“Assessment of the development of innovation activities in the regions: Case of Ukraine”

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ASSESSMENT OF THE DEVELOPMENT OF INNOVATION ACTIVITIES IN THE REGIONS: CASE OF UKRAINE

Abstract

The development of innovation activities is of great importance on the path to achieving the goals of sustainable development. Success on this path is closely related to the presence of comparable information on the development of innovation activities at the regional level. The aim of the paper is to assess the development of innovation activities in the regions of Ukraine and identify differences in results. The study is performed using relative indicators for the assessment of the development of innovation activities in the regions of Ukraine. The indicators were averaged and normalized. To analyze how innovation activities change over time, the dynamic indices based on the geometric mean of the growth rate of the relative indicators were used. The obtained results have significant differences in the regions being assessed. Most regions have a heterogeneous development of innovation activities. At the same time, they are at the top and bottom of the rankings of the regions in different indicators of the development of innovation activities. Only Cherkasy and Zaporizhzhia oblasts are at the top of the rankings in at least 75% of indicators. However, in 2017–2019, all indicators improved in at least 29% of regions. In addition, 75% of indicators improved in at least 54% of regions. Therefore, over time, most regions progressed in the development of innovation activities. Management decisions for the development of innovation activities should be complex for all regions and implemented primarily in the regions where there is no improvement over time.

Keywords innovation activity, industrial enterprise, sustainable development, management decision, regional competitiveness

JEL Classification O30, O31, O32

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INTRODUCTION

In 2015, the United Nations approved the Agenda for Sustainable Development 2030 (United Nations, 2015), which is a rich and global action plan focused on achieving economic prosperity, environmental sustainability, and social integration. The Agenda contains seventeen goals in the field of sustainable development, including goal No. 9 – to create sustainable infrastructure, promote comprehensive and sustainable industrialization and innovation. That is, its achievement of sustainable development depends on the development of innovation activities. Nowadays, many countries in the world are experiencing problems with the development of innovation activities. To solve these problems, countries are focused on developing necessary tools and means to enhance and catalyze innovation. The development of innovation activities at the regional level is of great importance on this path. The development of innovation activities is closely related to the availability of appropriate regional capabilities and resources.

The development of innovation at the regional level depends on management decisions. The results of innovation management are reflected in the innovation competitiveness of the regions. Therefore, to make successful management decisions, it is necessary to have relevant results of the assessment of the development of innovation activities. The problem is that it is difficult to conduct assessments at the regional level due to the specifics of individual territories, different scales, and features. Therefore, there is a certain lack of assessment of the development of innovation at the sub-national level and the innovation competitiveness of the regions. Based on this assessment it is possible to find probable management decisions for the development of innovation activities at the regional level. It also applies to Ukraine, where each region has both individual and national characteristics.

1. LITERATURE REVIEW

Innovation activities are organizational, scientific, technological, financial, and business performance, which leads to the introduction of innovations. The development of innovation activities includes creation, managing, and coordination of corresponding organizational networks.

In the world, there are various assessments of the development of innovation activities, which in most cases assess the structural components of innovation. There are many kinds of assessments of these components at the macro-level, on which basis innovative development ratings of countries and economies are compiled. Existing assessments mainly include gross product performance, investment in innovation, and number of people engaged in innovations. These assessments include the Global Innovation Index (Cornell University et al., 2020), which is a common ranking. In addition to the Global Innovation Index, there are many other assessments for countries, among which are the Technology Achievement Index (United Nations Statistics Division, 2001), the Innovation Capacity Index (Lopez-Claros & Mata, 2010), the Bloomberg Innovation Index (Bloomberg Business, 2015), the Social Innovation Index (Economist Intelligence Unit, 2016), the European Innovation Scoreboard (European Commission, 2020), the European Digital Social Innovation Index (Nesta, 2021), etc. The advantages of these assessments are that they are modern and informative for countries. However, as already noted, there is a certain shortage of such assessments for the regional level. Significant attempts to take into account the specifics of each individual territory in assessing the innovation development of regions were made in particular for the Innovation Index 2.0, made by the Indiana Business Research Center (2016). However, this assessment is suited to the territories of the USA for which it was designed.

The development of innovation activities in the regions has been studied even before the appearance of mentioned assessments. Nauwelaers and Reid (1995) analyzed the existing research at the time to assess the regional technological innovation potential and concluded that regional innovative databases should be developed. The continuation of the study in this direction was in the work of Autio (1998), where it is argued that regional systems of innovation are significantly different from national ones, and, thus, other approaches are called for in the assessment of regional systems of innovation. Oughton et al. (2002) investigated the regional innovation paradox concerning the contradiction in spending money on innovation in the regions. Doloreux and Parto (2005) generalized important ideas and arguments for theorizing regional innovation systems. Tödtling and Trippl (2005) analyzed different types of regions, considering their prerequisites for innovation, network and innovation barriers, and developed regional policy and strategy options.

