The Role of Digitalization in Development of Regional Economic Systems in the Technoglobalism Context

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Abstract

Modern conditions for development of socio-economic systems of any level cannot be imagined without digitalization. Digital technologies play an important role in competitiveness of regional economic systems (RES), improving quality of life of the population. At the same time, the trend of technoglobalism is increasingly failing at the global level, opening up new opportunities for development for regions. The purpose of the article is to substantiate theoretical and methodological principles of the digitalization role in development of RES in the technoglobalism context using the systemic approach. In the article, the methodological approach to assessing the digitalization role in the development of RES in the technoglobalism context is proposed. This approach involves calculating the integral development index of RES in the conditions of technoglobalism by multiplicative convolution, which consists of five subindices, calculated by nineteen indices and representing a system of tuples. Calculation of subindices using the weighted geometric mean taking into account the weights of pairwise numerical comparisons of the corresponding rows of the matrix. The results of calculations demonstrated the greatest weight of the digital transformation subindex, as well as the smallest differentiation by regions in the value of the digital transformation subindex, which proves the need for further activation of digitalization at the level of RES.

Keywords: Digitalization, Digital Technologies, Digital Transformation, Cloud Computing, Artificial Intelligence Technologies, ERP Software, Social Media, Technoglobalism, Region, Regional Economic System.

Introduction

As part of current global digitalization, enterprises facemodern globalization challenges of social development corresponding to post-industrial progress. Post-industrial social development cannot be imagined without innovative development, generation and dissemination of knowledge, development of intellectual and creative potential and digitalization. Rapid development of information and communication technologies directly affects economic efficiency of business, the state, regions, formation of new forms of activity and

management. Therefore, today it is relevant to deepen research into interrelationships of the development of RES of different levels with digitalization and technoglobalism, which are determinants of social development. Technoglobalism is considered today from several approaches:

first, as a component of globalization, which is innovative and informational in nature;

second, as spreading knowledge, innovations, and technologies between different regions, cross-border companies, and states;

third, as internationalization of technologies on the global scale;

fourth, evolutionary stage of society's development.

Technoglobalism manifests itself as a planetary process that contributes to unification of national innovation and technological systems through the international information space. Technoglobalism encompasses both scientific and innovative sphereand economic, political, ecological, ideological, social, cultural spheres of life at all levels of economic systems from the micro level to the global one.

Literature review

Du Weijian et al. (2025) analyzed how digitalization affects carbon emissions in different regions. Scientists have proven that digitalization contributes to low-carbon growth.Huynh, Da Van et al. (2025) provide suggestions on the effectiveness of tourist destination websites, the digitalization process, and reveal the features of using digital tools of tourist destinations.

Within the framework of the article Ospanov, Zhandoset al. (2024), strategies for increasing economic efficiency are proposed by analyzing its essence and evaluating mining enterprises of the region. The authors have identified five key areas that affect economic efficiency, namely: digital technologies, material resources, management, labor resources and the overall system.

ScientistsJie Y.et al.(2024) argue that digitalization contributes to reducing economic gap between urban and rural areas and outline mechanisms of its influence. It is proven that such mechanisms demonstrate configurational effects on development of regions, which vary depending on changes in contextual and conditional combinations.

Lyu Yanwei et al. (2024), Abdallah M.M.et al. (2025), Gasmi Farid et al. (2024) prove the importance of industrial structure modernization and technological innovation in the context of the rapid development of digitalization, investigate the impact of digital technologies on the energy problems of the region.Chen Yu et al. (2024), Jin X. et al. (2024) investigated that the stability of regional economic structures depends on available natural resources and digital transformation trends.

Popelo O. et al. (2025), Zhavoronok A. et al. (2024) analyzed digital business ecosystem and investigated the role of higher education in development of regions under the influence of digitalization. Tulchynska S. et al. (2024), Hrubliak O. et al. (2024) proved significant role of AL technologies in technoglobalism and investigated their role in the system of assessing safe business development, and analyzed using digital currency withinimplementation of the European Green Deal. Kychko I. et al. (2023), Popelo O. et al. (2023) analyzed the impact of digitalization on the labor market balancing and its role in formation of innovative strategies for enterprise development as a factor in ensuring economic security.

