

The Higher Education System in The Context of Innovative and Intellectual Development of Territories

Denys Krylov

D.Sc. in Economics, Assoc. Prof.,
Zaporizhia National University,
Zaporizhzhia, Ukraine.
krylov.denys2021@gmail.com

Yuliia Hermash

PhD in Pedagogy, Senior Lecture,
National Technical University of Ukraine
Igor Sikorsky Kyiv Polytechnic Institute,
Kyiv, Ukraine.
bryl.yuliia@ill.kpi.ua

Ihor Chobitok

PhD in Economics, Senior Lecture,
V. N. Karazin Kharkiv National University,
Kharkiv, Ukraine.
igor_chobitok@ukr.net

Svitlana Nazarko

PhD in Economics, Assoc. Prof.,
Penitentiary Academy of Ukraine,
Chernihiv, Ukraine.
s.nazarko@ukr.net

Rostyslav Pashov

PhD in Philosophy, Assoc. Prof.,
National Technical University of Ukraine
Igor Sikorsky Kyiv Polytechnic Institute,
Kyiv, Ukraine.
pashov.kpi@gmail.com

Abstract

Globalization trends prove the undeniable need for the development of territories on the intellectual and innovative basis, which in turn necessitates the need to pay more attention to the higher education system, which ensures the formation of intellectual potential and the innovative direction of the development of territories. The purpose is to develop methodological principles for evaluating the higher education system in the context of intellectual and innovative development of territories. Problems of the functioning of the higher education system in the context of ensuring intellectual and innovative development of territories are identified, namely: asymmetric spatial development of territories within the national economic system; effect of the legal regime of martial law; prevalence of practices of the command-administrative nature in the field of management and organization of educational activities both from the point of view of excessive bureaucratization of the system; formalized nature of the value perception of the higher education institution among the population; limited financial resources to ensure the proper level of material and technical base of domestic higher education institutions and sufficient level of material motivation of scientific and pedagogical workers; negative trends in the development of the socio-cultural environment. Separate indicators of the higher education system in terms of territories are analyzed, namely dynamics of the number of students in higher education institutions of Ukraine by region, number of higher education institutions and graduation of specialists by higher education institutions of Ukraine by region. The methodological approach to assessing the higher education system in the conditions of intellectual and innovative development of territories is proposed. It involves adhering to the principles of complexity and systematicity, as well as using the methodological apparatus of the taxonomic analysis to obtain comprehensive assessment, which involves constructing a system of descriptive indicators; qualitative analysis of the system of descriptive indicators; standardization of the values of constructing the observation matrix; construction of the “standard vector” , and on its basis

calculating the value of the Euclidean distance; calculation of the integral indicator for assessing the state of the higher education system in the conditions of intellectual and innovative development. The proposed methodological approach was tested on the example of the functioning of the higher education system in the territories of Ukraine.

Keywords: Education, Higher Education Institutions, Higher Education System, Innovative Development, Intellectual Development, Region, Territory.

Introduction

Today, one of the key system-forming vectors to ensure progressive economic growth within the main levels of organization of economic systems remains the intellectual and innovative component of development, aimed at intensifying scientific and technical, personnel, investment, natural and ecological potential of both individual spatial formations and the national economy as a whole. The outlined trends in the dynamics of socio-economic development are explained by paradigmatic transformation of economic systems embodied in gradual formation of post-industrial forms of organization of economic relations, focused on the specific approaches to management and the use of the resource potential of economic systems, as well as general reprioritization of key resource components of development as such.

The fundamental driving forces that ensure actualization of the issues of innovative and intellectual development are dynamic processes of changing the structural indicators of the return of key resource components of economic systems. These processes manifest themselves in strengthening the role of intellectual potential (as an inexhaustible resource for generating managerial and technical, and technological solutions), innovations (as tools for optimizing business processes and implementing fundamentally new methods, means and forms of economic activity), information resources (as a multivariate category that can serve as a primary resource for making managerial decisions, a product, a communication tool, etc.), creative potential (as an integral component for achieving full realization of the individual potential of the human resource, based on the relevant psycho-emotional and moral-value aspects), inclusive environment (as an

infrastructural aspect of ensuring physical opportunities for realizing the individual potential of all categories of the population), knowledge resources (as an objective basis for structural and analytical formalization, cognitive processing of information resources to achieve its functionality). It is worth noting that among the above-mentioned aspects of the implementation of intellectual and innovative development processes, a special place is occupied by the issue of building knowledge potential, which forms the basis for further implementation of intellectual and creative potential, using information resources, and generation of innovative products.

The leading role in the building and expanding the knowledge potential of economic systems belongs primarily to the higher education system, which is designed to ensure multifaceted development of the individual potential of individuals both in terms of basic skills and abilities, and in the formation of holistic qualification competencies for conducting professional activities in terms of specific functional aspects and also in terms of moral, ethical and psychological qualities necessary for establishing communication interactions and making managerial decisions.

It should be emphasized separately that it is important to consider the spatial aspect of the functioning of the higher education system in the context of intellectual and innovative development, which consists in the need to ensure sustainable and effective functioning of relevant educational and scientific institutions in the context of their ability to organize training of specialists with appropriate level of professional competence, taking into account the specific territorial conditions and needs of the region in human resources and their knowledge potential.