Arnkil et al. (2010) showed the importance of supporting innovation by regional authorities. Sarkar (2013) proved that innovation stimulates sustainable development of the environmental sector and promotes green economic growth at all levels. Sotnyk et al. (2013) investigated the influence of innovative information and communication technologies for achieving sustainable development of the country. Shkarupa (2015) developed an effective functional system for the phased process of innovative modernization and management of socio-economic systems in the region.

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In subsequent years, significant progress has been made. Ivanova and Masarova (2016) assessed the innovation activities of the Slovak regions, using the variable standardized method. The advantage of the method is that it considers the relative variability of indicators. The results showed that the innovation activities of the Slovak regions were changing continually. Then Ivanova and Kordos (2017) continued the research and assessed differences in innovation activities in individual regions of Slovakia, using a multi-criteria scoring method. The advantage of the method is its relative simplicity. The results showed strong differences in regions being assessed what is reflected in their economic performance and competitiveness differences. Stejskal et al. (2018) created a new method for assessing regional innovation systems and applied it to individual regions in the Czech Republic. The advantage of the method is that it can be easily used practically to map the development of individual innovative systems in a region. Horobchenko and Voronenko (2018) analyzed the impact of innovation factors on sustainable development in Ukraine. Kniazevych et al. (2018) assessed the effectiveness of the innovation infrastructure of Ukraine using the factor modeling method. The advantage of factor modeling is its simplicity. The results showed that the degree of development of innovation infrastructure is one of the main factors in the development of the Ukrainian innovation system. Ilyash et al. (2018) determined the correlation between the volume of industrial products sold and the main indicators of innovation in Ukraine using the math modeling method. The advantage of the method is its accuracy. Wu et al. (2019) assessed the development of scientific and technological innovation at the regional level in China using the method of principal component analysis. The advantage of the method is that it reflects most of the information of the indicators. The results showed that the levels and ratios at the regional level had significant differences. Boronos et al. (2020) assessed the level of innovative development of the territories of Ukraine using methods based on theoretical and empirical research. The advantage of the method is that it characterizes the results of the regional eco-friendly innovation policy. The results showed that Ukrainian regions are different from each other both in terms of scientific-technical and production potentials and in terms of socio-economic development. Kartanaitė et al. (2021) showed the necessity of assessment in forming a suggestion for decision-makers in the context of the innovation Industry 4.0.

2. AIMS AND METHODS

The paper aims to assess the development of innovation activities in each region of Ukraine and identify differences in assessment results.

The paper adds some relative indicators for the assessment of the development of innovation activities in the regions of Ukraine that were created from selected absolute indicators. Selected absolute indicators consider the innovation and research activities of organizations and enterprises, the implementation of innovative products, involvement of employees in innovation research, innovation costs, and expenses for research and development (R&D). The development of innovation activities in the regions of Ukraine was assessed using the next four relative indicators:

1. The indicator of involvement of industrial enterprises in innovation activities. It is defined as the ratio of the number of innovation active industrial enterprises in the region to the total number of active industrial enterprises in the region:

$$I_I = \frac{E_A}{E_I}, \quad (1)$$

where I_I – the indicator of involvement of industrial enterprises into innovation activities, E_A – the number of innovation active industrial enterprises in the region, units, E_I – total number of active industrial enterprises in the region, units.

2. The indicator of innovative productivity of employees in the implementation of R&D. It is defined as the ratio of the volume of innovative industrial goods and services sold by the region to the number of employees involved in R&D in the region:

$$I_P = \frac{P_V}{N_E}, \quad (2)$$

where I_P – the indicator of innovative productivity of employees in the implementation of R&D,

monetary units/person, P_V – the volume of innovative industrial goods and services sold by the region, monetary units, N_E – the number of employees involved in R&D in the region, person.

3. The indicator of cost-effectiveness for innovation of industrial enterprises. It is defined as the ratio of the volume of innovative industrial goods and services sold by the region to expenses for innovation of industrial enterprises in the region:

$$I_E = \frac{P_V}{C_I}, \tag{3}$$

where I_E - the indicator of cost-effectiveness for innovation of industrial enterprises, P_V – the volume of innovative industrial goods and services sold by the region, monetary units, C_I – expenses for innovation of industrial enterprises in the region, monetary units.