Tulchynska S. et al. (2023), Shaposhnykov K. et al. (2021) proved significant impact of digitalization of the national economy on the logistics sector in conditions of ever-increasing competition. Gong S. (2025), Shashyna M. et al. (2021), Tulchynska S. et al. (2021) analyzed the level of inclusive development of regions, and outlined principles of ensuring economic security of economic systems within digitalization.

However, despite the research results considered, it should be noted that the issue of studying the digitalization impact on development of RES in the technoglobalism context is an important that requires further thorough analysis.

Methodology

Regional development is characterized by the asymmetry of socio-economic development, which can be justified by objective reasons, while digitalization in the technoglobalism context can reduce this asymmetry by expanding opportunities for business and the population to take active part in social development and attract

innovations, due to which competitiveness of regions and their business entities increases, employment grows, and the standard of living of the population increases. To assess the influence of digitalization on RESdevelopment in the technoglobalism context, the authors propose the methodological approach based on the following principles:

- first, systemicity, since RES represent a certain complex system in which, according to systemicity principles, interaction of constituent elements gives a greater effect than the sum of actions of its individual components;
- second, connection, which implies the interconnection of development of regional economic entities with digitalization as the stage of post-industrial development directed totechnoglobalism ;
- third, formalization, which makes it possible to obtain specific values of certain indices and comprehensive understanding of the role of digitalization in RESdevelopment in the technoglobalism context based on the results of calculations;
- fourth, sufficiency, which essence is that when substantiating measurement indicators, selection of evaluation parameters is important, since it is both sufficient to highlight existing trends in development of RES due to digitalization, and also sufficiently extensive to provide the possibility of obtaining reliable results and operating with certain array of empirical data, but one that does not overload and complicate calculations in the methodological approach.

Identification of methodological principles as the basis of the methodological approach and their observance ensures validity of further calculations. The methodological approach is based on the approach of economic and mathematical modeling, which involves assessment of components of the integral index (I_{RET}), which includes five component sub-indices, namely:

- first, the subindex of production and investment activity of the region $I_{IA,}$ which characterizes the main indicators of regional economic development;
- second, the subindex of budget efficiency of the region $I_{BE,}$ which makes it possible to assess effectiveness of the budget policy in development of RES in the technoglobalism context;
- third, the subindex of human potential development of the region $I_{HP,}$ which is important for ensuring generation of knowledge and innovation;
- fourth, the subindex of innovative development of the region $I_{ID,}$ as a result of scientific and innovative activity in the regions;
- fifth, the subindex of digital transformation of regions of Ukraine $I_{DT,}$ which makes it possible to determine relationship and impact of digitalization and development of RES in the technoglobalism context.

Sub-indices, in turn, are calculated based on the estimated parameters and have their own structure. The structure of sub-indices is represented by a system of tuples, namely:

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$$\begin{cases} I_{IA} = \langle I_1, I_2, I_3, I_4 \rangle \\ I_{BE} = \langle I_5, I_6, I_7, I_8 \rangle \\ I_{HP} = \langle I_9, I_{10}, I_{11} \rangle \\ I_{ID} = \langle I_{12}, I_{13}, I_{14}, I_{15} \rangle \\ I_{DT} = \langle I_{16}, I_{17}, I_{18}, I_{19} \rangle \end{cases} \quad (1)$$

where $I_1$is the volume of industrial production sold in the region per person in relation to the average level of production in the country in the current year;

I_2– production and distribution of electricity, gas and water per capita in the region in the current year;

I_3– agricultural production per capita in the region in the current year;

I_4–volume of investments in fixed capital per capita of the region's population in the current year;

I_5–volume of local budget revenues per capita in relation to the national average value of the production level in the current year;

I_6–amount of budget expenditures per person in relation to the national average value of the production level in the current year;

I_7–volume of subsidies from the state budget per;

I_8–volume of gross regional product per capita;

I_9– education indicator (the number of the region's population with higher education per capita);

I_{10}– health and life expectancy indicator (life expectancy of the population of the region at birth);

