Comparative Analysis of Strategies for Innovative Development of The Economy: The Experience of The EU Countries

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Abstract

The relevance of the study. Innovative development of the EU countries provided additional incentives in the framework of the integration association, as all 27 countries are involved in the innovation process. The article examines the indicators of innovative development of the EU states. The authors rely on materials demonstrating that innovation leaders and strong leaders are in the European innovation ranking, at a high level of innovation convergence, as innovation within the EU is actively funded through the TEMPUS/TACIS and Horizon 2020 programs.
The practical significance of studying Cluster analysis allows us to study the real position and nature of innovative connections of EU countries in the dynamics, by establishing the closeness of the connection within the cluster and the characteristic differences between clusters.
The purpose of this study The purpose of the study is to examine changes in the position of innovation links of EU countries on the main indicators of the Global Innovation Index.
The method of research. The article uses the method of cluster analysis to process statistical information.
Research results. Our study showed that the countries on the level of innovation development are united into 3 clusters because due to the progressive development in the implementation of innovation strategies, the policy of convergence gives certain positive results.
Conclusions of the study. The obtained results of the research of innovation relations of EU countries based on indicators of the Global Innovation Index showed how a number of EU countries have improved their positions in comparison with the assessment of the European Innovation Scoreboard, in which countries are grouped into 4 clusters. The analysis carried out in the article showed that Estonia's position has significantly improved. In the implementation of innovation strategies, EU countries have achieved a reduction in the innovation gap through the development of joint projects and programs and the convergence of innovation links. As a result, the positions of many EU countries have improved and it is reasonable to combine them into 3 clusters: innovative leaders, innovative followers, and innovative outsiders.

Keywords: *innovation development, innovation gap, innovation strategies*

1. Introduction

The integration processes of the EU countries developed in the format of the concept of "different speeds" in stages by achieving convergence indicators in economic development. As a result, the integration process embraced countries with different levels of socio-economic development. The EU countries lagged behind the rest of the world in stimulating intellectual potential, creating research infrastructure, and defining priority areas of innovation financing. The consistent implementation of the programs TEMPUS/TACIS,

ERAZMUS+, and HORIZON 2020 enabled the EU countries to take leading positions in innovation ratings.

The Horizon 2020 budget amounted to €78.6 billion for the period 2014-2020 (Hessels et al., 19 May 2020).

We can see that the EU is implementing a proactive strategy through the funding of innovation programs, which makes it possible to bring EU countries into the category of global innovation leaders, which would be difficult for each individual country to achieve on its own.

The fragmentation of EU regions is noted in the study (Schmidt, 2019). EU regions are divided into innovative leaders and moderate innovators, lagging behind in terms of wealth and research activity. This innovation gap, in turn, threatens to reinforce the productivity gap between regions. The EU cohesion policy has recently shifted its focus to financing innovation, which has led to positive developments and reduced the innovation gap.

In assessing the innovation prospects of EU countries (Della Porta, et al., 2020), the authors address issues of ecology, energy, and digital transformation.

The research team (McKinsey Global Institute, 2019) touches on the need to actively implement digital transformation in the innovation process. McKinsey experts point out that digitalization can increase productivity growth by more than one percentage point per year, and by 2030, Europe could potentially add $2.7 trillion to its economic output if it develops artificial intelligence technologies in line with its current developments. Innovation is needed to create demand for high-skilled, high-paying jobs and limit potential inequality from the adoption of advanced technologies.

A number of authors have studied the EU Industrial R&D Investment Scoreboard in detail. Noting the comparative positions of European companies in the Investment Scoreboard (Moncada-Paterno-Castello & Hernandez, July 2018) emphasize that EU countries have improved the specialization of industrial companies over the past 10 years in the automotive and parts sector, healthcare equipment, pharmaceuticals, and biotechnology.

A ranking assessment of innovation development is analyzed in the publications : (World Intellectual Property Organization, 2020).

The overall index score also establishes a positive relationship between innovation and development. According to these criteria, countries are divided into 4 groups: innovation leaders, fulfillment of expectations above the level of development; fulfillment of expectations on the level of development; results below expectations on the level of development.