4. The indicator of the availability of costs for performance of R&D. It is defined as the ratio of expenses for performance of R&D in the region to the number of organizations in the region that performed R&D:

$$I_S = \frac{C_R}{O_R}, \tag{4}$$

where I_S - the indicator of the availability of costs for performance of R&D, monetary units/units, C_R – expenses for performance of R&D in the region, monetary units, O_R – the number of organizations in the region that performed R&D, units.

Increasing of all indicators characterizes the improvement of the level of the development of innovation activities. The optimal direction of changing I_I, I_P, I_E, I_S is growth. The first and fourth indicators characterize the conditions and factors for innovation activities (input indicators), the second and third indicators characterize the results (output indicators). The relative character of the indicators makes regions more comparable, eliminating the impact of the size of the region.

To smooth out fluctuations of indicators and analyze them over several years, the average values of indicators for each region were calculated using the arithmetic mean method.

Comparing the values of the indicators between regions, it is possible to assess the competitiveness of the regions in innovation activities. For this, the commonly known method of relative assessment of indicators compared to the best of the indicators was used. Since the optimal direction of changes in all four indicators is an increase, it is necessary to compare with the maximum values of the indicators. Relative assessment of competitiveness for each individual indicator I_I, I_P, I_E, I_S was performed by the formula:

$$C_I = \frac{I}{I_{\max}}, \tag{5}$$

where C_I – the indicator of the relative assessment of the competitiveness of the region in innovation activities for individual indicators I_I, I_P, I_E, I_S, I – the value of indicator I_I, I_P, I_E, I_S respectively, for each region, $I_{\max}$ – the maximum of values of the indicator I_I, I_P, I_E, I_S from all compared regions.

Thus, the normalization of indicators was used. The indicators of the relative assessment of the competitiveness of regions in innovation activities were calculated with average values, average maximum values of indicator I_I, I_P, I_E, I_S for each region.

To analyze how innovation activities change over time, the dynamic indices of the development of innovation activities were designed. They show whether the regions are moving toward improving the values of I_I, I_P, I_E, I_S. The dynamic indices base on the geometric mean of the growth rate of indicators I_I, I_P, I_E, I_S and are calculated by formulas:

$$i_I = \sqrt[N-1]{\prod_{n=1}^{N-1}\left(\frac{I_{I\{n+1\}}}{I_{I\{n\}}}\right)}, \tag{6}$$

$$i_P = \sqrt[N-1]{\prod_{n=1}^{N-1}\left(\frac{I_{P\{n+1\}}}{I_{P\{n\}}\cdot\left(1+r_{\{n+1\}}\right)}\right)}, \tag{7}$$

$$i_E = \sqrt[N-1]{\prod_{n=1}^{N-1}\left(\frac{I_{E\{n+1\}}}{I_{E\{n\}}}\right)}, \tag{8}$$

$$i_S = \sqrt[N-1]{\prod_{n=1}^{N-1}\left(\frac{I_{S\{n+1\}}}{I_{S\{n\}}\cdot\left(1+r_{\{n+1\}}\right)}\right)}, \tag{9}$$

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where i_I, i_P, i_E, i_S – dynamic indices of the development of innovation activities for indicators I_I, I_P, I_E, I_S; N – the number of years during which analysis is conducted; n – the designation number of the year; r – the inflation rate.

The optimality criterion for i_I, i_P, i_E, i_S is the value greater than 1.

The study was performed for Ukrainian oblasts, which are the regions of Ukraine. The data for Donetsk and Luhansk oblasts are incomplete and available from enterprises, institutions, and organizations that reported to the state statistics bodies of Ukraine. The data come from the State Statistics Service of Ukraine (2018, 2019, 2020). The Ukrainian hryvnia was used as the currency in the calculations.

3. RESULTS

The study was conducted for the period 2017–2019. The results for Donetsk and Luhansk oblasts could be distorted due to incomplete data.

Table 1 presents the results of calculating the indicators of involvement of industrial enterprises in innovation activities.

As one can see from the results of the calculations (Table 1), the largest number of innovation active industrial enterprises in the region in relation to the total number of active industrial enterprises was in the Ternopil oblast in 2019, although in the previous two years the value of this indicator was lower. Except for Ternopil oblast, also the indicator of Kharkiv oblast is larger than the indicators of other regions in 2019. In previous years, the values of the indicator of Kharkiv oblast were even higher. The smallest indicators have Zakarpattia and Khmelnytskyi oblasts with values amount to 0.008 in 2019. In previous years, the values of these regions were also low and decreased. Chernivtsi and Chernihiv oblasts have low values of the indicator compared to other regions. In these regions, over 2017–2019, the indicators changed towards a decrease. In general, in most regions, the number of innovation active industrial enterprises in relation to the total number of active industrial enterprises is relatively small.