I_{11}– GRP volume per capita in the current year;

I_{12}–number of patents issued per 10 thousand employed in the economy for the current period;

I_{13}– volume of production of innovative goods (services);

I_{14}–volume of innovative industrial products sold;

I_{15}–number of innovatively active enterprises in industry;

I_{16}–number of businesses that have a website and use social media;

I_{17}– number of enterprises using ERP software;

I_{18}–number of companies that exchange data electronically with suppliers or customers in the supply chain;

I_{19}–number of enterprises purchasing cloud computing services and using artificial intelligence technology services.Indexes 8-9, 12-18 are calculared in relation to the average value for the country in the current year.

Thus, five sub-indices contain 19 evaluation parameters. The integral index of development of RES in the technoglobalism context can be defined as multidimensional function of five variables of the form:

$$I = F_I(I_{IA}, I_{BE}, I_{HP}, I_{ID}, I_{DT}) \quad (2)$$

Considering the methodology of systems analysis, the study of the integral index of development of RES in the technoglobalism context which, presented in the form of formula (2), should be carried out through the detailed analysis of its internal structure and elements that form its structural components (subindices).

To calculate sub-indices and the integral index it is proposed to use the weighted geometric mean, which is represented by the formula:

$$I_i^{sub} = \sqrt[m]{\Pi_{j=1}^{m}\left(I_i j\right)^{w_j}} \quad (3)$$

where $i = \overline{1, N}$ –number of subindices included in the integral index, N = 5;

$j = \overline{1, m}$ –number of component indices in the corresponding subindex (in this case, the total sum of the estimated indices is 19 from 3 to 4 in each of subindexes);

w_j – weight of the *jth* index in the structure of the *ith* subindex, determined by calculating absolute values of numerical ratios when comparing corresponding components of the indices "more"/"less", this can be expressed through the formula of the following form:

$$M_i = \begin{pmatrix} 1 & I_{i1}/I_{i2} & I_{i1}/I_{ij} & I_{i1}/I_{im} \\ I_{i2}/I_{i1} & 1 & I_{i2}/I_{ij} & I_{i2}/I_{im} \\ I_{ij}/I_{i1} & I_{ij}/I_{i2} & 1 & I_{ij}/I_{im} \\ I_{im}/I_{i1} & I_{im}/I_{i2} & I_{im}/I_{i(m-1)} & 1 \end{pmatrix} \quad (4)$$

Based on the matrix M_i, presented in formula 4, weights of the component indices I_{ij}within the given subindex I_i are determined:

$$V_j = \frac{\sqrt[m]{\prod_{j=1}^{m} a_{jm}}}{\sum_{j}^{m}\left(\sqrt[m]{\prod_{j=1}^{m} a_{jm}}\right)} \quad (5)$$

where $v_j$is the weight of the *jth* component index included in the calculation of one of the five sub-indices;

$\sqrt[m]{\prod_{j=1}^{m} a_{jm}}$ – geometric mean value of pairwise numerical comparisons of the corresponding rows of the matrix (M_i);

a_{jm}–result of a numerical pairwise comparison of *the j* -th and *m* -th component indices;

$\sum_{j}^{m}\left(\sqrt[m]{\prod_{j=1}^{m} a_{jm}}\right)$–sum of geometric mean pairwise numerical comparisons for rows of the matrix (M_i).

To determine the role of digitalization in RESdevelopment in the technoglobalism context, we'd like to propose using calculation of relative value of subindices in the integral index of development of RES in the technoglobalism context *(I_{RET})*. For this, we use weighted multiplicative convolution, which is determined by the following formula:

$$I_{RET}^{mult} = \prod_{i=1}^{N} I_i^{sub\Omega i} \quad (6)$$

where I_i^{sub} –values of sub-indices included in the integral index of development of RES in the technoglobalism context;

Ω_i –relative value of subindices in formation of the integral index of development of RES in the technoglobalism context *(I_{RET})*, which is calculated by pairwise numerical comparisons for the rows of the matrix (M_i), but ticks for calculating the integral index.

