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Integrated Evaluation of Innovative Development of the New EU Member States and Other EU Countries

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Abstract

This study investigates the problem of estimating various aspects and qualitative features of innovative development. A new methodological approach to comprehensively assessing the polystructural nature of modern innovative development in the new EU member states and other EU countries is proposed, which allows us to identify growth points and promising areas to increase their innovative development. Aspects such as information adaptability, innovative orientation, and synergetic efficiency are considered. The analysis is based on a logical evaluation of indicators that characterize science, technology, and the digital society in accordance with the data presented in the public domain, from which the main indicators that characterize these three aspects of the EU's innovative development were selected. According to the algorithm of the matrix method for the new EU member states and other EU countries, the maximum (reference) value was chosen for each indicator and the coefficient

of compliance with the reference value of a particular indicator was calculated. As a result, integrated indicators of assessing information adaptability, innovative orientation, and synergetic efficiency and the integrated indicator of innovative development of the EU countries were calculated, which allowed us to rate them. The innovative development of the economies of the EU countries differs significantly in some indicators and aspects. The assessment and comparison of innovative development at the national level depends on many factors but is primarily determined by public policy and national priorities of a particular country. That is why a promising direction of increasing the innovative development of all EU countries should be, first of all, the further development of their mutual exchange of technologies based on the existing integration scientific and technical potential.

Keywords: innovative development, information adaptability, innovative orientation, synergetic efficiency, integrated indicator of innovative development

JEL: F15, F55, K23, O32, O33, P51

Introduction

In the modern scientific and technological paradigm of global economic development, the driving forces of economic growth in the 21st century are the effective implementation of human, scientific, technical, financial, infrastructural, and managerial resources. The emergence of a new, sixth technological system contributes to the importance of innovative development for countries and regions around the world. Therefore, it is natural that new technology, science, and innovation in general, which today determine not only social development, but also the direction of evolution of mankind as a whole has a growing influence on the economic growth.

However, the parameters of this process are not fully understood. The process can include the speed of processing information, communicative mobility, the availability of new technologies, as well as the ability of the state to generate and effectively commercialize innovative ideas, technologies, and institutions.

Therefore, if we consider the methodological aspects of this problem, the focus should be on the fact that modern innovative development has a polystructural nature, due to the three most important aspects: information adaptability, innovative orientation and synergetic efficiency. Information adaptability is people's ability to perceive and analyze the flow of information and, on this basis, predict and implement technological changes in accordance with the level of motivation, preferences, and desires to maximize the usefulness of activities to increase profits from new technologies. Innovative orientation is the fundamental direction of economic development. It determines the relevant trend in society in which many of the results of activities are invested in the future by creating conditions to develop and commercialize education, science, and technology. Synergetic efficiency is the most important determinant of in-

novative development, as it makes it possible to obtain revenues from the development, commercialization, and implementation of new technologies.

All this seriously complicates the issue of assessing the innovative development of countries in a globalized world. The innovative achievements of a national economy are quite difficult to capture in single indicators because it is impossible to reflect and quantify the full range of innovations used within one country. And if they could be quantified, the lack of reliable data makes it impossible to comprehensively analyze them. Therefore, there is a problem of choosing and quantitatively interpreting such indicators, especially when it comes to countries of different levels of development that are members of the same integration association, e.g., Central and Eastern European Countries (CEECs), including the new EU member states such as Bulgaria, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, Croatia, the Czech Republic, and Estonia, and other EU countries. In this sense, the purpose of the article is to calculate integrated indicators that will take into account the general condition of the new EU member states and allow a rating assessment of their innovative development compared to other EU countries.

Literature review

Currently, the innovative development of different countries are assessed in the context of world rankings by individual factors. Europe needs to adapt to tactical growth factors nowadays – to the technological innovation and to achieving the desideratum of the Union (Rădoi and Șerban 2019, p. 35). The success of regional development is highly dependent on the ability of human resources in districts to innovate district government organizations (Badrudin and Hale 2019, p. 986). Thus, the issues of evaluating innovative development are considered by the US Council on Competitiveness, the European Institute of Business Management (INSEAD), the Institute of Management Development (IMD), the Economist Intelligence Unit (EIU), and the World Economic Forum (WEF), in compiling indexes of global competitiveness of different countries.

