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Influence of Eurointegration Processes on Scientific Support of Digitalization of the Public Sphere and Education

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ABSTRACT
The article aims at determining the impact of scientific support on the development of digital economy in Ukraine and in other countries. Research methods used are the following: analysis and comparison, correlation analysis, grouping and clustering, statistical and graphical methods. It has been determined that China, the United States and the European Patent Office provide 70% of all the patents issued in the field of Digital communication. The rating of countries depending on the number of patents issued in Digital communication per million people shows that the leaders in this field are the Republic of Korea (147.60), the United States (105.67), and Japan (56.25). The ratingof countries by the number of research articles in Computer Networks and Communications per million people shows that the leaders here are Luxembourg (317.46), Finland (220.83), and Singapore (213.53).Having analyzed the impact of patent and research activity on digital economy development, as assessed by the ICT Development Index and the Networked Readiness Index, we have come to conclusion that these indicators have a weak correlation. To better understand this impact, a cluster analysis of the obtained results has been carried out, dividing the countries into groups depending on the data of the ICT Development Index, Networked Readiness Index, and indices characterizing the scientific support of digital economy (the number of research articles in Computer Networks and Communications per million people and the number of patents issued in Digital communication per million people). The cluster analysis has allowed us to identify four

groups of countries,the difference lying in the level of digital economy development and the scientific support provided. The countries included in Cluster 1 are characterized by the dependence of the level of digital economy development on the results of research activity; the countries in Cluster 2 have high levels of both research activity and digital economy development; the countries in Cluster 4 have low levels of both research activity and digital economy development. The authors of the article give recommendations as for the revival of research activity in the digital economy field.
Keywords:digital economy, patent activity, scientific support,Public Administration, European integration processes, state policy in the field of digitalization, e-government.

1. INTRODUCTION

According to the EU SCIENCE HUB [1], the development of the Internet as a means of modern communication, the reduction of computing costs, the spread of everyday mobile applications, the growing role of social networks and commercial platforms for business and the public, the emergence and introduction of new digital technologies such as the Internet of things, artificial intelligence and big data have a significant impact on business, public institutions, personal life and economic performance,in general. The European Commission [2] notes that the digital economy is a wide-ranging concept,applying not only to the ICT, content and media, e-commerce and e-business, digital services, etc., but also to all the traditional sectors of economy that use digital technologies for all economic processes, transactions, interactions and activities. According to the OECD [3], digital economy, unlike e-economy, is based on using any digital tools, while e-economy is based on using the Internet. The European Commission (WadimStrielkowski, Gryshova I.(2018)), in the framework of the Digital Single Market Strategy, determines the following key development trends: introducing digital technologies that work for people; introducing a fair and competitive digital economy; forming an open, democratic and sustainable digital society; Europeas a global digital player. The main characteristics of forming digital economy in the frame work of the European strategy for the digital single market are the following:
Spreading the trends of investing in the digital competence development; enhancing the role of protection against cyber threats; raising the responsibility of Internet platforms and online services for there liability and accuracy of information; introducing artificial intelligence out of concern for human interests; accelerating the use of high-speed broadband networks; using digital capacity to develop innovative solutions in medicine, transportation and environmental protection; increasing community activity in developing digital startups and implementing innovations; ensuring fair competition of the EU companies; expanding access to high-quality data alongside with the protection of personal and confidential data; providing the collection of data on public health to foster targeted research, revealing and treating diseases [Azer Dilanchiev, Gryshova Inna, Rogach Svetlana, Diachenko Oleksii, Batrakova Tetyana, Shabatura Tatyana. 2020; But as information society is developing, “digital inequality” between the regions of the world, individual countries, companies, and citizens is growing.

Digital inequality is assessed by international organizations through using various indices. The most famous among them are the ratings of countries, based on the following international indices: ICT Development Index (IDI); Networked Readiness Index (NRI); Digital Economy and Society Index (DESI); IMD World Digital Competitiveness Index (WDCI); Digital Evolution Index (DEI); the UN Global E-Government Development Index – (EGDI); E-Participation Index (EPART); Economic Digitization Index of Boston Consulting Group (e-Intensity); Global Connectivity Index (GCI, Huawei). International rankings differ in the selection of baseline indicators (i.e., characteristics of the level of using digital economy achievements in a country) and their grouping into sub-indices. Criteria for assessing digital inequality are the following: the availability of hardware and software; the autonomy of access to them; information technologies skills; social support in developing information technologies skills; purposes of using information technologies, etc.