The purpose of the study is to develop methodological principles for evaluating the higher education system in the context of intellectual and innovative development of territories.

To achieve the goal, the following tasks were solved:

- timeliness of scientific research in this area of interest for scientists and practitioners is substantiated, which is confirmed by the analysis of recent literary sources;

- problems of the functioning of the higher education system in the context of ensuring intellectual and innovative development of territories are identified;
- individual indicators of the higher education system by territory are analyzed;
- methodological approach to evaluating the higher education system in the context of intellectual and innovative development of territories is proposed;
- The proposed methodological approach was tested on the example of the functioning of the higher education system in the territories of Ukraine.

Literature review

Articles of Wang Halving et al. (2025), Allam H. M. et al. (2025), Sheng Yaninq. (2025) are devoted to the methodology formation for the strategy of implementing content innovations in digital education in higher professional colleges using artificial intelligence, and to the study the AI impact on sustainable development of innovations and transformation of higher education. Within the framework of research of Ocen S. et al. (2025), Gao Y. (2025), Gutiérrez-Leefmans M. et al. (2025), the role of AI in the development of higher education institutions, its impact on the formation of innovation in learning models, assessment systems, and personalized learning was analyzed.

The authors Barqawi L. et al. (2024), Alejandra Colmenares Garzon et al. (2024), Nugraheni Anjar Sri Ciptorukmi et al. (2024) focused their research on enhancing innovation in higher education through artificial intelligence and intellectual property, and proposed the use of the business intelligence dashboard as a technological innovation for analyzing digital transformation in higher education. Ruixin Zhang (2024), Dangying Liu (2024), Danli Huang (2024) demonstrate the experience of the AI use in higher education, proving that the artificial intelligence technology contributes to model innovations in higher education management and student learning mechanisms.

Alam Ashraf et al. (2022), Chedrawi C. et al. (2019), Popelo O. et al. (2024) demonstrate the results of developing a business model, business strategy, and innovation in higher education, consider AI as a revolutionary innovation in

higher education accreditation programs, and analyze global trends in university digitalization within the framework of the sustainable development concept. Kholiavko N. et al. (2023), Marhasova V. et al. (2023), Arefiev S. et al. (2022) analyze the path of a higher education institution to sustainable development, investigate the impact of digitalization on its innovative development, taking into account the challenges of war and pandemic. Djakona A. et al. (2021), Jakubek P. et al. (2023) consider the role of higher education in the information economy development, analyze managerial control in the system of ensuring economic security and innovative development.

However, taking into account the above-mentioned achievements of scientists, we can argue about the feasibility of conducting further research related to the higher education development in the context of innovative and intellectual development of territories.

Methodology

Within the framework of this study, it is proposed to use the methodological apparatus of the taxonomic analysis as a method to assess the state of the higher education system in the conditions of intellectual and innovative development of territories to ensure the complexity of the obtained results and possible quantitative formalization of the obtained effective assessment indicators. The substantive basis of the taxonomic analysis method is to calculate the quantitative level of the Euclidean distance between the analyzed objects of multidimensional space. Within the framework of the taxonomic analysis method, the dimension of this system is represented by a selected list of descriptive indicators of the studied objects. At the same time, the method allows you to freely vary the composition of the system of descriptive indicators, regardless of their dimension and typology, allowing you to form arrays of indicators that are heterogeneous in their economic nature without losing the properties of the assessment representativeness. The latter is achieved by carrying out a procedure for standardizing the values of the selected descriptive indicators, which ensures their comparability and quantitative uniformity, protecting against possible distortion of subsequent quantitative integral assessments.

Thus, the involvement of the methodological apparatus of the taxonomic analysis opens up opportunities for the formation of the comprehensive evaluation system based on a wide range of descriptive indicators of the higher education system in the context of intellectual and innovative development of territories, calculating on its basis generalized integral assessments for each of the studied regional objects.

Practical implementation of the taxonomic analysis involves implementation of some computational and analytical stages, which includes the sequence of actions described below.

1. Designing a system of descriptive indicators, which serves as the initial data set for further calculation and analytical operations; the system of descriptive indicators should be presented in the form of a matrix of obse

$$X = \begin{bmatrix} x_{11} & x_{1j} & x_{1m} \\ x_{i1} & x_{ij} & x_{im} \\ x_{n1} & x_{nj} & x_{nm} \end{bmatrix} \quad (1)$$

where: X is - observation matrix;

n – number of studied periods;

m – number of descriptive evaluation indicators;

x_{ij} – value of descriptive indicator j in the ith period.

2. Qualitative analysis of the formed array of descriptive evaluation indicators, which involves determining the nature of the focus of a particular indicator on the analyzed object, that is, under the condition of positive impact of the growth of the descriptive indicator, the state of the higher education system improves in the conditions of intellectual and innovative development of territories, in case of negative impact of the descriptive indicator, the corresponding state deteriorates.
3. Standardization of the values of the constructed observation matrix, which allows bringing the descriptive indicators system into a comparable form before performing further calculations (2).