According to the analysis, there are many methods to assess a country's innovative development, including the Technology Achievement Index (TAI) (United Nations 2019), The Global Innovation Index (GII), introduced by the European Institute of Business Administration (INSEAD, WIPO 2019), The Good Country Index, developed by Anholt (USA), with the help of Hovers (The Good Country 2019), The Knowledge Economic Index, developed by the World Bank (The World Bank 2019), the European Innovation Scoreboard, developed in the Netherlands (European Commission 2019), structural analysis of the innovative activity of the territory, proposed by Kortov (Kortov 2004), and The Information and Communication Technology Opportunity Index (ICT-OI) (World Information Society Report 2007).

There are also widespread methods of calculating indexes, which can be used to draw conclusions about the innovative development of countries, e.g., the method of calculating the index infostate – an index used to measure the Digital Divide, proposed by Orbicom, the International Network of UNESCO Chairs in Communications (UNESCO 2019), The Information and Communication Technology Development Index (IDI) calculation method is based on the International Telecommunication Union (ITU) method and includes three sub-indexes: ease of access, use and practical skills (International Telecommunication Union 2019c); methodology for calculating the Information Society Index (ISI), which includes 15 indicators grouped into four categories: computers, telecommunications, Internet, social development of society (IDC 2018); method of calculating the Digital Access Index (DAI), which includes four groups of indicators: infrastructure, accessibility, knowledge and quality, the actual use of ICT (International Telecommunication Union 2019a); E-Readiness Index (ERI) or Digital Economy Ranking (DER) calculation method, which contains six components: connection infrastructure and technologies; business environment; social and cultural environment; legal environment; public policy and strategy; acceptance by society and business, developed by the EIU (World Economic Forum 2019a)); methodology for calculating the E-Government Development Index (EGDI), which includes three groups of indicators: the degree of coverage and quality of Internet services, the level of development of ICT infrastructure, human capital (UN Department of Economic and Social Development 2019); Methodology for calculating the Networked Readiness Index (NRI), calculated by WEF and INSEAD based on statistics from the UN and other organizations, as well as the results of the annual survey of managers on 68 parameters, combined into three groups: environment, state, business and civil society use of ICT, use of ICT by the state, business and civil society (World Economic Forum 2019b); Digital Opportunity Index (DOI) calculation method based on the calculation of three sub-indexes: capability, infrastructure and use (International Telecommunication Union 2019b); ICT Diffusion Index (ICT-DI) calculation method based on two groups of indicators: communication (number of Internet hosts, personal computers, telephone lines and mobile subscribers per capita) and access (number of Internet users, adult literacy, cost of local call and GDP per capita) (International Telecommunication Union 2019d).

The shift of techno-socio-economic paradigm in the information age is associated with a shift in the character of innovation (Cantwell 2017; Filippetti et al. 2017; Castellani 2018). Thus, analyzing the work of scientists (Awate et al. 2015; Belderbos et al. 2016; Dovgal and Goncharenko 2019, 2015; Giannini et al. 2019; Cassetta et al. 2020; DeGrazia et al. 2020; Goncharenko et al. 2020; Ortiz and Fumás 2020), we can note the lack of a unified approach to assessing the innovative development of countries. There is also no generally accepted direction for calculating an indicator that would reflect the full diversity of this process. Existing methods of calculating indexes reflect the current practice in statistical accounting for one or more aspects of the analysis of innovative development, but they cannot characterize all manifesta-

tions of such a complex phenomenon. This is a deterrent in applied economic research of innovative development around the world and leads to difficulties when attempting to provide a prognostic assessment of the situation in this direction.

Existing realities require a comprehensive assessment of the qualitative features of innovative development and its aspects. The main problem is the need for a rational choice from the entire existing list of possible indicators of the most significant, informative determinants for a comprehensive study of the essence of innovative development and being able to apply these indicators practically. This issue is relevant today, as regulating the economy in the current trends of globalization and regionalization requires real assessment tools when choosing the appropriate strategic priorities for countries' development.