Results

To test the proposed methodology the authors selected the region of Ukraine. Data for calculating components of 19 indices based on which 5 sub-indices are calculated, and then the integral index of development of RES in the technoglobalism context was taken from official sources of statistical information. Not to oversaturate the article with statistical data, the authors already provide calculations that were made based on officially published statistical data.

Using the obtained weights calculated by formula (3), the subindex of production and investment activity of the region I_{IA}, the subindex of budget efficiency of the region I_{BE}, the subindex of human potential development of the region I_{HP}, the subindex of innovative development of the region I_{ID}, the subindex of digital transformation of the regions of Ukraine I_{DT} were calculated, which is presented in Table 1.

By calculating five sub-indices makes it possible to note that digital transformation sub-index (I_{DT}= 0.796) has the highest average value across all regions, and production and investment activity sub-index (I_{DT} = 0.475) has the lowest, which demonstrates active development and implementation of information and communication technologies (Fig. 1).

According to calculations, there is no region that would take the lead or, conversely, would be an outsider in all five sub-indices.

According to the subindex of production and investment activity, the leader is the Poltava region (I_{IA} = 0.874), the last region in the ranking is Luhansk (I_{IA} = 0.005). Differentiation between these two regions is 176.6 times. This differentiation is explained by several reasons, first, Covid-19 has strongly affected production, its competitiveness and caused changes in various logistical, resource and other relationships; second, since 2014, part of Ukraine's territory, namely the Donetsk and Luhansk regions, has been temporarily occupied, this situation has become even more acute, which has negatively and strongly affected investment activity in these regions and their production activity as a whole.

Table 1. Results of calculations of sub-indices of the integral index of development of RES in the technoglobalism context, 2023

Regions	I_{IA}	I_{BE}	I_{HP}	I_{ID}	I_{DT}
Vinnytsia	0.745	0.751	0.879	0.591	0.832
Volyn	0.572	0.523	0.847	0.529	0.800
Dnipropetrovsk	0.734	0.764	0.984	0.983	0.918
Donetsk	0.210	0.118	0.500	0.716	0.691
Zhytomyr	0.551	0.620	0.403	0.489	0.816
Transcarpathian	0.067	0.360	0.252	0.403	0.892
Zaporizhzhia	0.045	0.898	0.905	0.965	0.733
Ivano-Frankivsk	0.288	0.537	0.844	0.472	0.830
Kiev	0.738	0.816	0.926	0.811	0.893
Kirovohrad	0.713	0.628	0.761	0.860	0.744
Luhansk	0.005	0.166	0.429	0.509	0.721
Lviv	0.383	0.679	0.953	0.941	0.903
Nikolaev	0.500	0.768	0.764	0.654	0.750
Odessa	0.303	0.686	0.889	0.709	0.845
Poltava	0.874	0.757	0.944	0.965	0.760
Rivne	0.322	0.521	0.842	0.380	0.750
Sumy	0.408	0.655	0.905	0.513	0.737
Ternopil	0.382	0.511	0.884	0.573	0.901
Kharkiv	0.216	0.610	0.762	0.967	0.881
Kherson	0.469	0.541	0.831	0.474	0.744
Khmelnytsk	0.736	0.602	0.541	0.552	0.794
Cherkasy	0.751	0.648	0.661	0.668	0.750
Chernivtsi	0.168	0.194	0.575	0.531	0.599
Chernihiv	0.828	0.640	0.635	0.595	0.705
Kyiv	0.862	0.866	0.938	0.958	0.906
Average value	0.475	0.594	0.754	0.672	0.796

Source: calculated by the authors

According to the budget efficiency subindex, which is important for development of RES and competitiveness of regions in the technoglobalism context, calculations showed that Zaporizhzhia region had the highest value of the subindex (I_{BE} = 0.898), and Donetsk region had the lowest value (I_{BE} = 0.118), and the differentiation by the value of this subindex was 7.62 times.