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{\sigma_{x_j}} \quad (2)$$

where: x_{ij} – value of the i -th descriptive indicator in the array j;

$\bar{x}_j$ – average value of the i -th descriptive indicator in the array j;

σ_{x_j} – level of the standard deviation of the descriptive indicator i.

4. Formation of a “standard vector”, based on the results of the normalization of descriptive assessment indicators and the qualitative analysis of the impact nature of the studied descriptive indicators (3).

$$y_{0j} = \begin{cases} \max_i y_{ik}, & \text{provided that the descriptive indicator is positive} \\ \min_i y_{ik}, & \text{provided that the descriptive indicator is negatively oriented} \end{cases} \quad (3)$$

The constructed “standard vector” allows us to demonstrate at what standardized levels of descriptive assessment indicators the best state of the higher education system is achieved in the conditions of intellectual and innovative development of territories.

5. Based on the formed “standard vector”, the value of the Euclidean distance is calculated, namely the taxonomic distance between the available standardized values of descriptive indicators and the corresponding values of the “standard vector” (4).

$$d_{i0} = \sqrt{\sum_{j=1}^n (y_{ij} - y_{0j})^2} \quad (3)$$

where d_{i0} is the Euclidean distance between y_{ij} and the values of the “standard vector”.

6. The obtained values of the Euclidean distance between the “standard vector” and the values of the standardized values of descriptive indicators open up opportunities for further calculation of intermediate indicators to assess the state of the higher education system in the conditions of intellectual and innovative development of territories, which involves identifying quantitative parameters of deviations of the values of the “standard vector” from the actual standardized values generalized for the entire array of descriptive

indicators of a separate region. First, average levels of deviations of the taxonomic distance of indicators from the “standard vector”, the root mean square deviation of Euclidean distances for all descriptive indicators, the maximum deviation from the “standard vector” and the intermediate indicator for assessing the state of the higher education system in the conditions of intellectual and innovative development of territories for individual regions are calculated. The specified calculation procedures are carried out using the following formulas (4-7).

$$M(d_{i0}) = \overline{d_0} = \frac{1}{m} \sum_{i=1}^m d_{i0} \quad (4)$$

where $M(d_{i0})$ - average deviation of the descriptive indicator from the “standard vector”.

$$\sigma_0 = \sqrt{\frac{1}{m} \sum_{i=1}^m (d_{i0} - \overline{d_0})^2} \quad (5)$$

where σ_0 - value of the standard deviation of the indicator d_{i0} .

$$d_0 = \overline{d_0} + 3 \times \sigma_0 \quad (6)$$

where d_0 - maximum deviation of descriptive indicators from the “standard vector” (using the “three sigma rule”).

$$c_i^* = \frac{d_{i0}}{d_0} \quad (7)$$

where c_i^* - intermediate indicator of the assessment of the state of the higher education system in the conditions of intellectual and innovative development of territories.

7. Calculation of the integral indicator for assessing the state of the higher education system in the context of intellectual and innovative development of territories is implemented based on formula (8).

$$C_i = 1 - c_i^* \quad (8)$$

where C_i - indicator of the assessment of the state of the higher education system in the conditions of intellectual and innovative development of territories.

The calculated values of the integrated indicator allow us to obtain comprehensive integral assessment of the state of the higher education system in each of the studied regions based on wide array of descriptive indicators, taking into account the influence of time characteristic, that is, and dynamics of their change within the studied period.

Results

Currently, the higher education system in the context of ensuring intellectual and innovative development of territories faces a number of systemic problems that significantly limit possibilities of territories to accelerate relevant processes of intensification of economic development. Among the mentioned problems, it is advisable to highlight the following:

- asymmetric spatial development of territories within the national economic system, which manifests itself in available persistent deformations of a demographic and financial and economic nature;
- effect of the legal regime of martial law, which causes objective problems by organizing traditional forms of the educational process, as well as opportunities for applicants to effectively acquire knowledge within the framework of relevant educational competencies;
- prevailed practices of the command-administrative nature in management and organization of educational activities both from the point of view of excessive bureaucratization of the system and available functionally rudimentary formations in the organizational structure of responsible authorities;
- formalized nature of the value perception of the higher education institution among the population, which results in inconsistent declared competencies of graduates of higher education institutions with their objective availability;
- limited financial resources to ensure proper level of material and technical base of domestic higher education institutions and a sufficient level of material motivation of scientific and pedagogical workers;
- high level of competition within the domestic higher education system, which significantly complicates the opportunities for the development of regional higher

education institutions and the attraction of potential applicants;

- negative trends in the development of the socio-cultural environment, which lead to reduction in demand for relevant educational services among higher education applicants in favor of distance forms of education and self-education, which is mostly vocationally oriented.

Thus, the problems outlined above form a complex of systemic restrictions both to the development of higher

education within individual territories and within the national economic system as a whole, reducing the latter's potential to ensure intellectual and innovative development. The presented problematic aspects find their practical expression in corresponding quantitative indicators of the functioning of the national higher education system. One of these indicators is the indicator of the number of students in higher education institutions by region, the dynamics of which is presented in Table. 1.