The Readiness for frontier technologies index (United Nations Conference on Trade and Development, 2021) is quite interesting from the technological point of view and acquired skills.

As a result, we see that a great deal of attention is paid to measuring the level of innovation development in various index evaluation methodologies, which allows for high-quality comparative analysis.

In order to manage the issues of innovation development of EU countries, we see that a number of policies have been formed, namely:

-Cohesion policy, to address economic and social disparities. The funds distributed through it support regions with below-average GDP (European Commission, 2017).

- In the face of geopolitical changes, the current focus of the European Union's Research and Innovation (R&I) Policy is related to technological and economic trends and developments (Hessels et al., 19 May 2020)

- On May 6, 2015. The European Commission launched A Digital Single Market Strategy for Europe (DSM), based on three pillars 1) better access for consumers and businesses to online goods and services across Europe; 2) creating the right conditions for digital networks and services to thrive, and 3) maximizing the growth potential of Europe's digital economy (Maria Rosaria Della Porta et al., 2020).

- A similar program in the field of NGI infrastructure formation. This is an ambitious research and innovation program with an EU investment of more than €250 million in the initial phase between 2018 and 2020 and is an important part of the upcoming Horizon Europe program (2021-2027). The focus has been on cutting-edge technology to turn the Internet into an “Internet for People.” The initiative addresses privacy and trust, search and discovery, promoting decentralized architectures, blockchain, the Internet of Things (IoT), social networks, and interactive technologies, as well as technologies that support multilingualism and accessibility. Strategic Research and Innovation Agenda (SRIA) of the European Open Science Cloud (EOSC) (European open science cloud, n.d.).

Despite the implementation of a number of programs, the Smart Growth Operational Program. 2014-2020, it is noted that the creation of innovations requires significant labor and financial resources. However, the expenditure of Polish enterprises on research and development is still low, amounting to only 25% of the EU average. In Denmark, the figure is 150%, in Sweden, it is 176%, and in the neighboring Czech Republic it is 77%. As a resultof the implementation of the Smart Growth Operational Program: “12 000 - minimum number of companies which will get support for research and innovation, 20 500 - minimum number of jobs to be created due to support within the framework of SG OP EUR, 4.4 billion euro –the amount of money which the companies will allocate for research and innovation using their own resources”. (Smart Growth Operational Program, 2014-2020).

The final document showing the statistical evaluation of innovation implementation

is the European Innovation Scoreboards (Güell, 2020). In the European Innovation Scoreboard, all countries are grouped according to the level of innovation activity: innovation leader, strong innovator, moderate innovator, and modest innovator.

The view of Bednář & Halásková (2018) on innovation performance, which is improved by R&D funding. The authors confirmed the hypothesis that the study of innovation performance together with R&D expenditures is based on its relevance, when R&D expenditures as a percentage of GDP are considered the driving force of production knowledge and, therefore, the increase in regional competitiveness.

A number of European authors Szopik-Depczyńska et al. (2020) also pay attention to the study of the level of innovation development of EU countries based on statistical data of the European Innovation Scoreboard. The authors conclude that the traditional methodology does not give accurate results, especially in studies based on different indicators divided into many groups.

Of scientific interest from the point of view of the implementation of the strategy and tactics of innovative development are studies on EU countries by Kogut-Jaworska & Ociepa-Kicińska (2020); Innovation 2020 (2020). Polish researchers note that regional strategies of innovation and smart specialization (RIS3) are seen as one of the key tools for implementing the concept of smart and sustainable growth. The strategies allow focusing investments on research, development, and innovation (RD&I) in areas demonstrating the greatest economic and competitive potential of regions (Kogut-Jaworska & Ociepa-Kicińska, 2020).

The Innovation 2020 (2020) study notes that Ireland will become a global innovation leader, a strong, sustainable

economy with high employment, and a better society with a good quality of life, thanks to the progress of the national innovation system by building research capacity. Innovation contributes significantly to employment growth, exports, and investment; to the competitiveness of local manufacturing, the creation of a foreign direct investment base in Ireland, and the creation and application of new knowledge and technology.