Problems caused by the rise in digital inequality in various countries have been analyzed by Colin N., Landier A. et al. [7], Bukht R., HeeksR. [8], [9] , Benčič S., Kitsay Y. et al. [10], Bilozubenko V., Yatchuk O. et al. [11],Brynjolfsson, E., Kahin [12], B. Foster Ch., Azmeh Sh. [13]. Researchers determine that digital inequality is caused by many factors, but it is based on property, economic and social inequality. Lack of the required knowledge level, and limited access to education and tothe new hardware and software cannot but affect the formation of inequality in the new information sector. Research carried out by the Joint Research Center shows a doubling of ICT-related innovations. The average annual business expenditure on research, development and engineering in the ICT sector of the EU economies is 17% of total expenditure, and innovation in the ICT sector is up to 26% of total innovation production. The complex research program designed by the Joint Research Center includes analysis of the following points: research and development costs of the EU and other countries for ICT; the number of ICT patents; the dynamics of international ICT research; development of models and forecasts of economic indicators in ICT. Innovative processes and business activities introducing new digital technologies are also studied. The Joint Research Center notes that one of the most reliable and well-recognized sources of information on technological dynamics and the impact on the digital economy formation is data on patent activity in the field of ICT. The Digital Agenda for Europe [14]facilitates spending on research, development and engineering, and growth in the number ofICT research and development products.

Many researchers, who study the factors influencing the digital economy development, note the importance of scientific and technological support (Gryshova, I.; Kofman, B.; Petrenko, O.,2019).,(Dr. Tetiana Tielkiniena, Gryshova Inna, Shabatura Tatyana, NehodenkoViktoriia, Didur Hanna, Shevchenko Alisa,. 2020);But a number of the problems associated with the causes of inequality remain unidentified and unresolved. For example, the impact of scientific support on the digital economy development has not been defined yet. We make a hypothesis that countries with a high level of digital economy should have significant results in publishing and patent activity in this field.

Thus, the purpose of the research is to determine the impact of scientific support on the digital economy development in the world, in general, and in Ukraine, in particular. (AzerDilanchiev, Gryshova Inna, Rogach Svetlana, Diachenko Oleksii, Batrakova Tetyana, Shabatura Tatyana, 2020).

The objectives of the research determined the following tasks: to rank the countries by the level of research and patent activity; to determine the dependence of indices that characterize the level of the digital economy development on the number of patents and research articles on digital technologies; to divide the countries into groups depending on the level of the digital economy development and its scientific support; to provide recommendations for raising the digital economy level depending on the results obtained.

2. MATERIAL AND METHODS OF THE RESEARCH

Having analyzed a large number of international indices assessing the level of digital economy development, globally, we have chosen two indices as the basis for the analysis in this study, namely, the ICT Development Index (IDI), developed by the International Telecommunication Union [18], and the Networked Readiness Index (NRI), recommended by the Portulans Institute [19]. The choice of these indices is determined by the following criteria: the scope of the countries, the level of confidence in the index developer, completeness and reliability of indicators included in the index.(Wadim Strielkowski, Gryshova I..2018)

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The ICT Development Index is a composite indicator demonstrating the countries' achievements in the development of information and communication technologies (ICT). IDI calculations are made according to the methodology designed by the International Telecommunication Union, which is a specialized UN department with a task to determine global standards in ICT.

IDI was developed in 2007 on the basis of 11 indicators related to the access to ICT, their usage, and skills required, i.e. the population's level of practical knowledge of these technologies in the countries under study. IDI can be used as a tool for benchmarking study at the global, regional and national levels, allowing countries to monitor changes in time course. The study presents IDI data in 176 countries. The composition of the index and the methods of measuring ithave been under revision recently, and the annual publication of IDI results is planned to be resumedin 2020.