The solution to this scientific problem is of particular importance for the countries of the European Union (EU), which has traditionally occupied a leading position in the world in many indicators of innovative development. In addition to the level of technological development of the country, its innovation policy also depends on additional factors, such as the exchange of best practices, technological development path dependence, and civilizational and cultural peculiarities of national innovation systems (Jablonski 2018, p. 28). However, recently, the innovative level of other countries and regions of the world, mainly in Southeast Asia, allows them to compete successfully with European countries in terms of innovation development (European Union 2015).

Today, various methods and models are intensely adopted in the development of business management systems (Karmanov et al. 2020, p. 346). In this regard, there is a need to develop a methodological approach to comprehensively assess the polystructural nature of modern innovative development in the EU countries, taking into account its aspects such as information adaptability, innovative orientation, and synergetic efficiency, which make it possible to identify growth points and promising areas to improve their innovative development. Therefore, the purpose of this article is to develop an integrated indicator of innovative development of the EU, which will take into account the general state of the EU countries and allow a rating assessment of their innovative development in the EU economic system.

Data and methodology

To calculate the integrated indicator for assessing the innovative development of the new EU member states and other EU countries, taking information adaptability, innovative orientation and synergetic efficiency, the following methodology is proposed by the authors: 1) forming a hypothesis about the impact of factors that characterize the level of innovation development; 2) assessing factors and estimating their integrated indicators by EU countries; 3) calculating the integrated indicator of the EU countries innovative development. Schematically, the methodology can be seen in Figure 1.

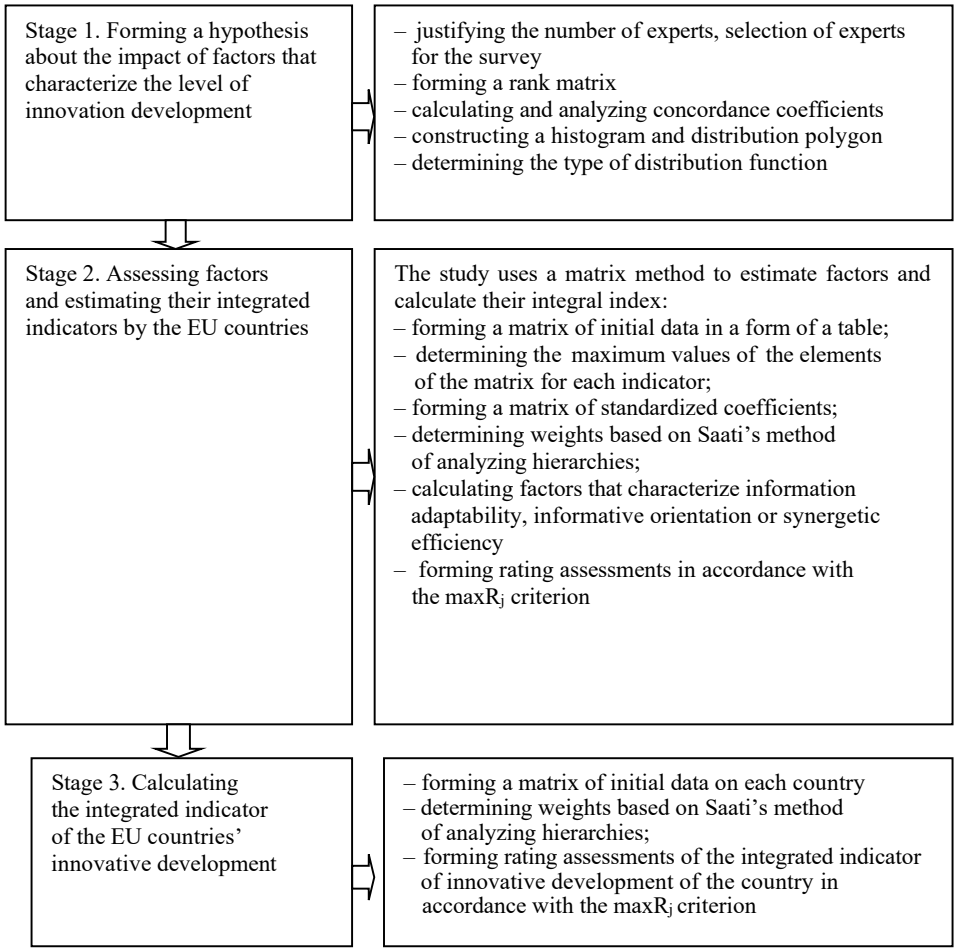

Figure 1. The sequence of calculating the integrated indicator of innovative development of the EU
Source: author's elaboration.