Table 1. Results of calculation of indicators I_I by regions of Ukraine, 2017–2019

Source: State Statistics Service of Ukraine (2018, 2019, 2020).

Region of Ukraine	Indicator I_I		
	2017	2018	2019
Vinnytsia oblast	0.019	0.018	0.019
Volyn oblast	0.024	0.018	0.013
Dnipropetrovsk oblast	0.014	0.018	0.015
Donetsk oblast	0.014	0.016	0.018
Zhytomyr oblast	0.016	0.013	0.015
Zakarpattia oblast	0.014	0.012	0.008
Zaporizhzhia oblast	0.021	0.017	0.021
Ivano-Frankivsk oblast	0.021	0.019	0.015
Kyiv oblast	0.012	0.018	0.013
Kirovohrad oblast	0.028	0.028	0.020
Luhansk oblast	0.014	0.010	0.019
Lviv oblast	0.018	0.016	0.015
Mykolaiv oblast	0.023	0.012	0.018
Odesa oblast	0.016	0.011	0.014
Poltava oblast	0.021	0.022	0.022
Rivne oblast	0.009	0.008	0.019
Sumy oblast	0.027	0.027	0.024
Ternopil oblast	0.031	0.024	0.032
Kharkiv oblast	0.031	0.032	0.030
Kherson oblast	0.015	0.014	0.012
Khmelnytskyi oblast	0.008	0.010	0.008
Cherkasy oblast	0.026	0.023	0.022
Chernivtsi oblast	0.014	0.015	0.011
Chernihiv oblast	0.011	0.016	0.011

Table 2 presents the results of calculating the indicators of innovative productivity of employees in the implementation of R&D.

Table 2. Results of calculation of indicators I_P by regions of Ukraine, 2017–2019

Source: State Statistics Service of Ukraine (2018, 2019, 2020).

Region of Ukraine	Indicator I_P, thousand Ukrainian hryvnias/person		
	2017	2018	2019
Vinnytsia oblast	725	821	1,374
Volyn oblast	213	1,043	1,086
Dnipropetrovsk oblast	33	132	136
Donetsk oblast	13,874	4,816	36,004
Zhytomyr oblast	380	501	900
Zakarpattia oblast	637	1,159	253
Zaporizhzhia oblast	959	988	720
Ivano-Frankivsk oblast	182	972	294
Kyiv oblast	427	968	575
Kirovohrad oblast	806	2,640	6,071
Luhansk oblast	38	135	2,154
Lviv oblast	163	266	210
Mykolaiv oblast	184	63	645
Odesa oblast	52	309	318
Poltava oblast	206	738	503
Rivne oblast	25	157	24
Sumy oblast	289	458	802
Ternopil oblast	352	1,276	1,136
Kharkiv oblast	169	248	286
Kherson oblast	393	614	814
Khmelnytskyi oblast	73	56	590
Cherkasy oblast	827	1,741	2,095
Chernivtsi oblast	57	67	44
Chernihiv oblast	494	1,334	1,318

According to the calculated indicators of recent years (Table 2), Donetsk oblast can be considered the most innovatively productive. Additionally, Kirovohrad, Luhansk, and Cherkasy oblasts demonstrate relatively large values. Vinnytsia, Volyn, Ternopil, and Chernihiv oblasts demonstrate the worst results. Two regions have low values of indicators in 2019, among them – Rivne and Chernivtsi oblasts. Generally, it can be stated that the level of innovative productivity of workers in the performance of R&D in most regions is relatively low, because one employee engaged in R&D has a much smaller volume of sold innovative products than in other leading regions, and this is a problem for the entire country.

Table 3 presents the results of calculating the indicators of cost-effectiveness for innovation of industrial enterprises.

Table 3. Results of calculation of indicators I_E by regions of Ukraine, 2017–2019

Source: State Statistics Service of Ukraine (2018, 2019, 2020).

Region of Ukraine	Indicator I_E		
	2017	2018	2019
Vinnytsia oblast	4.528	1.401	0.794
Volyn oblast	0.412	3.871	2.357
Dnipropetrovsk oblast	0.264	1.662	0.486
Donetsk oblast	4.552	1.501	10.495
Zhytomyr oblast	14.933	1.484	1.433
Zakarpattia oblast	13.641	30.172	3.111
Zaporizhzhia oblast	2.900	0.989	4.110
Ivano-Frankivsk oblast	0.786	3.859	0.615
Kyiv oblast	2.660	2.634	2.794
Kirovohrad oblast	0.804	8.107	7.069
Luhansk oblast	0.649	2.922	17.242
Lviv oblast	2.461	2.982	2.548
Mykolaiv oblast	1.284	0.531	1.028
Odesa oblast	1.049	3.493	3.655
Poltava oblast	3.564	7.106	0.420
Rivne oblast	1.267	9.221	0.255
Sumy oblast	1.006	1.340	0.835
Ternopil oblast	1.157	3.211	0.572
Kharkiv oblast	2.824	2.779	5.331
Kherson oblast	5.122	8.547	5.408
Khmelnytskyi oblast	1.131	1.328	14.065
Cherkasy oblast	4.676	10.207	12.029
Chernivtsi oblast	1.775	0.899	1.746
Chernihiv oblast	4.817	8.204	11.197