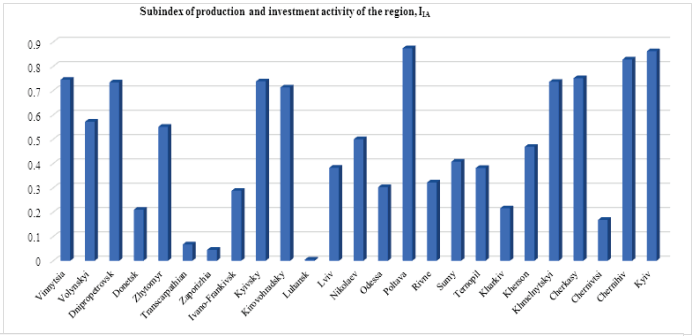
In the technoglobalism emergence, since generation of knowledge, development of innovations, transfer of innovations is not possible without participation of human capital. The highest value of the human development subindex belongs to Dnipropetrovsk region (I_{HP} = 0.984), and the lowest value belongs to Transcarpathian region (I_{HP} = 0.252), the differentiation according to this subindex was 3.9 times.

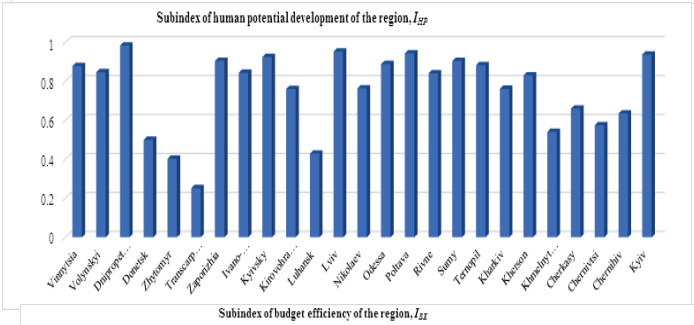
The subindex of innovative development of regions demonstrates small differentiation between regions, namely 2.6 times between the leader Dnipropetrovsk (I_{ID}= 0.983) and Rivne regions (I_{ID}= 0.380).

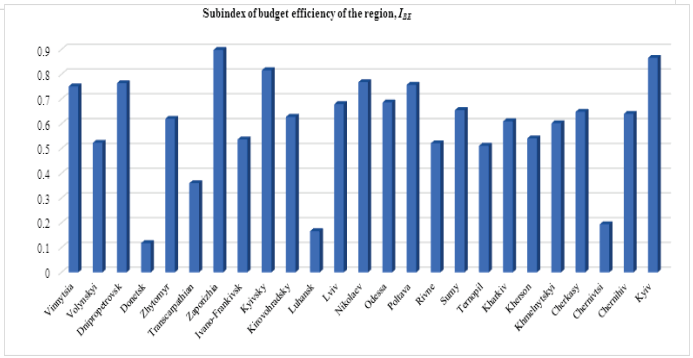
Digital transformation subindex due to calculations makes it possible to note that the highest value belongs to Dnipropetrovsk region (I_{DT} = 0.918), and the lowest to Odessa region (I_{DT}= 0.845). At the same time, an important point is that it is the digital transformation subindex that

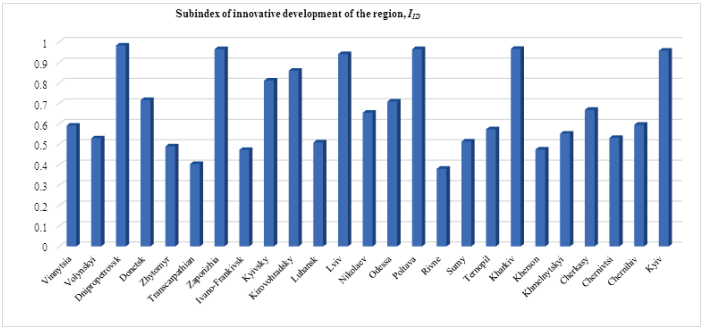
shows the least differentiation of only 1.5 times, which proves that modern information and digital technologies can be promoted almost equally in all RES in the technoglobalism emergence.