The second index under study is the Networked Readiness Index, a complex indicator characterizing the level of ICT development and the global level of network economy development. The NRI was designed in 2002 as a result of collaboration between the World Economic Forum and the INSEAD international business school as part of the annual reports on the global information society development. Since 2019, the NRI has been thoroughly updated and is now calculated by the Portulans Institute [19], a non-profit organization, in partnership with the World Information Technology and Services Alliance. NRI is considered to be one of the most important indices to assess the countries' innovation and technological potential in the field of high technology and digital economy.

The NRI measures the level of ICT development upon 62 indicators, which are clustered into four main groups: technology, people, management, impact. The calculation of the Index is based on statistical data of international institutions, as well as on the results of the annual polling of the organizations heads in the countries that are the objects of the research. The NRI authors relyupon the assumption that there is a close link between the ICT development and the economic well-being of a country. The authors of the article point out the leading role of the ICT in the following fields: innovation development;raising productive efficiency of labor and competitiveness of enterprises; economic diversification and stimulating business activity.Thus, the ICT helps to improve the living standards of acountry's population. The research is being carried out in 121 countries.

The number of research articles and patents in the field of digital technologies has been considered as a scientific support for the digital economy development. The correlation between research results and patent activity has been proven by many authors, including Meyer M. (Gryshova, I.; Shabatura, T.; Girdzijauskas, S.; Streimikiene, D.; Ciegis, R.; Griesiene, I., 2019), whereas the correlation of the former and the index of research activity has been substantiated by (Gryshova, I.; Kofman, B.; Petrenko, O, 2019).The ranking of countries,madeaccording to the ICT Development Index and Networked Readiness Index, as well as to SCImago Journal & Country Rank [23] and World Intellectual Property Organization databases,has provided the analytical framework of the study.(Gryshova, I.; Demchuk, N.; Koshkalda, I.; Stebliuk, N.; Volosova, N., 2019)

Research methods are the following: analysis and comparison, correlation analysis, grouping using clustering methods, statistical and graphical methods.

3. RESULTS AND DISCUSSIONS

Scientific support for the digital economy development throughout the world isassessed with respect to the number of research articlespublished and patents received in the field of digital technology. A study of patent activity in Digital communication in 2018, according to the World Intellectual Property Organization [24],has shown that patents on an invention were issued in 52 countries. The total number of patents issued in this field in 2018 was 144,994 patents, of which China obtained 55,466 patents (or 38.3%), the US obtained 34,521 patents (23.8%), and the European Patent Office granted 11,394 patents (7.9%). The study uses the rate of patents issued in Digital communication per million people,so that the size of economies can be taken into account, making it possible to compare patent activity by country. The ranking of countries upon this index is shown in Fig. 1.

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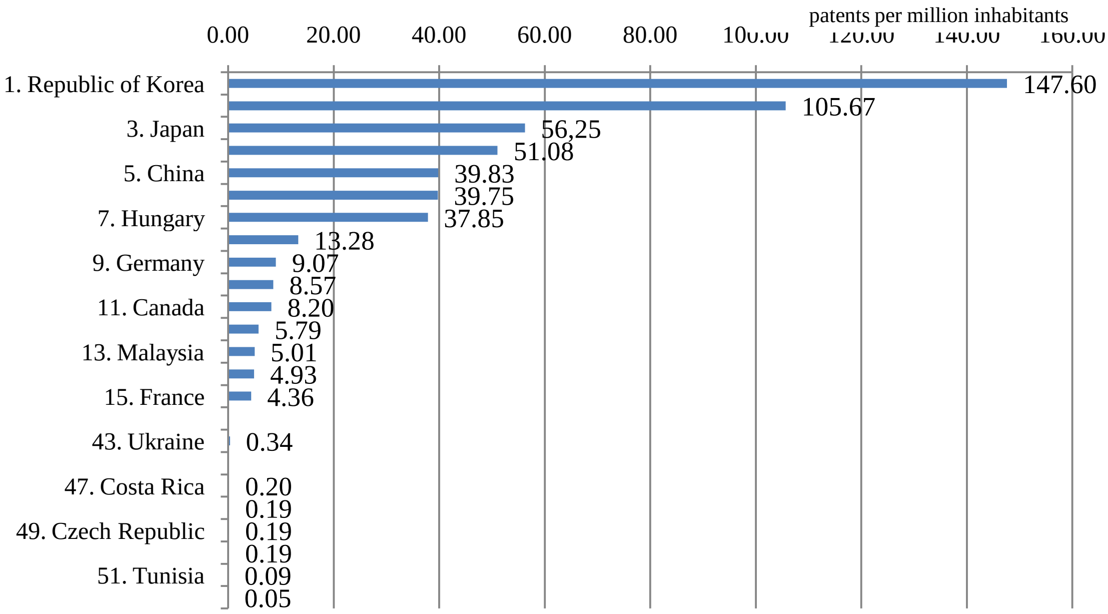