Table 1 – Dynamics of the number of students in higher education institutions of Ukraine by region (2019-2023)

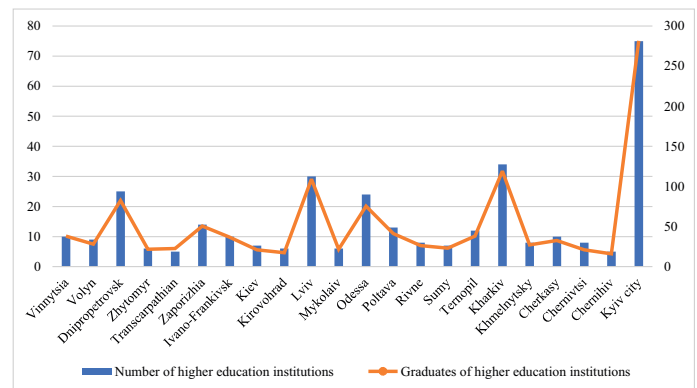
Region/Year	2019	2020	2021	2022	2023
Vinnitsia	41359	39347	32807	34492	37898
Volyn	24069	20678	19269	23054	28035
Dnipropetrovsk	107995	82685	70298	78653	82444
Donetsk	33390	27457	23932	–	–
Zhytomyr	26913	22352	17577	18597	21454
Transcarpathian	21589	20212	17394	21055	22493
Zaporizhzhia	66188	49049	46044	44501	50540
Ivano-Frankivsk	35323	32206	30184	38034	36610
Kiev	24845	18798	15883	17507	20868
Kirovohrad	13357	11626	10181	14614	17270
Luhansk	20078	17856	13233	–	–
Lviv	115700	95364	90385	97257	108968
Mykolaiv	29440	26958	21437	21631	21561
Odessa	95240	75060	67743	71332	75355
Poltava	41936	34019	29895	35038	41174
Rivne	30068	24290	18868	21032	26128
Sumy	31031	18879	18073	19177	22979
Ternopil	39546	28315	26982	31949	37971
Kharkiv	165230	124215	122386	113495	119032
Kherson	24801	20733	18579	–	–
Khmelnyskyi	29927	25308	22252	25195	27109
Cherkassy	36140	32422	28832	30132	32436
Chernivtsi	26575	22329	18748	20577	20964
Chernihiv	17684	12976	11917	12523	15941
Kyiv	341282	258755	253770	263925	281428

Source: State Statistics Service of Ukraine (2023)

Based on the above dynamics of the number of students in higher education institutions of Ukraine during 2019-2021, a steady downward trend is observed. The highest levels of reduction in the number of students were recorded in 2020 in Kyiv from 341,282 people to 258,755 people, which is 24.1%, Dnipropetrovsk region (reduction by 25,310 people, or 30.1%); Kharkiv region (reduction by 41,015 people, or 24.8%), Lviv region (reduction by 20,336 people, or 17.6%). These processes are explained by negative impact of the coronavirus pandemic, which led to a significant change in approaches to organizing the educational process, complicating access to traditional forms of educational activity, reducing the population and corresponding volume of solvent demand for educational services. At the same time, during 2022-2023, there is a partial recovery in the number of students in higher education institutions, in particular, the highest levels of the growth rate are observed among the following regions: Transcarpathian region (21.0%), Ivano-Frankivsk region (26.0%), Volyn region (19.6%), and Ternopil region (18.4%). The outlined trend is a direct result of the beginning of the full-scale invasion and the effect of the legal regime of martial law, which caused the migration outflow of the population, to regions remote from the line of hostilities, as well as the specific features of the regulatory and legal nature that are in force under the martial law regime. A further reduction in the number of students in higher education institutions during the specified period was observed among front-line regions, including Kharkiv region (-7.3%) and Zaporizhzhia region (-3.4%).

It is worth noting that an important aspect of ensuring functioning of the higher education system is available appropriate infrastructure and relevant parameters of their effectiveness, which is why we propose to consider the indicators of the number of higher education institutions and the volume of graduates of qualified specialists in 2023 (Fig. 1).

Figure 1 – Number of higher education institutions and graduates of higher education institutions of Ukraine by region (2023)



Source: State Statistics Service of Ukraine (2023)

Based on the data presented in Fig. 1, it can be stated that the highest concentration of higher education institutions in 2023 is observed in Kyiv (83 units), Kharkiv region (30 units), Dnipropetrovsk region (29 units), Lviv region (21 units) and Odessa region (21 units). Analyzing the absolute values of the indicator of the graduation of specialists by higher education institutions, the highest levels are recorded in Kyiv (101,454 people), Kharkiv (44,880 people), Lviv (40,619 people) and Odessa regions (30,422 people).

However, examining this issue from the perspective of estimates based on relative values, in particular, student graduation per 1 higher education institution among the regions of Ukraine, the highest levels are demonstrated by Ternopil region (2611.5 persons/unit of higher education institution), Chernivtsi region (2474.7 persons/unit of higher education institution), Poltava region (2111.1 persons/unit of higher education institution) and Lviv region (1934.2 persons/unit of higher education institution). This situation is explained by available large higher education institutions with the “national” status, which accumulate a significant number of applicants.

