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RANKING OF EU COUNTRIES ACCORDING TO INNOVATION POTENTIAL

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Abstract

The purpose of the paper is to rank all 27 countries of the European Union (EU) according to selected indicators of innovation potential. In a high-tech society, the main factor of economic development are activities related to research and development (R&D). The author singled out five relevant indicators from the Eurostat database in the assessment of the conditions for innovation development in the EU using the MOORA (Multi-Objective Optimization on the basis of Ratio Analysis) method. Based on the conducted multi-criteria analysis, the author concludes that Germany, Sweden, France and the Netherlands have the best innovation performance, so that these countries are the closest to achieving the goals of a highly competitive economy and sustainable economic development. On the other hand, Romania, Cyprus, Slovakia and Croatia show the weakest innovation potential, followed by other newer EU members.

Key words: *innovation, research and development (R&D), MOORA (Multi-Objective Optimization on the basis of Ratio Analysis) method, composite index, European Union (EU) countries.*

JEL Classification: C44, O30

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Introduction

Sustainable development is a multidisciplinary concept. It includes 17 goals, among which is Goal 9 - *Industry, innovation and infrastructure* [United Nations Development Programme, 2022]. The importance of this goal is also recognized by the European Union (EU), so the 2030 Agenda especially emphasizes innovations with the aim of reaching a high level of sustainable development within this integration of countries [Denoncourt, 2020]. Encouraging innovation and competitiveness in the area of the EU are listed as important goals within the framework of the Lisbon Strategy.

Innovative activities that are primarily aimed at researching long-term solutions for sustainable socio-economic development are particularly in the focus of policy makers. In order to achieve the principles of the concept of clean economy and sustainable development, environmental protection is extremely important. Greening the economy is at the top of the EU's priorities, so innovation and research and development (R&D) activities are often moderated towards environmental sustainability. This will enable industrialization in a sustainable way.

R&D are activities that improve knowledge and enable the use of that knowledge to create new products and services. Without scientific research, it is not possible to realize development based on knowledge and innovation. Countries that are leaders in innovation were the first to recognize the importance of innovative activities for economic development.

The paper aims to measure the innovation potential of EU countries according to the level of innovation performance. The Eurostat database and selected indicators were used as a data source: 1) *Gross domestic expenditure on R&D*, 2) *R&D personnel*, 3) *Tertiary educational attainment*, 4) *High-speed internet coverage*, and 5) *Patent applications to the European Patent Office*. The values of these indicators are from the last available year in the Eurostat database. The MOORA (Multi-Objective Optimization on the basis of Ratio Analysis) method was applied as a multi-criteria analysis method, while the equal weighting approach was used to determine the weighting coefficients that reflect the relative importance of the indicators.

The study is important for two reasons. First, based on the calculated innovation potential, a comparison will be made of the success of EU countries in achieving sustainable and smart development. On the other hand, poorly positioned countries can, from the experience of high-ranking countries, implement similar programs to

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promote education, the importance of innovation and R&D. As a rule, European economies that invest insufficiently in infrastructure and the scientific research sector lag behind economic development.

The paper consists of several sections. The first section is dedicated to the importance of selected indicators for building innovation potential and sustainable development. Then, the applied methodology is described in detail. The final section summarizes and discusses the results. The concluding remarks provide an overview of the most important research results, their implications and suggestions for future research.

Literature Review and Theoretical Background

Innovations are the basis of competitiveness of every economy and a factor of economic development [Kaynak *et al.*, 2017]. Herman [2018] points out that a strong connection between innovation, competitiveness and entrepreneurship is needed in order to achieve sustainable and inclusive development. Innovations play a significant role in changing the economic structure and dynamics of investments. In this way, they can solve the problem of high import dependence and insufficient exports. That is why economic policy makers implement support measures to increase the interest of individuals in innovation, as well as increase the number of scientists in scientific institutions. The globalization process and the development of information and communication technology have contributed to the development of innovations.

Higher allocations for R&D enable sustainable growth and development through increased productivity, efficiency and new employment. If innovation is directed towards the development of environmentally clean technologies and increased safety and security at work, R&D can play a decisive role in environmental protection and the achievement of social sustainability and sustainable industrialization.

Many studies deal with the role and importance of innovation in the economy. The authors study the innovation potential of the economy, especially at the EU level, and use mostly similar indicators. Thus Baescu *et al.* [2015], in addition to indicators related to R&D activities and education of the population, also use the level of economic development and exports of countries. However, they argue that R&D expenditures do not have a positive effect on increasing the number of patent applications, unlike the number of employees in the R&D sector.