Fig.1 Number of patents issued in Digital communication, per million people
***Source*:WorldIntellectualPropertyOrganization[24]**

The results obtained show that the largest number of patents in Digital communication per million people was issued in the Republic of Korea (147.60), the second place is taken by the United States (105.67), while the third place is taken by Japan (56.25). Ukraine ranks 43rd out of 52 countries by the number of patents issued in Digital communication per million people (0.34 patents per million).

The study of research activity in Computer Networks and Communications, carried out in 2018 under the SCImago Journal & Country Rank [23], shows that research publications were made by scientists from 168 countries. The total number of research publications in this area in 2018 amounted to 167,932 articles, globally, of which 32,554 articles (19.4%) belong to scientists from China, 22852 articles (13.6%) belong to those from India, and 18,587 articles (11.1%) belong to those from the United States. Only 52 countries, also showing patent activity, were used in the further analysis to compare the world countries. To compare research activity by country, with respect to the size of the economy, the number of research articles in Computer Networks and Communications published per million peoplehas been used as an indicator. Fig. 2 gives the ranking of the world countries made upon this indicator.

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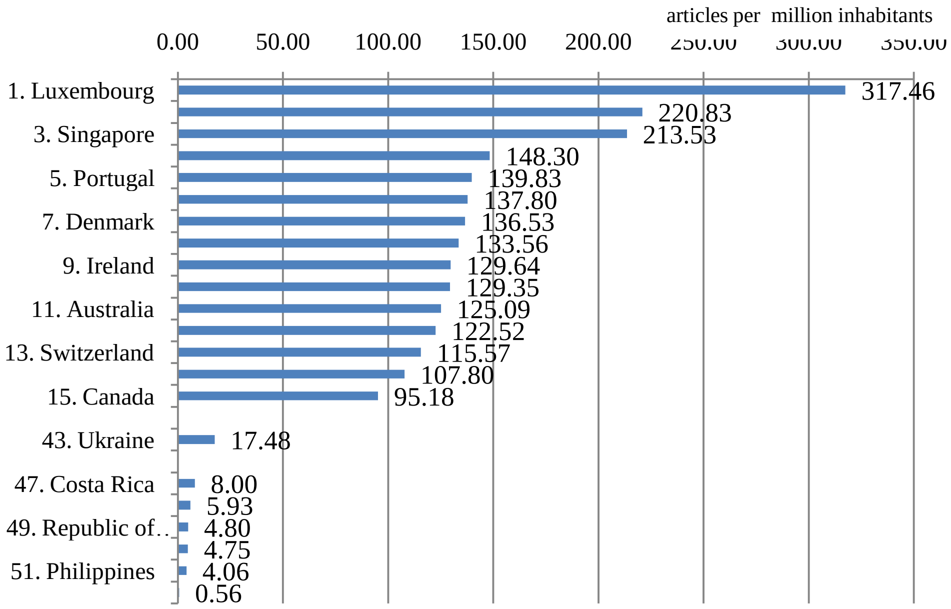

Fig.2 Number of research articles in ComputerNetworksandCommunications published, per million people
***Source*:Journal&CountryRank[23]**

The calculations made, as well as the ranking of the world countries provided (Fig. 2), demonstrate that the largest number of research articles in Computer Networks and Communications per million people were published in Luxembourg (317.46), Finland takes the second place (220.83), and Singapore the third place (213.53). Ukraine ranks 43rd out of 52 countries as to the number of research articles in Computer Networks and Communications published, per million people (17.48 articles per million).