2. Methods

Cluster analysis of the innovative development of EU countries

The methodology of the research of innovative development of EU countries was carried out by means of cluster analysis. The purpose of the cluster analysis is to determine the comparative positions of EU countries by the level of innovation development by grouping into clusters and identifying the same parameters across countries and their fundamental differences between clusters.

The information base of the study in this article used the rating estimates of 27 EU countries The Global Knowledge Index (UNDP, 2021) includes 8 sub-indices:

Var 1 - general rating;
Var 2 - rating of pre-university education;
Var 3 - technical and vocational education;
Var 4 - higher education;
Var 5 - research, development, and innovation;
Var 6 - information and communication technology;
Var 7 - economics;
Var 8 - the surrounding infrastructure.

The sub-indices are standardized and do not require further processing and randomization of information, as they are objective in nature. These sub-indices allow us to establish the relationship of knowledge, technology, and the level of innovation on the economic development of countries. Innovative development is always higher in countries where great attention is paid to all types of education, the development of technical skills. The countries, in which the high level of introduction of information and communication technologies faster overcome the digital gap, carrying out researches and introducing innovations. On the part of the state, favorable internal conditions are formed, and additional financial resources are allocated, which contributes to the development of innovative infrastructure. Therefore, it is possible to determine the competitive positions in the clusters and dispositions of the countries in terms of the taxonomy of innovative development of the EU as a whole on the basis of the Global Knowledge Index, prepared by the United Nations Development Programme's (UNDP) in 2021.

Based on the Global Knowledge Index rankings, we sampled 27 EU countries (Table 1).

Countries	Var1	Var2	Var3	Var4	Var5	Var6	Var7	Var8
Sweden	70	80,7	63,7	69	56,4	70,3	69,7	85,6
Finland	69,9	82,7	68,8	64,1	51,7	74,3	67,9	85
Netherlands	69,5	80,7	70,6	68,5	52,7	68,5	67,9	81,2
Denmark	69	81,7	62	66	50,6	70,3	74,5	82,5
Luxembourg	67,3	71,3	65,6	68,4	50,2	70,6	67,5	82,3
Germany	66,9	77,5	72,8	64,8	48,4	60,4	69,8	78,9
Austria	66,8	73,2	71,3	67,3	46,7	65	68,4	80,7
Estonia	66,7	77,3	65,9	64,8	46,9	71,1	67,6	76,2
Belgium	65,5	80,7	67,4	65,6	45	58	68,4	77,1
France	64,9	81,5	61,4	61,5	47,8	62,6	68,2	75,1
Slovenia	63,7	80,3	64,7	60,1	43,6	60,6	65,8	74,8
Czech Republic	62,4	78,8	66,6	67,6	42,7	56,8	64,7	73,5
Malta	61,9	78,5	53,7	60,2	41,1	59,1	71,5	72,3
Portugal	61,8	78,8	62,7	63,5	38,3	55,7	61,7	77,4
Spain	61	75,1	63	56,6	40,8	60,7	62,2	72,9
Hungary	60,2	74,2	71	50,6	39,2	56,9	64,7	67,6
Latvia	60,1	78,8	65,2	53,7	37,4	58,5	64	65,2
Slovakia	59,8	77,7	70,5	53,8	35,4	54,4	60,7	69,2
Poland	59,6	79,2	58,7	55,9	34	62,9	60,7	68,5
Cyprus	59,3	73,4	53,6	52,8	40,1	64	66	68,2
Lithuania	59,1	70,9	55	59,4	32,2	61,3	65,2	74,3
Italy	58,88	74,9	60,3	52,9	46,2	53	60	68,5
Croatia	58,5	75,5	62,3	55,5	36	57	59,3	66,3
Bulgaria	55,8	58,5	57,8	60,9	39,1	55	59,2	62,1
Romania	54,3	56,5	55	57,7	36,3	52,6	62	64,2
Greece	51,5	66,1	47,1	48,7	37	51,2	50,1	64,8

Table 1: Ranking of the Global Knowledge Index 27 EU countries
Source: (UNDP, 2021). Global Knowledge Index, 2021, p. 5.