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According to the global composite index - European innovation scoreboard [European innovation scoreboard, 2021], Sweden, Finland, Denmark and Belgium have the best innovation performance in the EU. In addition, the EU as an economic integration has a lower innovation performance compared to South Korea, Canada, Australia, the United States and Japan. That is why the EU must encourage innovation through various strategies and programs, primarily in lower-ranked countries.

The aim of this paper is to quantify such a complex problem with an appropriate multi-criteria decision-making method. It is an aggregate method that transforms various variables into a unique composite index on the basis of which the achieved level of development is assessed. Recently, the role of composite indicators in the evaluation of innovation potential and performance has increased [Paas & Poltimäe, 2010]. They are significant not only for understanding the position of an individual economy, but also for international comparisons. There is also a wide range of innovation indicators that can be included when aggregating data, as well as many methods of multi-criteria analysis.

As human capital is the main factor in the creation of innovations [Hollanders & Arundel, 2007], the following indicators were used in the research: R&D personnel and Tertiary educational attainment. Human capital creates and uses innovation. Consequently, it is important that as many people as possible successfully complete tertiary education, and that some of them carry out R&D activities. Creative and smart industry is based mainly on quality human resources. That is why the EU aims to reach the target of 45% of the population aged 25 to 34 with a tertiary degree by 2030 [SDG 9 - Industry, innovation and infrastructure, 2022]. This goal has been achieved by 11 EU countries so far. According to Eurostat data, Luxembourg is the most successful in this, while Romania is at the back.

Another significant indicator of the innovation potential of the economy is the number of patent applications. The most common representation of a country's innovation potential is the number of patents and investments in R&D [Paas & Poltimäe, 2010]. Their realization is of key importance for smart and sustainable development at the EU level in the future [Roszko-Wójtowicz & Białek, 2016], and especially for generating knowledge and creating patents [Janjić *et al.*, 2021].

All EU countries aim to increase the speed of communication, because it affects the speed of transactions, greater availability of services and faster business in all sectors: agriculture, industry, service sector. Digitization of the economy and information and communication technologies enables its accelerated economic

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development, and provides the population sector with better access to health care and educational services Malta is the only country with 100% high-speed internet coverage in the EU [Eurostat, 2022].

Based on the researched literature and the availability of data in the Eurostat database, the author chose five key indicators that best represent the conditions for innovation development. They refer to financial allocations for R&D, human capital, adequate infrastructure and the number of registered patents. Table 1 highlights the analyzed indicators and provides a brief explanation for each of them.

Table no. 1. Description of innovation indicators

Indicator	Interpretation
Gross domestic expenditure on R&D (in %; 2020)	This indicator describes the share of gross domestic product that is directed to R&D.
R&D personnel (in %; 2020)	This indicator represents the share of R&D personnel in the total labour force in the country.
Tertiary educational attainment (in %; 2021)	The indicator shows the share of the population who completed tertiary studies in the age group of 25 to 34 years.
High-speed internet coverage (in %; 2021)	The indicator aims to show how many households (in %) have the possibility to use a fixed network of very high capacity.
Patent applications to the European Patent Office (2021)	This absolute indicator measures the number of applications for patent protection by applicants'/inventors' country of residence.

Source: *Eurostat*, 2022.

Methodology

The MOORA method is a newer, widely used multi-criteria decision-making method [Marjanović *et al.*, 2019]. The goal is to obtain composite index values that will reduce multidimensional issues such as this to a single measure. The value obtained by applying this method will indicate the degree of innovation potential, with higher values indicating higher success in creating conditions for the development of innovation and high-tech industry. On the other hand, an equal weighting approach was used as a method for determining the weight coefficients, where each criterion/indicator will have equal relative importance in the

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construction of the composite index. In this way, subjectivity is avoided in determining the importance of indicators.

Application of the MOORA method requires compliance with the following steps [Brauers & Zavadskas, 2006; Gadakh *et al.*, 2013; Madić *et al.*, 2015; Marjanović *et al.*, 2019]:

Step 1. Formation of a normalized decision matrix:

$$x_{ij}^{*} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}}$$

where:

i = 1, 2, …, m (number of indicators); and j = 1, 2, …, n (number of alternatives).

Step 2. In this step, the sum of the values for the cost indicators is subtracted from the sum of the values for the revenue indicators:

$$y_{ij} = \sum_{j=1}^{g} w_j x_{ij}^{*} - \sum_{j=g+1}^{n} w_j x_{ij}^{*}$$

where:

i = 1, 2, …, g (the indicators to be maximized); and $i = g+1, g+2, \ldots, n$ (the indicators to be minimized), w_j - the weight coefficients.

Step 3. Ranking of the alternatives according to the decreasing values of the composite index.

Results and Discussion

The practical part of the research begins with descriptive statistics. Table 2 summarizes the minimum, maximum and mean values of the indicator for the 27 EU countries, as well as the size of the standard deviation. EU countries show the biggest differences in performance related to *Patent applications to the European Patent Office*.