It should be noted that the study of the functioning of the higher education system in the conditions of intellectual and innovative development of the territory is a complex issue with the presence of a wide range of influential factors, both systemic and situational, directly affecting the

indicators of the efficiency of the higher education system and corresponding effectiveness in the context of accelerating intellectual and innovative development. That is why, assessing the state of the higher education system in the conditions of intellectual and innovative development of territories requires going beyond traditional methods of statistical analysis and requires the formation of more representative forms of organizing a comprehensive assessment process based on the tools of economic and mathematical analysis.

Based on the above-presented sequence of implementation of the taxonomic analysis within the framework of the study of the state of the higher education system in the context of intellectual and innovative development of territories, one of the key stages is the construction of a system of descriptive indicators. Taking into account the need to adhere to the principles of complexity and systematicity, within the framework of this study it is proposed to expand the applied plane of the analysis in relation to selected analytical indicators. This need is explained by the inexpedient isolated consideration of indicators that characterize exclusively the state and dynamics of the higher education development, since the issues of intellectual and innovative development also cover the issue of the effective knowledge potential generated by higher education institutions in the context of the functioning of the regional economic system as a whole. That is why, by constructing a matrix of observations of the initial values of descriptive indicators, it is proposed to rely on the following analytical aspects:

1. The educational aspect encompasses a set of indicators that allow for a comprehensive assessment of the current state and effectiveness of the region's higher education system, both from the perspective of indicators that quantitatively characterize the levels of applicant engagement and from the perspective of adequate staffing to support the functioning of higher education institutions. Within this aspect, it is proposed to use the following descriptive indicators: number of higher education institutions; number of students; number of first-time admissions to higher education institutions; number of women among higher education students; number of

graduates from higher education institutions; number of scientific and pedagogical staff of higher education institutions; number of scientific and pedagogical staff with a doctorate degree; number of scientific and pedagogical staff with a candidate degree.

2. The socio-economic aspect characterizes the indirect impact of the efficiency of the higher education system in terms of the formation of the knowledge base of graduates of higher education institutions on the main social and economic parameters of the region, while simultaneously reflecting the state and dynamics of the development of the economic situation within the region. Within this aspect, it is proposed to use the following descriptive indicators: number of operating business entities; added value at the cost of production of business entities; capital investments; share of enterprises that have incurred losses in the total number of enterprises; net profit (loss) of enterprises.

3. The ecological aspect reflects the state of the natural and ecological environment of the organization of the functioning of the higher education system of the region, reflects one of the key aspects of ensuring sustainable development within the framework of the intellectual and innovative orientation of the relevant transformation processes. Within this aspect, it is proposed to use the following descriptive indicators: emissions of pollutants into the atmospheric air from stationary sources; emissions of carbon dioxide into the atmospheric air from stationary sources of emissions by region.

Thus, the constructed model for assessing the state of the higher education system in the context of intellectual and innovative development of regions includes 15 descriptive indicators; the research period is 2019-2023.

Due to the methodological apparatus of the taxonomic analysis based on the formed initial array of descriptive indicators of the state of the higher education system in the conditions of intellectual and innovative development of territories, the following intermediate indicators were obtained, which are presented in Table 2.

Table 2 – Intermediate indicators of the calculation of the integral indicator of the state of the higher education system in the conditions of intellectual and innovative development of territories

Region/Year	2019		2020		2021		2022		2023	
	d _{io}	c _i [*]	d _{io}	c _i [*]	d _{io}	c _i [*]	d _{io}	c _i [*]	d _{io}	c _i [*]
Vinnitsia	19,646	0.770	19,620	0.779	19,736	0.774	19,824	0.786	19,281	0.663
Volyn	20,294	0.796	20,450	0.811	20,424	0.801	20,360	0.807	19,925	0.686
Dnipropetrovsk	17,854	0.700	17,972	0.713	18,163	0.712	18,049	0.716	17,079	0.588
Donetsk	20,787	0.815	20,764	0.824	20,854	0.818	-	-	-	-
Zhytomyr	20,330	0.797	20,433	0.811	20,587	0.807	20,759	0.823	20,353	0.700
Transcarpathian	20,296	0.796	20,371	0.808	20,479	0.803	20,556	0.815	20,211	0.695
Zaporizhzhia	19,228	0.754	19,416	0.770	19,478	0.764	20,133	0.798	21,277	0.732
Ivano-Frankivsk	20,068	0.787	19,958	0.792	20,030	0.785	19,818	0.786	19,736	0.679
Kiev	19,680	0.772	19,930	0.791	19,921	0.781	20,238	0.802	18,944	0.652
Kirovohrad	20,600	0.808	20,694	0.821	20,705	0.812	20,581	0.816	20,303	0.699
Luhansk	20,615	0.808	20,606	0.818	20,748	0.813	-	-	-	-
Lviv	17,021	0.667	17,486	0.694	17,582	0.689	17,451	0.692	15,640	0.538
Mykolaiv	20,101	0.788	20,212	0.802	20,301	0.796	20,639	0.818	20,358	0.701
Odesa	17,779	0.697	18,129	0.719	18,262	0.716	18,742	0.743	17,917	0.617
Poltava	19,641	0.770	19,639	0.779	19,836	0.778	19,861	0.787	19,132	0.658
Rivne	20,346	0.798	20,408	0.810	20,460	0.802	20,546	0.815	20,185	0.695
Sumy	20,238	0.793	20,436	0.811	20,501	0.804	20,789	0.824	20,318	0.699
Ternopil	19,869	0.779	20,163	0.800	20,260	0.794	20,190	0.800	19,771	0.680
Kharkiv	15,847	0.621	16,142	0.641	16,333	0.640	17,449	0.692	16,751	0.576
Kherson	20,235	0.793	20,354	0.808	20,406	0.800	-	-	-	-
Khmelnyskyi	20,053	0.786	20,004	0.794	20,138	0.789	20,143	0.799	19,728	0.679
Cherkasy	19,892	0.780	19,943	0.791	20,052	0.786	20,070	0.796	19,699	0.678
Chernivtsi	20,400	0.800	20,533	0.815	20,724	0.812	20,665	0.819	20,495	0.705
Chernihiv	20,572	0.807	20,692	0.821	20,709	0.812	21,070	0.835	20,756	0.714
Kyiv	11,029	0.432	11,821	0.469	11,351	0.445	12,248	0.486	4,249	0.146
M(d _{io})	19,2969356		19,44706486		19,52161464		19,55361522		18,73220044	
σ ₀	2,070063519		1,918043702		1,995238004		1,890060734		3,443191791	
d ₀	25,50712616		25,20119596		25,50732865		25,22379742		29,06177581	