The World Intellectual Property Organization index (WIPO, 2020) is similar in nature.

The presented ranking contains a subindex Innovation Links, which is used in our study. The subindex is represented by the following indicators:

Var 1 - innovation connections;
Var 2 - cooperation between universities and industry;
Var 3 - status of cluster development;
Var 4 - R&D financed from abroad, % of GDP;
Var 5 - JV-strategic alliance deals/milliard of GDP by PPP;
Var 6 - Patent Families 2+, bln. GDP at PPP.

The above Innovation Linkages subindex provides us with an opportunity to assess practical cooperation in the implementation of innovation strategies. This rating can serve as the basis for further analysis and comparison of countries, systematizing them into groups by determining the nature of

innovative cooperation.

Based on the Innovation Linkages subindex of the Global Innovation Index, we sampled 24 EU countries (Table 2). For other countries, there is no information in the rating.

Countries	Var1	Var2	Var3	Var4	Var5	Var6
Austria	12	19	15	3	56	13
Belgium	15	12	17	6	29	15
Bulgaria	40	63	41	14	80	48
Czech Republic	23	37	66	1	74	29
Denmark	9	10	12	11	15	12
Estonia	34	48	82	19	22	32
Finland	3	3	20	8	9	7
France	24	26	23	23	26	16
Germany	13	8	3	21	30	9
Greece	80	119	118	24	62	38
Hungary	51	57	65	18	86	36
Italy	27	40	1	25	50	18
Latvia	39	41	57	27	28	43
Lithuania	37	34	92	15	34	35
Luxembourg	6	9	10	45	8	1
Netherlands	7	5	6	10	23	1
Poland	72	87	67	47	65	34
Portugal	47	32	36	38	64	30
Romania	106	69	103	55	94	57
Slovakia	77	94	68	40	116	37
Slovenia	32	42	73	13	46	25
Spain	50	67	33	37	54	31
Sweden	2	7	18	7	3	1
Cyprus	19	75	59	32	4	22

Table 2: Indicators of the Innovation Links subindex of the Global Innovation Index for 24 EU countries
Source: (Dutta, Lanvin & Wunsch-Vincent (ed.), 2020).

With the help of this sample, we made a grouping of countries by determining their positions in the implementation of innovation policy. Clustering of countries in this case is necessary to determine the degree of proximity in the development of countries on a number of criteria to determine their further integration with each other. Clustering will help systematize countries according to their integration priorities.

Let us choose the most appropriate method of cluster analysis for a small sample. The cluster analysis was conducted in the STATISTICA 13.0 program in the module CLUSTER Analysis using the k-means method. The distances between clusters were calculated using the Euclidean metric. On the basis of this sample, we will group the countries according to their positions in the implementation of innovation policy. Let's choose the method of cluster analysis most suitable for a small sample. The criterion of optimality of the cluster model is the minimization of variability within clusters and maximization of variability between clusters:rij→min,Rij→max.

3. Results and Discussion

3.1. Main indicators of innovative development of EU countries and their assessment

The main parameters of clusters selected in the model are represented by the following criteria: the density of objects in hyperspace; the volume that the cluster occupies; the connectivity of elements in the middle of the cluster; the distance between clusters compared to their diameters. The main indicator to estimate the distance between clusters in the model is the Euclidean metric, estimated by the formula:

Where xil,xjl–values of the l-th attribute in the i-th (j-th) object (l=1,2,..k,i,j=1,2,…n).

$$\rho_E(x_i, x_j) = \sqrt{\sum_{l=1}^{k}(x_{il} - x_{jl})^2},$$

Several iterations resulted in a model consisting of three clusters. The spatial model of the cluster analysis is shown in Fig. 1.