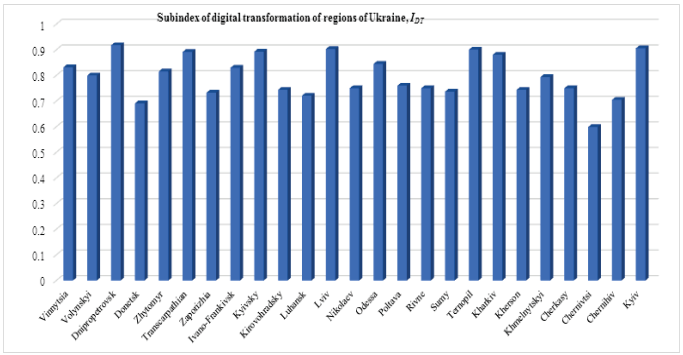
Fig. 1. Results of calculations of sub-indices











Source: calculated by the authors

According to the proposed methodology for determining the impact of sub-indices, including the digital transformation sub-index, it was proposed to determine the weight (vj) according to formula 5 of each sub-index. The vectors of relative weights of sub-indices according to the proposed methodology are given in Table 2.

Table 2. Results of calculations of relative weights of sub-indices in the integral index of development of RES in the conditions of technoglobalism, 2023

Regions	Relative weight of sub-indices				
	$\Omega\ (I_{IA})$	$\Omega\ (I_{BE})$	$\Omega\ (I_{HP})$	$\Omega\ (I_{ID})$	$\Omega\ (I_{DT})$
Vinnytsia	0.194	0.196	0.230	0.153	0.217
Volyn	0.173	0.158	0.256	0.160	0.243
Dnipropetrovsk	0.165	0.172	0.222	0.222	0.207
Donetsk	0.093	0.052	0.222	0.317	0.306
Zhytomyr	0.190	0.213	0.139	0.168	0.280
Transcarpathian	0.044	0.138	0.163	0.070	0.575

Zaporizhzhia	0.017	0.252	0.347	0.186	0.189
Ivano-Frankivsk	0.096	0.179	0.281	0.157	0.276
Kiev	0.174	0.193	0.219	0.192	0.212
Kirovohrad	0.190	0.167	0.203	0.230	0.199
Luhansk	0.006	0.198	0.313	0.210	0.263
Lviv	0.098	0.174	0.245	0.242	0.232
Nikolaev	0.144	0.221	0.220	0.188	0.216
Odessa	0.087	0.198	0.256	0.205	0.244
Poltava	0.201	0.174	0.218	0.222	0.175
Rivne	0.113	0.183	0.296	0.134	0.263
Sumy	0.126	0.202	0.278	0.158	0.227
Ternopil	0.116	0.155	0.269	0.174	0.274
Kharkiv	0.062	0.175	0.220	0.279	0.253
Kherson	0.152	0.175	0.268	0.153	0.241
Khmelnytsk	0.226	0.185	0.166	0.169	0.244
Cherkasy	0.214	0.184	0.188	0.190	0.214
Chernivtsi	0.080	0.093	0.275	0.254	0.287
Chernihiv	0.241	0.186	0.185	0.173	0.205
Kyiv	0.188	0.189	0.205	0.210	0.198