Source: compiled by the author based on calculations

Based on the obtained intermediate indicators of the state of the higher education system in the conditions of intellectual and innovative development of the territories, the corresponding integral indicator was calculated. The

dynamics of the integral indicator of the state of the higher education system in the conditions of intellectual and innovative development of the regions of Ukraine during 2019-2023 is presented in Table 3.

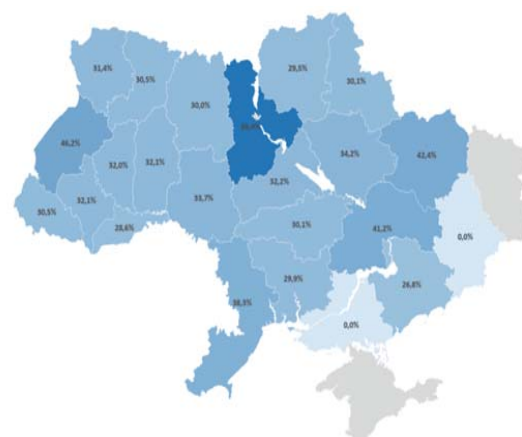
Table 3 – Dynamics of the integral indicator of the state of the higher education system in the conditions of intellectual and innovative development of regions (2019-2023)

Region	Year					Absolute deviation			
	2019	2020	2021	2022	2023	2020 to 2019	2021 to 2020	2022 to 2021	2023 to 2022
Vinnysia	23.0%	22.1%	22.6%	21.4%	33.7%	-0.8%	0.5%	-1.2%	12.2%
Volyn	20.4%	18.9%	19.9%	19.3%	31.4%	-1.6%	1.1%	-0.6%	12.2%
Dnipropetrovsk	30.0%	28.7%	28.8%	28.4%	41.2%	-1.3%	0.1%	-0.3%	12.8%
Donetsk	18.5%	17.6%	18.2%	-	-	-0.9%	0.6%	-	-
Zhytomyr	20.3%	18.9%	19.3%	17.7%	30.0%	-1.4%	0.4%	-1.6%	12.3%
Transcarpathian	20.4%	19.2%	19.7%	18.5%	30.5%	-1.3%	0.5%	-1.2%	11.9%
Zaporizhzhia	24.6%	23.0%	23.6%	20.2%	26.8%	-1.7%	0.7%	-3.5%	6.6%
Ivano-Frankivsk	21.3%	20.8%	21.5%	21.4%	32.1%	-0.5%	0.7%	0.0%	10.7%
Kiev	22.8%	20.9%	21.9%	19.8%	34.8%	-1.9%	1.0%	-2.1%	15.1%
Kirovohrad	19.2%	17.9%	18.8%	18.4%	30.1%	-1.4%	0.9%	-0.4%	11.7%
Luhansk	19.2%	18.2%	18.7%	-	-	-0.9%	0.4%	-	-
Lviv	33.3%	30.6%	31.1%	30.8%	46.2%	-2.7%	0.5%	-0.3%	15.4%
Mykolaiv	21.2%	19.8%	20.4%	18.2%	29.9%	-1.4%	0.6%	-2.2%	11.8%
Odesa	30.3%	28.1%	28.4%	25.7%	38.3%	-2.2%	0.3%	-2.7%	12.7%
Poltava	23.0%	22.1%	22.2%	21.3%	34.2%	-0.9%	0.2%	-1.0%	12.9%
Rivne	20.2%	19.0%	19.8%	18.5%	30.5%	-1.2%	0.8%	-1.2%	12.0%
Sumy	20.7%	18.9%	19.6%	17.6%	30.1%	-1.7%	0.7%	-2.0%	12.5%
Ternopil	22.1%	20.0%	20.6%	20.0%	32.0%	-2.1%	0.6%	-0.6%	12.0%
Kharkiv	37.9%	35.9%	36.0%	30.8%	42.4%	-1.9%	0.0%	-5.1%	11.5%
Kherson	20.7%	19.2%	20.0%	-	-	-1.4%	0.8%	-	-
Khmelnyskyi	21.4%	20.6%	21.1%	20.1%	32.1%	-0.8%	0.4%	-0.9%	12.0%
Cherkasy	22.0%	20.9%	21.4%	20.4%	32.2%	-1.1%	0.5%	-1.0%	11.8%
Chernivtsi	20.0%	18.5%	18.8%	18.1%	29.5%	-1.5%	0.2%	-0.7%	11.4%
Chernihiv	19.3%	17.9%	18.8%	16.5%	28.6%	-1.5%	0.9%	-2.3%	12.1%
Kyiv	56.8%	53.1%	55.5%	51.4%	85.4%	-3.7%	2.4%	-4.1%	33.9%