To increase the objectivity of the assessment of factors that characterize the level of innovation development, we proposed applying the algorithm of a priori analysis based on the analysis of experts' points of view. The information obtained a priori is processed using the methods of rank correlation. The algorithm for conducting a priori analysis based on the method of expert evaluations includes blocks: forming a rank matrix; calculating and analyzing concordance coefficients; constructing a histogram; determining the type of distribution function.

The concordance coefficient is calculated by the formula (Shmoylova 2008):

$$W = \frac{12 \cdot S}{m^2 \cdot (n^3 - n)} = \frac{12}{m^2 \cdot \left(n^3 - n\right)} \left(\sum_{j=1}^{m} \left(\sum_{i=1}^{n} a_{ij} - \frac{\sum_{j=1}^{m} \sum_{i=1}^{n} a_{ij}}{n} \right)^2 \right) \quad (1)$$

where a_{ij} – is the rank of the i-th factor in the j-th specialist; m – is the number of specialists; n – is the number of factors.

The study uses correlation analysis to check the results, a comparative assessment, and the possibility of excluding some factors. According to statistics, a matrix of pairwise correlation coefficients is formed, which determines the degree of connection of each of the factor-features (x) with the resultant factor (y) and with each other.

The correlation coefficient is calculated by the formula (Shmoylova 2008):

$$r_j = \frac{\sum x_j \cdot y_i - \frac{\sum x_j \cdot \sum y_j}{m}}{\sqrt{\left(\sum x_j{}^2 - \frac{\left(\sum x_j \right)^2}{m} \right) \left(\sum y_j{}^2 - \frac{\left(\sum y_j^2 \right)}{m} \right)}} \quad (2)$$

where x – is the value of the factor-sign; y_j – is the value of the productive factor; m – is the value of the statistical ensemble.

Pearson's t-test is used to assess the significance of the correlation of coefficient r. This determines the actual value of criterion t (Shmoylova 2008):

$$t_r = r \cdot \sqrt{\frac{m-2}{1-r^2}} \quad (3)$$

The system of indicators for assessing the degree of investment attractiveness of objects will include indicators for which the correlation coefficient r is considered significant, that is, the opinion of experts on this indicator is confirmed. Thus, a list of indicators that characterize information adaptability, innovative orientation, or synergetic efficiency is formed.

The content of the second stage is comparing individual objects of analysis and choosing the most promising among them.

In the course of the comparative analysis, we propose using methods of multidimensional analysis, in particular the matrix method. When assessing a country's level of innovative development in accordance with the selected three determinants, the matrix makes it possible consider the level of significance of each indicator, increasing the accuracy of the assessment (Shmoylova 2008).

The rating is determined by the formula (Malitskiy and Solovev 2006):

$$R_j = \sum_{i=1}^{n} k_i \cdot x_{ij} \tag{4}$$

where k_i – is the weighting factor determined by experts based on the method of analysis of hierarchies for the i-th indicator; x_{ij} – standardized coefficient of the i-th indicator of the j-th country.

Weights during the calculation of the integrated indicator are determined based on Saati's (1993) method of analysis of hierarchies, which is based on a hierarchical procedure for evaluating alternatives. To record the result of comparing a pair of alternatives, the scale presented in Table 1 is used. Similarly, the significance of the calculated integrated indicators is assessed according to the established aspects of the level of innovative development.

Table 1. Scale for evaluating the results of comparing alternatives

Scores	Characteristics of similarity of alternatives
1	Equivalence
3	Moderate advantage
5	Strong advantage
7	A very strong advantage
9	The highest advantage
2, 4, 6, 8	Intermediate values

Source: compiled by the authors based on data derived from (Saati 1993).

The index method is used to calculate the integrated indicator of innovative development of the countries. According to the value of the integrated indicators calculated in the previous stage, the general indicator of innovative development of the country is calculated, according to which the EU countries are ranked.

Empirical results

According to the first stage of the evaluation, based on the logical analysis of indicators that characterize science, technology, and digital society in accordance with the data 2007–2020 presented in the public domain, the main indicators were selected. These indicators characterize information adaptability, innovative orientation, and the synergetic efficiency of innovative development of the EU countries and are grouped by three aspects of analysis (Annex 1).