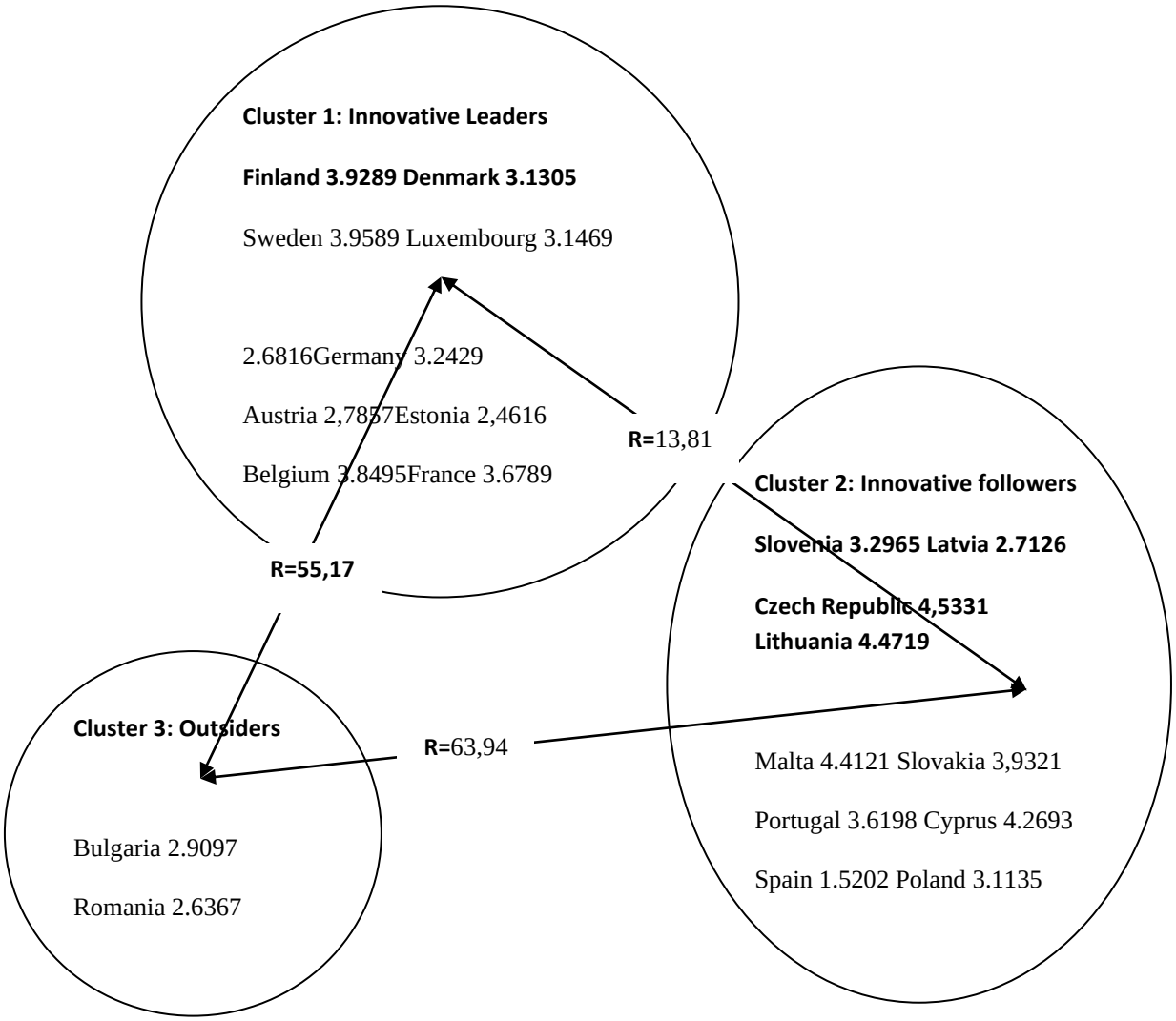

Figure 1: Spatial model of cluster analysis of 27 EU countries according to the Global Knowledge Index

Based on the spatial model of cluster analysis, we interpret the results of the cluster analysis on the assessment of the 27 EU countries of the Global Knowledge Index sub-indexes as follows:

Cluster 1 includes countries that implement the strategy of innovative leadership. This cluster includes the countries, which initially stood at the basis of the creation of the EU in the first and second waves, and initially their level of economic development was high enough, which allowed them to form and strengthen innovative potential. Of the countries in this cluster, the position of Estonia should be noted since the high level of school training allowed the formation of a high-level IT market and information and telecommunication infrastructure.