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Table no. 2. Descriptive statistics of indicators

	Minimum	Maximum	Mean	Std. Deviation
Gross domestic expenditure on R&D	0,47 (Romania)	3,53 (Sweden)	1,78	0,92
R&D personnel	0,41 (Romania)	2,12 (Denmark)	1,32	0,50
Tertiary educational attainment	24,90 (Romania)	60,60 (Luxembourg)	43,38	9,18
High-speed internet coverage	10,20 (Greece)	100,00 (Malta)	65,14	23,50
Patent applications to the European Patent Office	22 (Latvia)	25.969 (Germany)	2.507,89	5.320,66

Source: Author's calculation.

Sweden is the leader in R&D expenditures with 3.53% of the gross domestic product. The EU has predicted that allocations for these purposes will be over 3% by 2030 [Maier, 2018]. Looking at individual countries, in addition to Sweden, only three other EU countries reached that target: Belgium, Germany and Denmark. [Eurostat, 2022]. Romania shows the lowest values of indicators related to *Gross domestic expenditure on R&D*, *R&D personnel* and *Tertiary educational attainment*.

Table 3 shows the calculated weight coefficients that participate in determining the final value of the composite index. The author chose the approach of equal weighting, since each of the criteria has equal relative importance for assessing the position of countries according to the conditions for the development of innovations.

Table no. 3. Weighting coefficients obtained by the equal weighting method

Indicator	Weights
Gross domestic expenditure on R&D	0,20
R&D personnel	0,20
Tertiary educational attainment	0,20
High-speed internet coverage	0,20
Patent applications to the European Patent Office	0,20

Source: Author's calculation.

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Table 4 provides an overview of the ranking of European countries according to the value of the obtained composite index. The most successful countries in creating the conditions for innovation development are Germany, Sweden, France, the Netherlands and Denmark. These are countries that are at the very top in terms of the intensity of R&D at the EU level. In addition, Germany and France have the highest number of patent applications. On the other hand, at the bottom of the list are Romania, Cyprus, Slovakia and Croatia. These are newer EU member states. All countries below Slovenia in the table have a composite index value below the EU average of 0.1611. Romania is in the worst position, so it must be in the focus of EU economic policy makers in the area of innovation in the coming period.

Table no. 4. Composite index of innovation performance of EU countries (MOORA method)

Country	Score	Rank	Country	Score	Rank
Germany	0,3436	1	Lithuania	0,1367	15
Sweden	0,2381	2	Estonia	0,1359	16
France	0,2316	3	Poland	0,1321	17
Netherlands	0,2308	4	Czechia	0,1293	18
Denmark	0,2272	5	Malta	0,1223	19
Belgium	0,2195	6	Latvia	0,1206	20
Finland	0,2016	7	Hungary	0,1201	21
Austria	0,1851	8	Bulgaria	0,1096	22
Luxembourg	0,1802	9	Greece	0,1094	23
Ireland	0,1658	10	Croatia	0,1060	24
Slovenia	0,1612	11	Slovakia	0,1019	25
Spain	0,1606	12	Cyprus	0,0946	26
Portugal	0,1548	13	Romania	0,0844	27
Italia	0,1459	14			

Source: Author's calculation.

Conclusion

Germany is by far the most successful country when it comes to innovation performance. Sweden is in second place in terms of innovation potential in the EU. The key factors of the high position are high investments in the R&D sector (Sweden), as well as a large number of patent applications to the European Office (Germany). The experience and practice of Germany and Sweden can be of

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importance to other countries that want to improve their innovation potential. However, the author believes that highly developed countries have significantly greater opportunities for convergence due to significant investments in education and R&D. Therefore, in addition to structural reforms, additional funds must often be provided for the development of innovations in less developed countries. The author concludes that the countries of Western and Northern Europe have the best innovation potential. On the other hand, Romania and Cyprus record the lowest values of the composite index of innovation according to the results of the applied method.

The EU members who joined the EU at the latest must implement structural reforms in order to improve innovation capacity because they have shown the worst results. In doing so, science and technology must play a major role. Despite the many socio-economic challenges they face, adopting strategies to support innovation can help achieve economic growth in the long term. The benchmark can be high-ranking European countries, whose practice can serve them for convergence in the future. The results of this paper show a similar ranking as shown by previous studies that measured the innovation potential and performance of EU countries.

Future research can include more variables in the evaluation of the innovation potential of EU countries. Also, the analysis may include candidate countries for EU membership after the data are available in the Eurostat database. In addition, authors can use other methods of multi-criteria decision-making such as TOPSIS, PROMETHEE, Gray Relational Analysis, etc.

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