From the results of the calculation of indicators for 2017–2019 (Table 3), the ratio of sold innovative industrial goods and services to the cost of innovation of industrial enterprises in Donetsk, Luhansk, Khmelnytskyi, Cherkasy, and Chernihiv oblasts is relatively large, indicating good cost-effectiveness of innovation enterprises compared with other regions. The worst value of the cost-effectiveness for innovation is in Rivne oblast, for which it is 0.255 in 2019. In addition, relatively low values are in Poltava and Dnipropetrovsk oblasts, where the value of the indicator is less than 0.5 in 2019. In total, there are seventeen regions where the value of the indicator is greater than 1 in 2019. However, the cost of innovation has an effect only after a few years in the form of a significant increase in sales of innovative products.

Table 4 shows the results of calculating the indicators of the availability of costs for the performance of R&D.

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Table 4. Results of calculation of indicators I_S by regions of Ukraine, 2017–2019

Source: State Statistics Service of Ukraine (2018, 2019, 2020).

Region of Ukraine	Indicator I_S, thousand Ukrainian hryvnias/units		
	2017	2018	2019
Vinnytsia oblast	2,037	2,336	2,201
Volyn oblast	2,046	2,048	1,658
Dnipropetrovsk oblast	41,888	36,246	40,526
Donetsk oblast	736	955	1,548
Zhytomyr oblast	3,122	3,406	4,395
Zakarpattia oblast	6,905	9,388	7,769
Zaporizhzhia oblast	29,486	53,381	56,980
Ivano-Frankivsk oblast	1,650	3,422	3,008
Kyiv oblast	9,974	13,693	14,919
Kirovohrad oblast	5,041	6,717	2,487
Luhansk oblast	1,955	3,073	3,022
Lviv oblast	4,880	5,928	6,747
Mykolaiv oblast	13,436	13,779	10,756
Odesa oblast	5,630	6,504	6,710
Poltava oblast	2,999	4,036	2,626
Rivne oblast	1,248	1,757	1,468
Sumy oblast	10,044	13,031	7,201
Ternopil oblast	1,477	2,516	3,233
Kharkiv oblast	16,104	22,301	20,605
Kherson oblast	3,505	4,273	3,439
Khmelnytskyi oblast	2,189	2,661	2,137
Cherkasy oblast	4,868	4,929	3,253
Chernivtsi oblast	3,796	4,885	8,133
Chernihiv oblast	3,164	3,517	4,634

The results of the calculation of indicators (Table 4) show that most regions have relatively low costs for R&D per relevant organization. However, some regions, such as Dnipropetrovsk, Zaporizhska, Kyiv, Mykolaiv, Ternopil, and Kharkiv oblasts, show relatively better results. Volyn, Donetsk, and Rivne oblasts demonstrate small values. Note the relatively small deviations in the values of indicators for all regions over 2017-2019.

Tables 5 and 6 show the results of calculating the average values of the indicators I_I, I_P, I_E, I_S and values of the indicator C_I over 2017-2019 for each region. Values are ranked in descending order, i.e. the regions with the best indicators are at the top of the list.

Table 5. Average values of indicators I_I, I_P, and for them, the values of indicators C_I by regions of Ukraine, 2017–2019

Source: State Statistics Service of Ukraine (2018, 2019, 2020).