According to the presented sequence, we obtained a priori information on the degree of influence of each of the assessed indicators. The methods of rank correlation based on expert surveys were used. The results were summarized in a table – a matrix

of ranks to identify the main factors of information adaptability, innovative orientation and synergetic efficiency.

The analysis of the rank matrixes showed that experts' assessments of the degree of influence that factors have on the innovative development differ slightly. By our calculation, the concordance coefficients at an estimation of factors of innovative development regarding information adaptability is 0.69, for innovative orientation – 0.73, and for synergetic efficiency is 0.83. Therefore, with a probability of 0.95, it can be argued that the consensus of experts is not accidental.

The group of factors that will be included in the further study for each aspect of the analysis is summarized in Table 2.

Table 2. The factors that characterize the innovative development of the EU countries are singled out as a result of the priori expert analysis

Aspects of innovative development	The name of the factor
Indicators for assessing information adaptability	High-tech patent applications to the European Patent Office (EPO) (X1)
	Broadband penetration rate (X31)
	Patent applications to the EPO for the priority year (X3)
	Frequency of mobile Internet use (X16)
	Expenditure on information technology, in millions of Euros and % of GDP (X29)
	Internet use and activity (X24)
	Enterprises – Internet access level (X18)
	Market share in telecommunications (X30)
	Fixed broadband connection, market share (X25)
Indicators for evaluating innovation orientation	Total turnover due to innovative products according to NACE (X13)
	Expenditure on research and development (BERD) of enterprises in the ICT sector, in % of total R&D expenditure on NACE activities (X30)
	R&D expenditures at national and regional levels (X1)
	Innovation in high technology (CIS 2008, CIS 2010, CIS 2012), EU Member States and individual countries (X27)
	Number of scientific and technical staff at national and regional levels (X6)
	Venture capital investment HTEC (X22)
	Total internal costs for R&D by type of activity
	Number of enterprises with innovative activity (X9)
Indicators for assessing synergetic efficiency	Total government budget expenditures on research and development (GBAORD), in % of the total state budget
	R&D costs per patent
	GNP growth of the state due to high-tech industries

Source: author's.

For the selected factors, matrixes of pairwise correlation coefficients were compiled for each aspect of the analysis, confirming their significance with the help of corre-

lation coefficients. Thus, a system of indicators that characterize the innovative development of the new EU member states and other EU countries in three aspects was formed.

Based on the system of indicators, at the next stage, matrixes of initial data to calculate the integrated indicator of innovative development regarding information adaptability, innovative orientation and synergetic efficiency were formed.

Based on the algorithm of the matrix method, for each indicator, the maximum value was chosen and the coefficient of compliance was calculated with the reference value of a particular indicator.

At the next stage, we assessed the level of significance of indicators that characterize information adaptability, innovative orientation and synergistic efficiency by the method of hierarchy levels.

The results of calculatng the integrated indicator of innovative development and its aspects (integrated indicators for assessing information adaptability, innovative orientation and synergetic efficiency) are presented in Table 3.

Table 3. Integrated assessment of innovative development of the new EU member states and other EU countries and its aspects, 2019

	An integrated indicator of information adaptability	An integrated indicator of innovation orientation	Integral indicator of synergetic efficiency	An integrated indicator of innovative development
Belgium	0.17171138	0.084140778	0.3106522	0.19005295
Bulgaria	0.0763596	0.003908588	0.1024535	0.06132269
Czech Republic	0.04637599	0.022038094	0.4604155	0.17911792
Denmark	0.08802018	0.071208356	0.3013829	0.15501561
Germany	0.96057348	0.769633288	0.9293509	0.88694753
Estonia	0.0755352	0.001964972	0.226657	0.10263845
Ireland	0.07784342	0.013088213	0.0913327	0.06106056
Greece	0.10666103	0.009113942	0.2764979	0.13221503
Spain	0.19365445	0.101947282	0.3362231	0.21186443
France	0.65528756	0.40885517	0.4092773	0.49032137
Croatia	0.29322782	0.003007053	0.1701116	0.15559545
Italy	0.05602372	0.159471703	0.5272793	0.25038844
Latvia	0.05220141	0.000564598	0.0766133	0.04346129
Lithuania	0.03574048	0.001923421	0.1615178	0.06734515
Luxembourg	0.15239839	0.005891607	0.1747653	0.1116559
Hungary	0.27583997	0.017765122	0.144205	0.14591938
Netherlands	0.20327514	0.116619676	0.560755	0.29622198
Austria	0.17252061	0.084611167	0.5091282	0.25795709
Poland	0.05518047	0.032485992	0.2109227	0.10064366
Portugal	0.05465951	0.023281419	0.4833499	0.19005948
Romania	0.02467962	0.006025889	0.2237742	0.08621604
Slovenia	0.0624881	0.007680435	0.132872	0.0683321

