-34 (3,17 per 1000 population) and R&D expenditure in the public sector (1,07% of GDP). The strengths of the finish innovation system lay in the implementation of complex innovation strategy giving priority to industrialization and creation of national technology advantages, development of the national infrastructure, increase of R&D allocations and tight cooperation between public and private sector. Long-term investments in higher education resulted in increasing the amount of good quality engineers. Stable macroeconomic policy, healthy financial sector, domestic competition and openness to external ideas jointly contributed to creation of innovation as well as to diffusion of technology in the economy (Aho, Alkio and Lakaniemi, 2013).

To summarize the results of authors' research, few observations ought to be outlined. Firstly, Sweden (leader in 2017) have allocated the highest amount of expenditure on R&D activities in business sector. It corresponds to the findings of economic literature and the results of other studies. Strategy Europe 2020 appointed that most expenditures on research and development in the EU should be financed by the private sector since innovative activities of companies influence the level of country's innovativeness to the greater extent (European Commission, 2010, pp. 8-10). It turns out to be a crucial factor for strong innovative potential as well, even though all factors were given the same wages in TOPSIS procedure.

Secondly, human capital with capacities to conduct R&D activities has revealed its importance. The share of population involved in lifelong learning and the share of researchers in total R&D employment in business sector have reached the highest levels in Sweden against the background of the EU countries in 2017. The public funding for R&D was also relatively high. It may lead to a conclusion that the innovative potential is shaped jointly by financial and human resources.

Thirdly, tertiary education attainment has proved to be less important factor in building country's capacity to innovate. It may result from quite high achievements of the EU member states in the process of improving the educational level of population (only Romania and Italy presented relatively low indices). Second explanation may be appointed that high qualifications without possibilities to use them to perform R&D activities in business sector remain useless. Human capital only in combination with the appropriate amount and efficiency of research and development expenditures can contribute to economic innovativeness (Roszko-Wójtowicz and Białek, 2017).

5. Conclusions

The aim of this paper was achieved through creation of classification characterizing the innovative potential of the European Union's Member States. Input approach to country's innovativeness (sparse in the recent literature) was applied in this research, because country's ability to use national resources remains crucial in determining the level of its innovativeness as well as in attracting the transfer of technology from abroad. The authors' research confirmed that Scandinavian countries display the highest innovative capacity against the background of the EU member states. In 2017 Sweden have achieved the highest value of the synthetic measure. Together with Finland and Denmark they constituted the upper class of innovators.

The evaluation of determinants of innovative potential has proved that financial and human resources had a similar significance in shaping countries' ability to innovate. Leader of the classifications has spent the highest amount of expenditure on R&D

activities in business sector, but also population involved in lifelong learning and the share of researchers in total R&D employment in business sector revealed their importance in the analysis.

The approach to measuring the innovative potential applied in this study was more narrow (which was the goal of the authors) than the methodology used in GII Reports and the European Innovation Scoreboard. Despite those differences countries presenting the strongest and the weakest innovative potential remain the same in all rankings.

References:

Aho, E. Alkio, M. and Lakaniemi, I. 2013. The Finish approach to innovation strategy and indicators, [in:] F. Gault (ed.), Handbook of Innovation Indicators and Measurement, Cheltenham, Northampton: Edward Elgar Publishing Limited, 320-331.

Cornell University, INSEAD, WIPO. 2017. The Global Innovation Index 2017: Innovation Feeding the World, 16-17.

European Commission. 2019. European Innovation Scoreboard 2019. Luxembourg: Publications Office of the European Union, 6-7.

Furman, J.L. Porter, M.E. and Stern, S. 2002. The determinants of national innovative capacity. Research Policy, Volume 31, Issue 6, 899-900.

Gault, F. 2018. Defining and measuring innovation in all sectors of the economy. Research Policy, Volume 47, Issue 3, 617-618.

Golejewska, A. 2014. Innowacyjność Input-Output regionów grupy wyszehradzkiej. Oeconomia Copernicana, No.1, 65.

Iwacewicz-Orłowska, A. and Sokołowska, D. 2018. Czynniki warunkujące innowacyjność państw grupy OECD w latach 2013 i 2017. Przedsiębiorstwo & Finanse, 2 (21), 9-10.

Kijek, A. 2019. The Effect of Public Procurement and its Spillovers on Innovativeness of Enterprises in European Countries. European Research Studies Journal, Volume XXII, Issue 1, 104.

Kundera, J. 2019. The future of EU: Towards a two Speed Europe. European Research Studies Journal, Volume XXII, Issue 3, 262.

NBP. 2016. Potencjał innowacyjny gospodarki: uwarunkowania, determinanty, perspektywy, raport. NBP Warszawa, 23, 105-106.

Paiva, I.S. and Lourenço, I.C. 2015. R&D Activities in Family Firms [in:] L.C. Carvalho (ed.), Handbook of Research on Internationalization of Entrepreneurial Innovation in the Global Economy, Hershey: Business Science Reference, an imrint of IGI Global, 330.

Pro Inno Europe. 2011. Innovation Union Scoreboard 2010. The Innovation Union's performance scoreboard for Research and Innovation, 7.

Reddy, P. 2011. Global Innovation in Emerging Economies. New York, Oxon: Routledge, 4-5.

Roszko-Wójtowicz, E. and Białek, J. 2017. Evaluation of the EU countries' innovative potential – multivariate approach. Statistics in Transition new series, Vol. 18, No. 1, 167-180.

Roszkowska, E. 2009. Application the TOPSIS Methods for Ordering Offers in Buyer-Seller

Transaction. Optimum-Studia Ekonomiczne, 3(43), 120-122.
Roszkowska, E. 2011. Multi-criteria Decision Making Models by Applying the Topsis Method to Crisp and Interval Data. Multiple Criteria Decision Making, Vol. 6, 201-208.
Roszkowska, E. and Lašakevič, R. 2017. Taksonomiczna analiza zróżnicowania rozwoju rynku pracy na Litwie w latach 2004-2014. Optimum. Studia Ekonomiczne, 6(90), 46.
Weresa, M.A. 2014. Polityka innowacyjna. Warszawa: PWN, 22-32.
Wieprow, J. 2016. Financing innovative undertakings from the European Union Structural Funds [in:] K. Łobos, P. Schiffauer (eds.), Between crisis and innovation. European Policies through National and Transnational Perspectives. Warszawa: CeDeWu.pl, 63.