The study of the impact of scientific support for the digital economy development (patent and research activity) in the world countries on the ICT Development Index and Networked Readiness Index has been conducted through using correlation analysis. The calculation of Pearson’s correlation coefficient between the number of patents issued in Digital communication per million people and the indices characterizing the level of digital economy development (ICT Development Index and Networked Readiness Index) hasdemonstrated a weak correlation, reaching 0.26 and 0.28, respectively; Pearson’s correlation coefficient between the number of research articles published in Computer Networks and Communications per million people and the ICT Development Index was 0.64; the same coefficient between the number of respective articles and Networked Readiness Index was 0.69.

Thus, we can conclude that scientific support does influence the digital economy development in the world countries, but this influence is insignificant. To better understand this influence, the authors of the article suggest making cluster analysis of the results obtained and divide the countries into groups taking into account the data of indices, characterizing the digital economy development (ICT Development Index and Networked Readiness Index), and indicators, characterizing the scientific support for digital economy (the number of research articles published in Computer Networks and Communications per million people; and the number of patents issued in Digital communication per million people), using the Statistica package 10.

In order to determine the number of clusters and the countries’ proximityas to the scientific support for digital economy, a hierarchical classification has been made using the unifying frameworkand the complete linkage method (the Euclidean distance taken as the proximity measure). The presented results allow us to assume that countries form four natural clusters depending on the level of scientific support for the digital economy development.

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This assumption has been checked using the K-means method, on the one hand, which consists in calculating k randomly selected observations (for the purposes of our research$k$ = 4), the latter becoming the centers of the groups of countries; and changes in the object composition of clusters, on the other hand,in order to minimize the variability within clusters and maximize the variability between clusters. A graphical estimate of how different the clusters are is shown in Fig. 3.

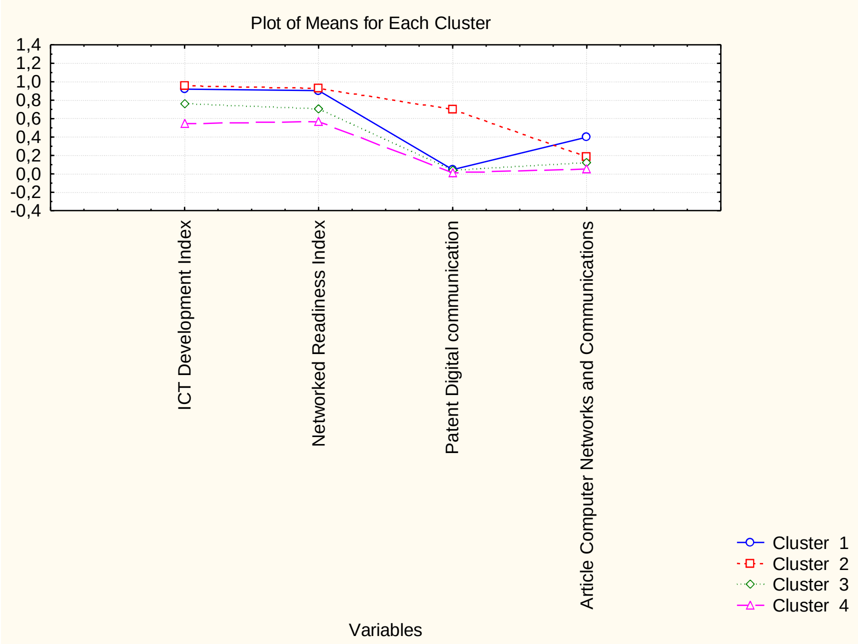

Fig. 3 Plot of means for the defined clusters
***Source*: calculatedby the authors**

The results of clustering obtained by the K-means method have been estimated on the basis of the analysis of variance (table 1).
The table demonstrates that the value of p is <0.05, which indicates insignificant difference between the clusters.
The clusters elements together with their characteristics are given in Table 2.