	An integrated indicator of information adaptability	An integrated indicator of innovation orientation	Integral indicator of synergetic efficiency	An integrated indicator of innovative development
Slovakia	0.15432816	0.004812195	0.1137611	0.0911951
Finland	0.25866374	0.05433714	0.2120396	0.17538375
Sweden	0.6286747	0.107681421	0.2561006	0.33007172
Weighting factor	0.33	0.33	0.34	

Source: own calculations.

Thus, according to the criteria for maximizing the integrated indicator of innovative development, the general rating of the EU countries can be presented (Table 4).

Table 4. Ranking of the EU countries on the integrated indicator of innovative development, 2019

Country	An integrated indicator of innovative development	Ranking
Germany	0.88694753	1
France	0.49032137	2
Sweden	0.33007172	3
Netherlands	0.29622198	4
Austria	0.25795709	5
Italy	0.25038844	6
Spain	0.21186443	7
Portugal	0.19005948	8
Belgium	0.19005295	9
Czech Republic	0.17911792	10
Finland	0.17538375	11
Croatia	0.15559545	12
Denmark	0.15501561	13
Hungary	0.14591938	14
Greece	0.13221503	15
Luxembourg	0.1116559	16
Estonia	0.10263845	17
Poland	0.10064366	18
Slovakia	0.0911951	19
Romania	0.08621604	20
Slovenia	0.0683321	21
Lithuania	0.06734515	22
Bulgaria	0.06132269	23
Ireland	0.06106056	24
Latvia	0.04346129	25

Source: own calculations.

Conclusions

Summarizing the results of calculations of the integrated indicator of innovative development and its aspects of the new EU member states and other EU countries, we can conclude that the innovative development of EU economies differs significantly in individual indicators of information adaptability, innovative orientation, and synergetic efficiency.

First, in terms of information adaptability indicators such as high-tech patent applications to the European Patent Office (EPO), speed of penetration in the broadband network, patent applications to the EPO by priority year, information technology costs, and frequency of mobile Internet use, the leaders of innovative development are Germany, France, the Netherlands, and Sweden, which indicates the dynamic spread of information technology and, on this basis, future technological changes in economic development. Among the CEECs, the new EU member states of Croatia, Hungary, and Slovakia achieved the best results in these indicators, even ahead of such highly developed countries as Italy and Portugal. This corresponds to their development strategies, which set a course for the introduction of modern information technologies, creating the necessary infrastructure, and motivating the population to expand their use in their activities.

Secondly, by indicator of innovation orientation (total turnover due to innovative products, the number of developments in the ICT sector, R&D expenditures, innovations in high technology, the number of scientific and technical staff, the volume of venture investment in R&D, total domestic R&D expenditures, and the number of enterprises with innovative activities) the leading role among was played by Germany, France, Italy, and Spain, which is a consequence of a purposeful state policy on the creation and dissemination of innovations. Poland, the Czech Republic, and Hungary, as expected, became leaders among the new EU member states. They show the greatest rates of innovative economic renewal, primarily through awareness of its importance, as well as significant investment in education, science and technology development, and greenfield investment.

Third, in terms of total government budget expenditures on research and development (GBAORD), R&D expenditures on one patent, and the growth of state GDP due to high-tech industries that characterize synergetic efficiency, Germany, Austria, Sweden, Portugal, Denmark, Italy, and the Netherlands are ahead, as is the Czech Republic (the first of the CEECs), which indicates the gradual awareness of the importance of innovation in the economic development of most European member states.