Region of Ukraine	I_I	C_I for I_I	Region of Ukraine	I_P	C_I for I_P
Kharkiv oblast	0.031	1.000	Donetsk oblast	18,231	1.000
Ternopil oblast	0.029	0.935	Kirovohrad oblast	3,172	0.174
Sumy oblast	0.026	0.839	Cherkasy oblast	1,554	0.085
Kirovohrad oblast	0.025	0.806	Chernihiv oblast	1,049	0.058
Cherkasy oblast	0.023	0.742	Vinnytsia oblast	973	0.053
Poltava oblast	0.022	0.710	Ternopil oblast	921	0.051
Zaporizhzhia oblast	0.02	0.645	Zaporizhzhia oblast	889	0.049
Vinnytsia oblast	0.019	0.613	Volyn oblast	781	0.043
Ivano-Frankivsk oblast	0.019	0.613	Luhansk oblast	776	0.043
Volyn oblast	0.018	0.581	Zakarpattia oblast	683	0.037
Mykolaiv oblast	0.018	0.581	Kyiv oblast	657	0.036
Lviv oblast	0.016	0.516	Kherson oblast	607	0.033
Donetsk oblast	0.016	0.516	Zhytomyr oblast	594	0.033
Dnipropetrovsk oblast	0.016	0.516	Sumy oblast	516	0.028
Zhytomyr oblast	0.015	0.484	Ivano-Frankivsk oblast	483	0.026
Luhansk oblast	0.014	0.452	Poltava oblast	482	0.026
Kyiv oblast	0.014	0.452	Mykolaiv oblast	298	0.016
Kherson oblast	0.014	0.452	Khmelnytskyi oblast	240	0.013
Odesa oblast	0.014	0.452	Kharkiv oblast	234	0.013
Chernivtsi oblast	0.013	0.419	Odesa oblast	226	0.012
Chernihiv oblast	0.013	0.419	Lviv oblast	213	0.012
Rivne oblast	0.012	0.387	Dnipropetrovsk oblast	100	0.005
Zakarpattia oblast	0.011	0.355	Rivne oblast	68	0.004
Khmelnytskyi oblast	0.009	0.290	Chernivtsi oblast	56	0.003

Table 6. Average values of indicators I_E, I_S, and for them, the values of indicators C_I by regions of Ukraine, 2017–2019

Source: State Statistics Service of Ukraine (2018, 2019, 2020).

Region of Ukraine	I_E	C_I for I_E	Region of Ukraine	I_S	C_I for I_S
Zakarpattia oblast	15.641	1.000	Zaporizhzhia oblast	46,615	1.000
Cherkasy oblast	8.971	0.574	Dnipropetrovsk oblast	39,553	0.849
Chernihiv oblast	8.073	0.516	Kharkiv oblast	19,670	0.422
Luhansk oblast	6.938	0.444	Kyiv oblast	12,862	0.276
Kherson oblast	6.359	0.407	Mykolaiv oblast	12,657	0.272
Zhytomyr oblast	5.95	0.380	Sumy oblast	10,092	0.216
Donetsk oblast	5.516	0.353	Zakarpattia oblast	8,021	0.172
Khmelnytskyi oblast	5.508	0.352	Odesa oblast	6,282	0.135
Kirovohrad oblast	5.327	0.341	Lviv oblast	5,851	0.126
Poltava oblast	3.697	0.236	Chernivtsi oblast	5,605	0.120
Kharkiv oblast	3.645	0.233	Kirovohrad oblast	4,749	0.102
Rivne oblast	3.581	0.229	Cherkasy oblast	4,350	0.093
Odesa oblast	2.732	0.175	Chernihiv oblast	3,772	0.081
Kyiv oblast	2.696	0.172	Kherson oblast	3,739	0.080
Zaporizhzhia oblast	2.666	0.170	Zhytomyr oblast	3,641	0.078
Lviv oblast	2.664	0.170	Poltava oblast	3,220	0.069
Vinnytsia oblast	2.241	0.143	Ivano-Frankivsk oblast	2,693	0.058
Volyn oblast	2.214	0.142	Luhansk oblast	2,684	0.058
Ivano-Frankivsk oblast	1.753	0.112	Ternopil oblast	2,409	0.052
Ternopil oblast	1.647	0.105	Khmelnytskyi oblast	2,329	0.050
Chernivtsi oblast	1.473	0.094	Vinnytsia oblast	2,191	0.047
Sumy oblast	1.06	0.068	Volyn oblast	1,917	0.041
Mykolaiv oblast	0.948	0.061	Rivne oblast	1,491	0.032
Dnipropetrovsk oblast	0.804	0.051	Donetsk oblast	1,080	0.023

Tables 5 and 6 show that Cherkasy and Zaporizhzhia oblasts are the most competitive regions in innovation activities over 2017-2019 in Ukraine: they are at the top of the rankings in three indicators. Innovation management in these regions is better. Several other regions – Kharkiv, Ternopil, Sumy, Kirovohrad, and Vinnytsia oblasts – are leading in two indicators. Outsiders include Khmelnytskyi, Chernivtsi, and Rivne oblasts; they are at the end of the competitiveness ranking in three indicators. Odesa and Rivne oblasts are at the bottom of the ranking in two indicators. Most regions fall simultaneously at the top and bottom of the list in different indicators.