Cluster 2 included the EU countries of the third and fourth waves of enlargement. Inclusion in the EU of these countries allowed to raise the level of education, thanks to the reforms and programs of the EU. As a result, the countries were able to raise the level of economic development through the introduction of innovation. This cluster also includes the PIGS countries: Portugal, Spain, and Italy (except Greece). The countries of this cluster implement strategy of innovative followers.

Cluster 3 includes Bulgaria, Romania, and Greece countries innovative outsiders.

If we look at the external differences between clusters, the third cluster is quite distant from the first and second clusters, because the countries in this cluster have a low level of economic development.

The average indicators for the clusters are shown in Figure 2.

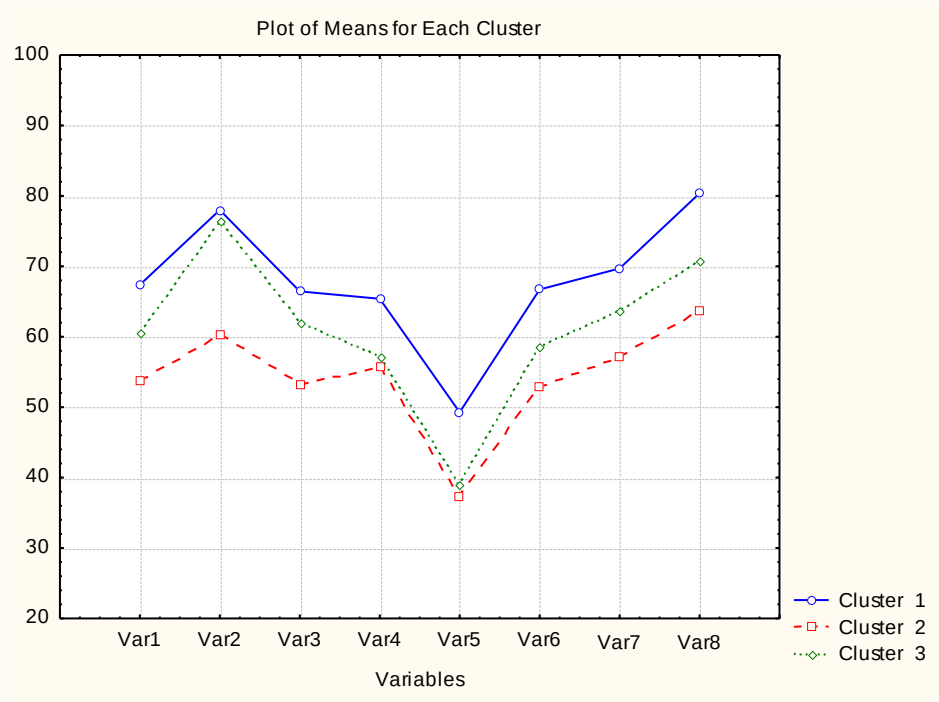

Figure 2: Average values by cluster

According to the results of the average values for the clusters, based on Fig. 3, according to the indicator of cooperation between universities and industry, clusters 1 and 3 are close, like cooperation on EU countries with Bulgaria, Romania, and Greece is implemented in the framework of ERASMUS+ programs in order to close the innovation gap. However, in terms of average values, the differences between the clusters are rather small, since the rating assessment is in points.

In order to assess innovation strategies more effectively, we will conduct a cluster analysis of innovation strategies based on the Global Innovation Index Innovation Links subindex.

The results of the analysis will be presented in Table 3.