Thus, as a result of the study, it can be noted that Germany is a leader in innovative development in the European economic system, as its integrated indicator of innovative development is significantly higher than in all other countries. France, which, according to the calculations, is second in the ranking, lags behind the values of the integrated indicator of Germany by 0.396 points. The Czech Republic's 10th place in the overall ranking (the first place among the new EU member states)

is quite logical, in our opinion. It reflects the results of the country's recent structural reforms and economic modernization, due in part to a significant inflow of foreign investment. For the vast majority of CEECs, their low rating is evidence of the direct relationship between innovation development and economic development indicators, despite the fact that they are all members of the same integration association. Therefore, to ensure the technological development of the new EU member states today, it is necessary to focus on those areas of activity where it is advisable to combine the technology of "Industry 4.0" with Smart TEMP factors (Technology, Environment, Manufacturing, Products), which creates sustainable demand in new markets and value for consumers.

As for the practical results of the study, a comprehensive assessment of the polystructural nature of modern innovative development in the new EU member states and other EU countries, taking into account aspects such as information adaptability, innovative orientation, and synergetic efficiency, allows us to identify growth points and promising areas to increase their innovation. Assessing and comparing innovative development at the national level depends on many factors, but it is primarily determined by the public policy and national priorities of a particular country. That is why, in our opinion, the further development of their mutual exchange of technologies based on the existing integration of scientific and technical potential should be perspective directions to increase the innovative development in all EU countries.

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Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

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Annex 1. Indicators for assessing the innovative development of countries

Indicators for assessing information adaptability	Indicators for assessing innovative orientation	Indicators for assessing synergetic efficiency
High-tech patent applications to the European Patent Office (EPO) for the priority year	Expenditures on research at the national and regional levels	The total amount of GBAORD, in % of the total state budget
Biotechnological patent applications to the EPO for the priority year	Total internal R&D expenditures by the type of activity	Total trade in high-tech trade, in millions of Euros and % of total
Patent applications to the EPO for the priority year	Total costs for research and development (GER) by industry and type of research	Percentage of the ICT sector in GDP
High-tech patent applications to the EPO for the priority year (pat_ep_ntec)	Expenditures on research and development of enterprises (BERD) by type of economic activity and source of funding	Growth rates of 20% or more (since 2008, NACE Rev. 2)
ICT patent applications to the EPO for the priority year (pat_ep_nict)	Total internal R&D expenditure (GER) by efficiency sectors and NUTS 2 regions	GNP growth of the state due to high-tech industries
Biotechnological patent applications to the EPO for the priority year (pat_ep_nbio)	Number of scientific and technical staff at the national and regional levels	Number of patents per employee in R&D
Nanotechnology patent applications to the EPO for the priority year (pat_ep_nnano)	Total volume of scientific and technical staff and researchers by field of effectiveness, in % of total labor force and total employment and by sex	R&D costs per patent
Radio navigation with the help of patent applications for satellite communication to the EPO for the priority year (pat_ep_nrns)	The total number of GBAORD by financing method	
Patent applications for energy technologies to the EPO for the priority year (pat_ep_nrg)	Number of enterprises with innovative activity	
Application of energy technologies under the Patent Cooperation Treaty (PTA), which is intended for the EPO for the priority year (pat_ep_nrgpct)	Number of enterprises with innovative activity by size class	
Registered trademarks of the European Union (EUTM) per 1 billion GDP (ipr_tr_gdp)	Number of enterprises with innovative activity in the production sector by technology sectors	
Registered trademarks of the European Union (EUTM), per 1 million population (ipr_tr_pop)	The level of export intensity of innovative firms by size class	