Source: compiled by the author based on calculations

A graphic visualization of the distribution of regions of Ukraine by the state of the higher education system in the conditions of intellectual and innovative development of the territories is presented in Fig. 2.

Figure 2 – Cartogram of regions of Ukraine by the state of the higher education system in the context of intellectual and innovative development (2023)



Source: author's development

Conclusions

The scientific novelty of the study lies in the substantiation of the methodological principles of assessing the higher education system in the conditions of intellectual and innovative development of territories, which involves adhering to the principles of complexity and systematicity, as well as using the methodological apparatus of taxonomic analysis to obtain the complexity of the assessment, which involves constructing a system of descriptive indicators; qualitative analysis of the system of descriptive indicators; standardization of the values of constructing the observation matrix; construction of a “standard vector” and, based on it, calculating the value of the Euclidean distance; calculation of the integral indicator of assessing the state of the higher education system in the conditions of intellectual and innovative development.

The proposed methodological approach to assessing the higher education system in the context of intellectual and innovative development of territories using the example of regions of Ukraine was tested. Based on the results obtained, it can be stated that during 2019-2022, there was a significant deterioration in the state of higher education in the context of intellectual and innovative development of regions of Ukraine, which is explained by the direct effect of the factors of the coronavirus pandemic and the effect of the legal regime of martial law. The highest levels of decline in the integral indicator were recorded in Kharkiv region (from 37.9% in 2019 to 30.8% in 2022), Zaporizhzhia region (from 24.6% to 20.2%) and Kyiv city (from 56.8% to 51.4%). However, during 2023, there is a gradual improvement in the functioning of the higher education system in the territories, which is due to the adaptation of the regions to the legal regime of martial law, at the same time, there is a slowed-down recovery dynamics among the front-line regions, and on the contrary, an accelerated recovery among the regions remote from the lines of hostilities. In general, it is worth noting the presence of significant disparities in the level of the functioning of the higher education system in the conditions of intellectual and innovative development of the territories, in particular, the highest levels are characteristic of Kiev, Lviv, Kharkiv, Dnipropetrovsk and Odessa regions, the lowest -

Zaporizhzhia, Chernivtsi, Mykolaiv and Chernihiv regions.

The proposed methodological approach to evaluating the higher education system in the context of intellectual and innovative development of territories and the obtained test results have practical significance and can be used by higher education institutions, state, regional and local authorities to ensure more effective work of the higher education sector and increase its impact on ensuring intellectual and innovative development of territories.

Further research is required on the issues related to increasing the efficiency of higher education activities to ensure the intellectual and innovative development of regions.

References

- Alam, Ashraf, Mohanty, Atasi. (2022). Business Models, Business Strategies, and Innovations in EdTech Companies: Integration of Learning Analytics and Artificial Intelligence in Higher Education. *2022 IEEE Sth Conference on Information and Communication Technology, CICT 2022*. <https://doi.org/10.1109/CICT56698.2022.9997887>.
- Alejandra Colmenares Garzon, Yesica, Damian Guina Escobar, Edwin, Cardona-Roman, Diana M. (2024). Business intelligence dashboard as a technological innovation for analysis on digital transformation in higher education. *Proceedings of the LACCEI international Multi-conference for Engineering, Education and Technology*. DOI: 10.18687/LACCEI2024.L1.1725.
- Allam, H. M., Gyamfi, B., & AlOmar, B. (2025). Sustainable Innovation: Harnessing AI and Living Intelligence to Transform Higher Education. *Education Science*. 15(4), 398. <https://doi.org/10.3390/educsci15040398>.
- Arefiev, S., Popelo, O., Rogulska, O., Rudnitska, K., & Derevianko, D. (2022). Higher education as a determinant of sustainable development. *Revista de la universidad del zulia*, 13(38), 734-746. <http://dx.doi.org/10.46925/rdluz.38.40734>.
- Barqawi, L., Al-Arasi, S., Abdallah, M., Numan, Bernadette H., Al-Afoishat, Muneer Mohammad