Table 1. Analysis of variance used to determine the significance of the differences between the obtained clusters

Index	BetweenSS	cc	F	Significance level$p$
ICT DevelopmentIndex	1,006625	0,143432	112,2905	0,000000
NetworkedReadinessIndex	0,936561	0,216898	69,0876	0,000000
PatentDigitalcommunication	1,246815	0,475503	41,9536	0,000000
Article Computer Networks and Communications	1,135689	0,858374	21,1691	0,000000

Source: calculatedby the authors

Table 2. The clusters elements and their characteristics

Cluster number	The world countries included in the cluster	The cluster characteristics

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ClusterNumber 1	Australia, Austria, Belgium, Canada, China (Hong Kong), Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Israel, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Singapore, Slovenia, Sweden, Switzerland, United Kingdom	The countries included in the cluster are characterized by a high level of the digital economy development, they actively implement the results of their own inventions (the level of publication support for digital economy development here is higher than the one in other countries), but the patent activity of these countries is lower than the one in the leading countries.
ClusterNumber 2	Japan, Republic of Korea, United States of America	Thecountriesincludedintheclusterarecharacterizedbyahighlevelofthe digitaleconomydevelopment, theyactivelyimplementtheresultsoftheirowninventions(the patent activity level in these countries is much higher than the one in other countries; the research activity level is also high).

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ClusterNumber 3	Argentina, Chile, China, Costa Rica, Czech Republic, Hungary, Italy, Latvia, Malaysia, Poland, Moldova, Romania, Russian Federation, Serbia, Slovakia, Spain, Turkey	Thecountriesincludedintheclusterarecharacterizedbyamoderatelevelofdigitaleconomydevelopment, theyactivelyimplementdigitaltechnologiesintolife, buttheirscientific support for the digital economy development remains at a lower level than the one in the leading countries.
ClusterNumber 4	Brazil, Colombia, Dominican Republic, Mexico, Morocco, Peru, Philippines, Tunisia, Ukraine	Thecountriesincludedintheclusterarecharacterizedbyalowlevelofthedigitaleconomydevelopment, theyimplementdigitaltechnologiesinamuchslowerwaythanthemajorityofthecountriesanalyzed, theirscientific support for the digital economy development remains at a lower level than the one in the leading countries.

Source: made by the authors

The study confirms that there is a correlation between the research activity results, consisting in articles published and patentsissued in the Digital technologies, and the level of the country's digital economy development. This correlation is most noticeable for the countries included in Cluster 1 and Cluster 2 (which demonstrate a high level of scientific support and that of the digital economy development), and Cluster 4 (which demonstratesa low level of scientific support and a low level of the digital economy development).

For the countries included in Cluster 4, and Ukraine among them, the following recommendations can be provided to raise the level of the digital economy development: they should increase spending on research and inventions in the Digital technologies field; involve business in financing research and invention in the Digital technologies field by providing tax benefits to enterprises that implement digital innovations; create integrated "science-business-state" systems, engaged in the commercialization of research and innovations in digital technologies in both the traditional and information sectors of the economy.

4.CONCLUSIONS

The research made allows us to draw the following conclusions:
1. The inequality in the level of the digital economy development in different countries has been substantiated.
2. It has been determined that China, the United States and the European Patent Office provide 70% of all the patents issued in Digital communication. But the ranking of the world countries by the number of patents issued in Digital communication per million people demonstrates that the Republic of Korea is the leader of the ranking (147.60), the United States take the second place (105.67), and Japan takes the third place (56.25) . Ukraine ranks 43rd out of 52 countries (0.34 patents per million people).
3. The ranking of the world countries by the number of research articles in Computer Networks and Communications per million people shows that Luxembourg takes the first place (317.46), Finland takes the second place (220.83), and Singapore takes the third place (213.53). Ukraine ranks 43rd out of 52 countries.
4. Having analyzed the impact of the patent and publishing activity on the digital economy development (ICT Development Index and Networked Readiness Index), we have found a weak correlation between these indices.
5. The cluster analysis has allowed us to identify four groups of countries that differ according to the level of the digital economy development and scientific support for such an economy. The dependence of the level of the digital economy development on the results of research activity in a country can be traced for the countries included in Cluster 1, Cluster 2 (having a high level of scientific support and a high level of digital economy development), and Cluster 4 (having a low level of scientific support and a low level of digital economy development).

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