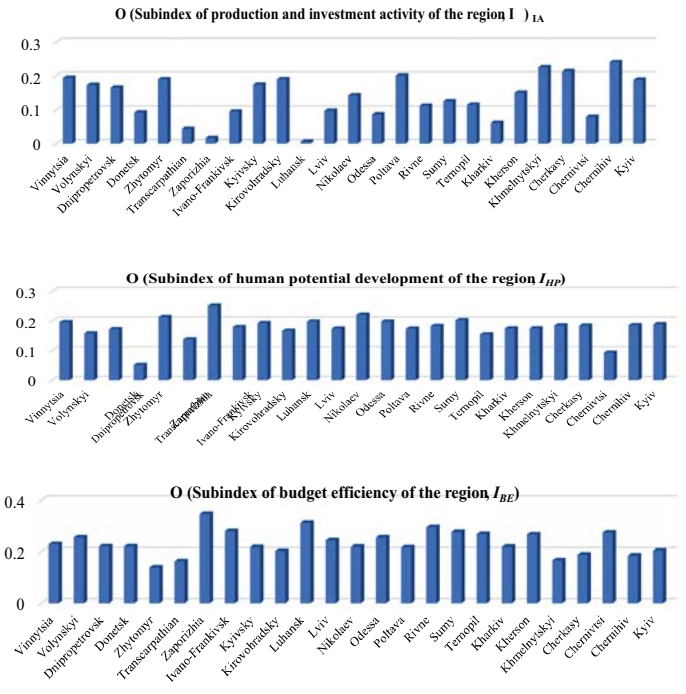
Source: calculated by the authors

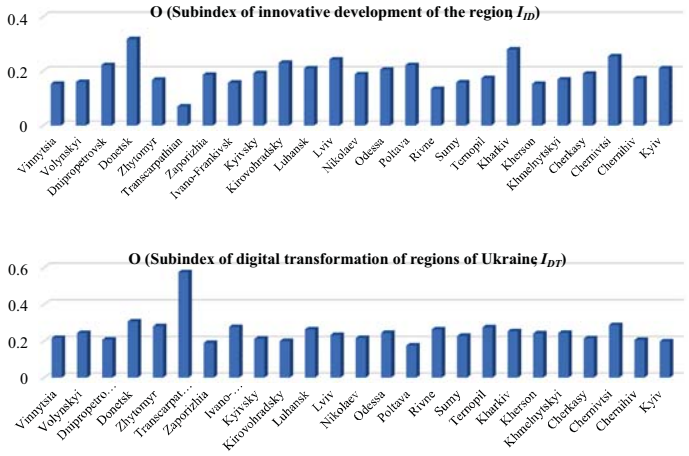
In the regions as Vinnytsia, Zhytomyr, Transcarpathian, Ternopil, Kherson, Khmelnyts, Cherkasy, Chernivtsi, the digital transformation subindex is the largest among all subindexes(Fig. 2).This is also confirmed by calculating the weights of the subindexes, since in general it is the digital transformation subindex that has the greatest weight among the indices included in the calculation.

Figure3 illustrates digital transformation subindex and the relative weight of this subindex in relation to the integral index of development of RES in the technoglobalism context.

Visualization of the digital transformation subindex and the value of the relative weight of this subindex in the integral index of development of RES in the technoglobalism context makes it possible to note that there is no direct relationship between these two indicators. That is, if the value of the digital transformation subindex is high in a region, this does not mean that the weight of this index is dominant in relation to the integral index.