Since the obtained results do not consider changes over time, it is necessary to calculate and analyze the dynamic indices of the development of innovation activities. The results of calculating the dynamic indices for 2017-2019 and the ranking of regions by their values are presented in Tables 7 and 8.

Table 7. Results of calculating dynamic indices i_I and i_P by regions of Ukraine, 2017–2019

Source: State Statistics Service of Ukraine (2018, 2019, 2020).

Region of Ukraine	i_I	Region of Ukraine	i_P
Rivne oblast	1.45	Luhansk oblast	7.04
Luhansk oblast	1.16	Khmelnytskyi oblast	2.66
Donetsk oblast	1.13	Kirovohrad oblast	2.57
Kyiv oblast	1.04	Odesa oblast	2.31
Dnipropetrovsk oblast	1.04	Volyn oblast	2.11
Poltava oblast	1.02	Dnipropetrovsk oblast	1.90
Ternopil oblast	1.02	Mykolaiv oblast	1.75
Vinnytsia oblast	1.00	Ternopil oblast	1.68
Zaporizhzhia oblast	1.00	Sumy oblast	1.56
Khmelnytskyi oblast	1.00	Chernihiv oblast	1.53
Chernihiv oblast	1.00	Donetsk oblast	1.51
Kharkiv oblast	0.98	Cherkasy oblast	1.49
Zhytomyr oblast	0.97	Poltava oblast	1.46
Sumy oblast	0.94	Zhytomyr oblast	1.44
Odesa oblast	0.94	Kherson oblast	1.35
Cherkasy oblast	0.92	Vinnytsia oblast	1.29
Lviv oblast	0.91	Kharkiv oblast	1.22
Kherson oblast	0.89	Ivano-Frankivsk oblast	1.19
Chernivtsi oblast	0.89	Kyiv oblast	1.09
Mykolaiv oblast	0.88	Lviv oblast	1.06
Ivano-Frankivsk oblast	0.85	Rivne oblast	0.92
Kirovohrad oblast	0.85	Chernivtsi oblast	0.82
Zakarpattia oblast	0.76	Zaporizhzhia oblast	0.81
Volyn oblast	0.74	Zakarpattia oblast	0.59

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Table 8. Results of calculating dynamic indices i_E and i_S by regions of Ukraine, 2017–2019

Source: State Statistics Service of Ukraine (2018, 2019, 2020).

Region of Ukraine	i_E	Region of Ukraine	i_S
Luhansk oblast	5.15	Ternopil oblast	1.38
Khmelnytskyi oblast	3.53	Chernivtsi oblast	1.37
Kirovohrad oblast	2.97	Donetsk oblast	1.36
Volyn oblast	2.39	Zaporizhzhia oblast	1.30
Odesa oblast	1.87	Ivano-Frankivsk oblast	1.26
Cherkasy oblast	1.60	Luhansk oblast	1.16
Chernihiv oblast	1.52	Kyiv oblast	1.14
Donetsk oblast	1.52	Chernihiv oblast	1.13
Kharkiv oblast	1.37	Zhytomyr oblast	1.11
Dnipropetrovsk oblast	1.36	Lviv oblast	1.10
Zaporizhzhia oblast	1.19	Kharkiv oblast	1.06
Kherson oblast	1.03	Odesa oblast	1.02
Kyiv oblast	1.02	Rivne oblast	1.01
Lviv oblast	1.02	Zakarpattia oblast	0.99
Chernivtsi oblast	0.99	Vinnytsia oblast	0.97
Sumy oblast	0.91	Kherson oblast	0.93
Mykolaiv oblast	0.89	Khmelnytskyi oblast	0.92
Ivano-Frankivsk oblast	0.88	Dnipropetrovsk oblast	0.92
Ternopil oblast	0.70	Poltava oblast	0.88
Zakarpattia oblast	0.48	Volyn oblast	0.84
Rivne oblast	0.45	Mykolaiv oblast	0.84
Vinnytsia oblast	0.42	Sumy oblast	0.79
Poltava oblast	0.34	Cherkasy oblast	0.76
Zhytomyr oblast	0.31	Kirovohrad oblast	0.66

From the calculation results of Tables 7 and 8, according to the values of the dynamic indices i_P, i_E, i_S, respectively, 83%, 58%, 54% of the regions of Ukraine have an increase over time in the values of three indicators of the development of innovation activities. In such regions the values of dynamic indices are higher than 1.

Only 29% of the regions have i_I values greater than 1, which means that the share of innovatively active industrial enterprises in other regions is decreasing. The i_P index is less than 1 in only four regions, which indicates a decrease in time over the volume of innovative products sold by the region per employee involved in research. Less than half of the regions have values of the i_E and i_S indices less than 1, which is unsatisfactory for them. Moreover, most regions show an increase in performance and, accordingly, they have better competitiveness.