- Shada. (2024). Enhancing Innovation in Higher Education through Artificial Intelligence and Intellectual Property. *Journal of Ecohumanism*. <https://doi.org/10.1108/TQM-12-2024-0523>.
- Chedrawi, C., Howayeck, P. (2019). Artificial Intelligence a Disruptive Innovation in Higher Education Accreditation Programs: Expert Systems and AACSB. In: Baghdadi, Y., Harfouche, A. (eds) ICT for a Better Life and a Better World. *Lecture Notes in Information Systems and Organisation*, 30. Springer, Cham. https://doi.org/10.1007/978-3-030-10737-6_8.
 - Dangying Liu. (2024). Artificial Intelligence Technology Facilitates Model Innovation in Higher Education Management and Student Training Mechanisms. *Applied Mathematics and Nonlinear Sciences*, 9(1). <https://doi.org/10.2478/amns-2024-1173>.
 - Danli Huang. (2024). Artificial Intelligence Driving Innovation in Higher Education Management and Student Training Mechanisms. *Applied Mathematics and Nonlinear Sciences*, 9(1). <https://doi.org/10.2478/amns-2024-0835>.
 - Djakona, A., Kholiavko, N., Dubyna, M., Zhavoronok, A., Fedyshyn, M. (2021). Educational dominant of the information economy development: a case of Latvia for Ukraine. *Economic Annals-XXI*, 192(7-8(2)), 108-124. <https://doi.org/10.21003/ea.V192-09>.
 - Gao Y (2025) The role of artificial intelligence in enhancing sports education and public health in higher education: innovations in teaching models, evaluation systems, and personalized training. *Front. Public Health*, 13, 1554911. doi: 10.3389/fpubh.2025.1554911.
 - Gutiérrez-Leefmans, M., Picazo-Vela, S., Kareem, Olanrewaju. (2025). Adoption of artificial intelligence in higher education: a diffusion of innovation approach. *TQM Journal*. DOI: 10.1108/TQM-12-2024-0523.
 - Jakubek, P., Guzonova, V., Rudenko, O., Zahurska-Antoniuk, V., Filipova, N. (2023) Management control in the system of ensuring the economic security of private companies and public institutions. *Journal of interdisciplinary research*, 13(02), XXXV, 160-167. <https://doi.org/10.33543/j.130235.160167> <https://www.magnanimitas.cz/13-02-xxxv>.
 - Kholiavko, N., Popelo, O., Hryhorkiv, M., Kosmii, O., Oleksiienko, O., Zhavoronok, A. (2023). EU higher education institution toward the sustainable development. *Management Theory and Studies for Rural Business and Infrastructure Development*, 46(2), 124-132. <https://ejournals.vdu.lt/index.php/mtsrbid/article/view/4739/2760>.
 - Marhasova, V., Kholiavko, N., Popelo, O., Krylov, D., Zhavoronok, A., & Biliaze, O. (2023). The Impact of Digitalization on the Sustainable Development of Ukraine: COVID-19 and War Challenges for Higher Education. *Revista De La Universidad Del Zulia*, 14(40), 422-439. <https://produccioncientificaluz.org/index.php/rluz/article/view/40076>.
 - Nugraheni, Anjar Sri Ciptorukmi, Widono, Salim, Saddhono, Kundharu, Yamtinah Sri, Nurhasanah, Farida, Murwaningsih, Tri. (2024). Innovations in Education: A Deep Dive into the Application of Artificial Intelligence in Higher Learning. *2024 4th International Conference on Advance Computing and Innovative Technologies in Engineering, ICACITE*. <http://dx.doi.org/10.1109/ICACITE60783.2024.10616739>.
 - Ocen, S., Elasu, J., Aarakit, S.M., & Olupot, C. (2025). Artificial intelligence in higher education institutions: review of innovations, opportunities and challenges. *Front. Educ.*, 10, 1530247. doi: 10.3389/feduc.2025.1530247.
 - Popelo, O., Kholiavko, N., Safonov, Y., Shaposhnykov, K., Babukh, I., Yamniuk, B. (2024). Global trends of universities digitalization under the sustainable development concept. *Management Theory and Studies for Rural Business and Infrastructure Development*, 46(4), 473–481. <https://doi.org/10.15544/mts.2024.44>.
 - Ruixin Zhang. (2024). Application of 'Artificial Intelligence + Education' Innovation Model in Higher Education Management and Student Training. *Applied Mathematics and Nonlinear Sciences*, 9(1).

<https://doi.org/10.2478/amns-2024-1027>.

- Sheng, Yaninq. (2025). Research on teaching reform and innovation in higher education based on artificial intelligence. *Proceedings of 2024 International Conference on Artificial Intelligence and Future Education, AIFE 2024*. (pp. 320-324). <https://doi.org/10.1145/3708394.3708449>.
- Statistical Yearbook of Ukraine for 2023. *State Statistics Service of Ukraine*. URL: https://ukrstat.gov.ua/druk/publicat/kat_u/2023/zb/11/year_23_u.pdf.
- Wang, Halving, Liu, Mingwei. (2025). Methods and content innovation strategies of digital education in higher vocational colleges under the background of artificial intelligence. *Journal of Computational Methods in Sciences and Engineering*, 25(3). <https://doi.org/10.1177/14727978251321337>.