Indicators for assessing information adaptability	Indicators for assessing innovative orientation	Indicators for assessing synergetic efficiency
Applications completed for registration of one or more Community (CD) designs up to the year of approval (ipr_da)	Circulation due to innovative products, according to NACE	
Community Programs (CD) (ipr_da_tot)	Intensity of innovation for NACE	
Financial activities via the Internet	The number of innovative enterprises, taking into account the importance of goals for NACE	
Frequency of mobile internet use	Factors that hinder innovative enterprises due to a serious delay of projects by class size	
Computer and Internet at enterprises	Number of innovative enterprises supported by the government to NACE	
Businesses – the level of access to the Internet	Products and technological innovations that hinder innovation	
Activities on the Internet – enterprises		
Integration of internal business processes	Organizational and marketing innovations	
Enterprises working in the field of ICT/IT specialists	Extremely important consequences of organizational innovations	
Single Digital Market – Promoting e-commerce for businesses	Venture capital investments in the HTEC sector	
Businesses connected to a broadband connection	Venture capital investment at the development stage	
Internet use and business activity	Employment in technology and spheres of knowledge at the National level in terms of education	
Fixed broadband connection – market share	HRST operates by categories, age, and activity of NACE	
Mobile communication – incomes	R&D expenditures in high technology industries	
Telecommunication services: investments (isoc_tc_inv)	Innovation in high technology (CIS 2008, CIS 2010, CIS 2012), EU Member States and separate countries	
Telecommunication services: circulation (isoc_tc_tur)	Personal qualities of doctoral students	
Expenditures on information technology in millions of euros and % of GDP (isoc_tc_ite)	Employment of doctoral students	

Indicators for assessing information adaptability	Indicators for assessing innovative orientation	Indicators for assessing synergetic efficiency
Market share in telecommunications (isoc_tc_msht)	Expenditure on research and development (BERD) of enterprises in the ICT sector, in % of total R&D expenditure on NACE activities	
Broadband connections penetration rate (isoc_tc_broad)	R&D staff in ICT sector, in % of total R&D for NACE	

Source: compiled by the authors based on data derived from World Information Society Report (2007), IDC (2018), International Telecommunication Union (2018), European Commission (2019), INSEAD, WIPO (2019), International Telecommunication Union (2019a, 2019b, 2019c, 2019d), The Economist Intelligence Unit (2019), The Good Country (2019), The World Bank (2019), UNCTAD (2019), UN Department of Economic and Social Development (2019), UNESCO (2019), United Nations (2019), World Economic Forum (2019a, 2019b), CIA World Factbook (2020), Destatis (2020), Eurostat (2020).

Zintegrowana ocena innowacyjnego rozwoju nowych państw członkowskich UE i innych krajów UE

W niniejszym opracowaniu poruszono problem szacowania różnych aspektów i cech jakościowych rozwoju innowacyjnego. Zaproponowano nowe podejście metodologiczne do kompleksowej oceny polistrukturalnego charakteru nowoczesnego rozwoju innowacyjnego w nowych państwach członkowskich UE i pozostałych państwach członkowskich UE. To pozwoliło na identyfikację punktów wzrostu i obiecujących obszarów umożliwiających zwiększanie ich innowacyjnego rozwoju. Przeanalizowano takie aspekty jak zdolność do absorpcji informacji, innowacyjna orientacja i efektywność synergii. Analiza opiera się na logicznej ocenie wskaźników charakteryzujących naukę, technologię i społeczeństwo cyfrowe w oparciu o dane dostępne publicznie, z których wybrano główne wskaźniki charakteryzujące te trzy aspekty innowacyjnego rozwoju UE. Według algorytmu metody macierzowej dla nowych państw członkowskich UE i pozostałych państw UE dla każdego wskaźnika wybrano wartość maksymalną (referencyjną) i obliczono współczynnik zgodności z wartością referencyjną danego wskaźnika. W efekcie obliczono zintegrowane wskaźniki oceny zdolności do absorpcji informacji, innowacyjnej orientacji i efektywności synergii oraz zintegrowany wskaźnik rozwoju innowacyjnego krajów UE, co pozwoliło na ich ocenę. Innowacyjny rozwój gospodarek krajów UE różni się znacznie w odniesieniu do niektórych wskaźników i aspektów. Ocena i porównanie rozwoju innowacyjnego na poziomie krajowym zależą od wielu czynników, ale są determinowane przede wszystkim polityką państwa i priorytetami danego kraju. Dlatego obiecującym kierunkiem zwiększania innowacyjności wszystkich krajów UE powinien być przede wszystkim dalszy rozwój wzajemnej wymiany technologii w oparciu o istniejący naukowo-techniczny potencjał integracji.

Słowa kluczowe: rozwój innowacyjny, zdolność do absorpcji informacji, innowacyjna orientacja, efektywność synergii, zintegrowany wskaźnik rozwoju innowacyjnego

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