4. DISCUSSION

The obtained values of I_I indicators determine the share of innovatively active enterprises in all considered regions as small, while the contribution of innovatively active industrial enterprises to the overall development of innovation activities in the region is the most significant. In many cases, a small value of the indicator points to a small investment in innovation.

The results of calculating I_P indicators specify the productivity of the release of innovative goods and services per one employee engaged in R&D as relatively low in most regions. This can indicate that such regions have low integration of education, science, industry, and business.

From the results of calculating the I_E indicators, one can see that the ratio of the volume of sold innovative industrial goods and services to the costs of innovation of industrial enterprises in most regions is relatively small. Although, high costs of innovation are a positive factor, as they will have a positive effect in the future.

Based on the obtained data for calculating the I_S indicators, one can see that most regions have relatively low costs for performing R&D per organization that may be due to the underfunding of this area from both the regional budget and the state. However, this can indicate that the network of scientific organizations is not optimal.

The results of calculations of the average values of indicators I_I, I_P, I_E, I_S and the indicators for their relative assessment of competitiveness in innovation activities demonstrate that no region would fall to the top of the competitiveness rankings in all four indicators. Moreover, most regions fall simultaneously at the top and bottom of the rankings that indicates the heterogeneity of the development of innovation activities and confirms the results.

The values of i_I, i_P, i_E, i_S indices for most regions are greater than 1, which indicates that these regions progress in innovation activities over time and potential for further development. However, regions with relatively large index values may need large investments to maintain the pace of innovation. The

regions with values less than 1 have a declining level of the development of innovation activities.

The obtained results are generally a continuation of the research of other scientists. Comparing with results by Kniazevych et al. (2018), it is found that the management decisions for the development of innovation activities in the region are also the main factors in the development of the Ukrainian innovation system. Results by Ilyash et al. (2018) are traced in this study in I_P, I_E indicators for the regions. Boronos et al. (2020) developed normalized indicators for assessing the level of development of the territorial innovation system, where the basis of comparison is the best absolute value of the indicator. It is suitable for assessing the competitiveness in innovation. Results showed that Ukrainian regions are different from each other in innovation development. The method in this study is quite simple and at the same time it covers the main areas of innovation activities of the regions with the opportunity to be improved. Indicators have the relative character that makes them comparable, eliminating the scope of absolute values of their components. Some components of indicators in any form are used in calculations of popular global indices, but they are quite universal, which allows using them at the regional level. In addition, the method contains dynamic indices that show changes in characteristics over time. This is especially important in cases where the factor used in the calculations has a delayed effect. The results show that in comparison with the existing results, most regions of Ukraine also have relatively low values of the indicators of the development of innovation activities, but over time, most of them have improved.

CONCLUSION

Assessment of the development of innovation activities in the individual regions of Ukraine using the relative indicators show that all considered regions of Ukraine have significant differences in results. For most regions, the values of indicators of the development of innovation activities are relatively low. The average values of these indicators and the indicators of the competitiveness in innovation activities demonstrate that most considered regions have heterogeneous development of innovation activities. However, over time all indicators improved in at least 29% of regions. In addition, on three indicators out of four, the values improved in at least 54% of regions.

Such differences in results are influenced by the nature of regional management decisions. The goal of ensuring the high competitiveness of the region through the development of innovative activities is common at the level of each region since competitiveness and innovation are interdependent. According to the above, management decisions in all considered regions of Ukraine should be aimed at the implementation of integration processes on an innovative basis in education and science, industry and business, as well as increasing the level of innovation activity of enterprises, especially in the form of promoting appropriate investment. It should be increasing in funding for the implementation of R&D, and the optimization of the activities of organizations engaged in R&D. However, efforts should be aimed not so much at increasing the costs of innovation, but at increasing the efficiency of these costs. Management decisions should be comprehensive for all considered regions. For the regions where there is no improvement over time, the proposed management decisions should be implemented first.

The different competitiveness of the regions reflects the differences in the development of innovation activities of the regions. The most notable impact on the development of innovation activities is the funding of innovation activities. The sufficient funding of innovation activities in each region can be one of the means of mitigating regional differences. Therefore, it is important to ensure effective funding for innovation activities at the regional level in Ukraine.

The practical use of the obtained results is the application of the proposed assessment methods, management decisions regarding the development of innovation activities in the region, and increasing the competitiveness of the region in innovation activities.

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Opportunities for future research in this direction lie in the plane of identifying specific factors influencing the innovation activities of the most competitive regions. In addition, the study of new sources of progress in sustainable development based on the development of innovation activities in the regions is of scientific interest.

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