Cluster3		Cluster1		Cluster2	
Austria	14,0214	Poland	13,5811	Greece	19,9340
Belgium	5,4986	Czech Republic	15,4907	Bulgaria	17,2683
Denmark	5,0433	Estonia	14,2955	Romania	17,0742
Finland	9,7725	Hungary	16,5356	Slovakia	15,9174
France	9,1470	Latvia	10,5480		
Germany	5,4560	Lithuania	15,9037		
Italy	17,4786	Portugal	15,8396		
Luxembourg	14,5213	Slovenia	8,0619		
Netherlands	6,4783	Spain	15,7489		
Sweden	11,5586	Cyprus	23,2986		

Table 3: Cluster analysis of the Innovation Links sub-index of the Global Innovation Index
Source: Authors' own calculations

Based on the assessment data in Table 3, we see that Cluster 1 has quite different densities for this indicator, where the innovation leaders are Germany (5.45604), Belgium (5.49864), and Denmark (5.04331), because.

Innovation links in these countries are higher due to the development of cooperation between universities and industry, which leads to the formation of innovation clusters through R&D funding and technology licensing.

Overall, the distance between cluster 1 and cluster 2 is almost the same, while the distance between clusters 1, 2 (30.93), and 3 is twice as high (61.077).

The average values across clusters for the Innovation Linkages subindex are reflected in Fig. 3.

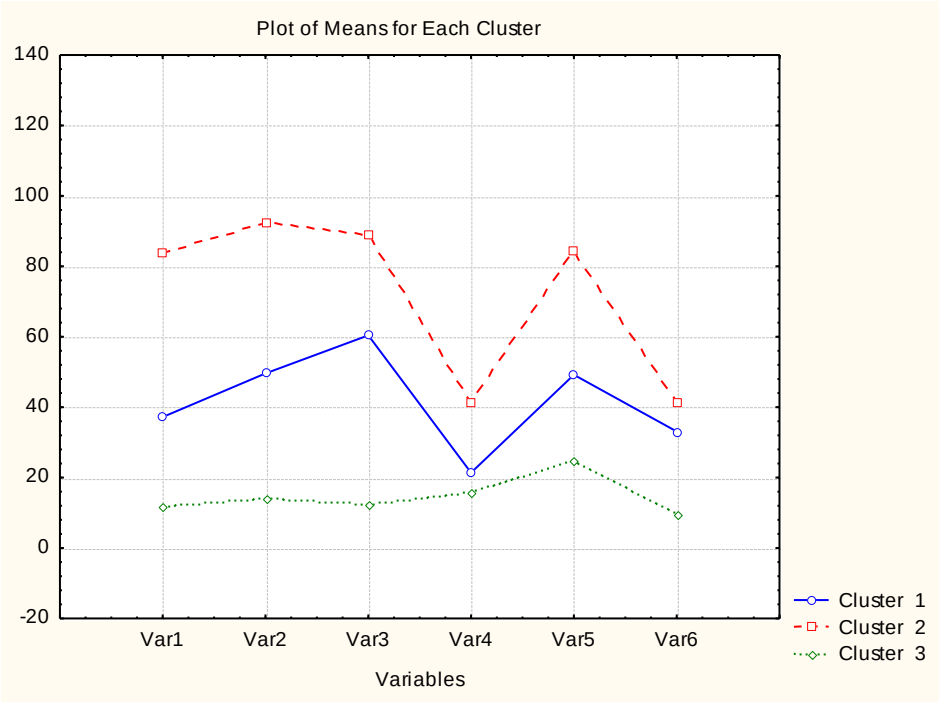

Figure 3: Average values by cluster

Unlike the first cluster model, in this model, the density of average values shows significant differences between clusters in this indicator and reflects the positions of countries in the clusters.

4. Conclusion

Based on the methods of comparative and cluster analysis, the article assessed 27 EU countries on the indicators of the Global Knowledge Index, developed by the UNDP, and the indicators of the sub-index Innovation Links, developed by the World Intellectual Property Organization. Based on the cluster analysis conducted in several iterations, three clusters of countries that implement strategies were identified: innovation leaders, innovation followers, and innovation outsiders.

In the implementation of innovation strategies, EU countries have achieved a reduction in the innovation gap through the development of joint projects and programs aimed at improving innovation processes. The spatial cluster model showed a fairly high density within clusters and a fairly high level of difference between clusters, which correlates with the stages of EU accession and respectively the level of economic development.

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