Fig. 2. Results of calculations of relative weights of sub-indices

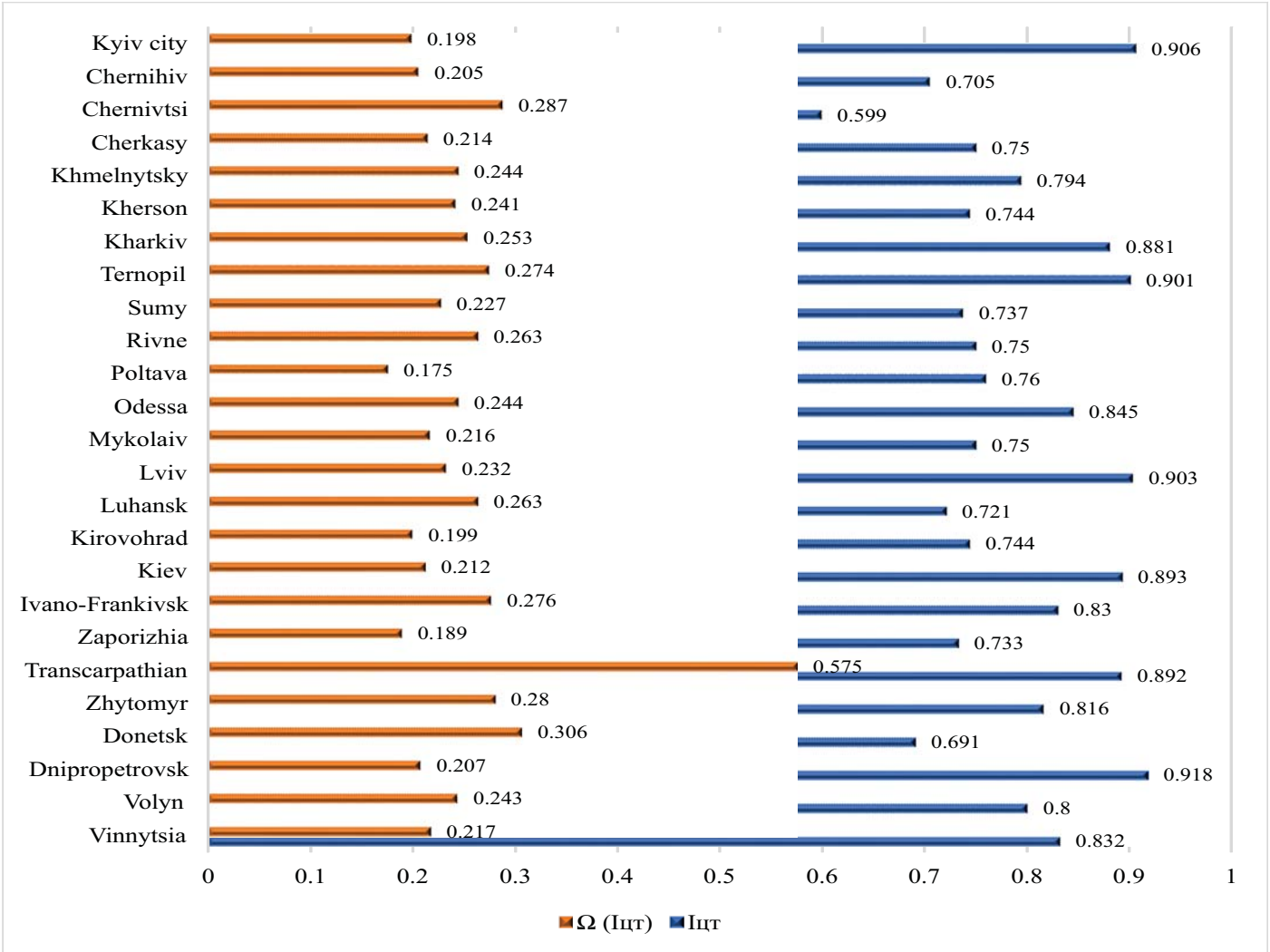




Source: calculated by the authors

For example, in Transcarpathian region, both the digital transformation subindex and the value of the relative weight of this subindex in the integral index of this region are high. At the same time, in Dnipropetrovsk region, the value of the digital transformation subindex is high, but the relative weight of this subindex in the integral index is not so significant.

Fig. 3. Digital transformation sub-indices and the value of its relative weight in the integral index by region in 2023



Source: constructed by the authors based on the results of calculations

The next stage of the proposed method is the calculation of the integral index of RESdevelopment in the technoglobalism context using multiplicative convolution (see formula 6). Calculations of the integral index are presented in Table 3.

Table 3. Results of calculations of the integral index of development of RES in the technoglobalism context, 2023

Regions	I_{RET}	Region rank
Vinnytsia	0.766	7
Volynsk	0.669	15
Dnipropetrovsk	0.883	2
Donetsk	0.530	23
Zhytomyr	0.593	21
Transcarpathian	0.539	22
Zaporizhzhia	0.834	5
Ivano-Frankivsk	0.636	18
Kiev	0.840	4
Kirovohrad	0.745	9
Luhansk	0.412	25
Lviv	0.808	6
Mykolaiv	0.696	12
Odessa	0.724	10
Poltava	0.865	3
Rivne	0.601	20
Sumy	0.667	16
Ternopil	0.684	14
Kharkiv	0.751	8
Kherson	0.630	19
Khmelnytsk	0.652	17
Cherkasy	0.697	11
Chernivtsi	0.466	24
Chernihiv	0.685	13
Kyiv	0.907	1

Source: calculated by the authors

In general, according to calculations, determination of the integral index based on relative weights of the subindices using the proposed method demonstrates high level of statistical significance according to the Student's t-test and the correlation of the obtained arrays of subindices.

Conclusions

Thus, based on the results of the calculations, we can state the asymmetric development of regions according to the integral index and its sub-indices.Among the calculated sub-indices, the digital transformation sub-index has the highest average value across all regions (IDT = 0.796). In 2023, according to the values of the integral index of development of RES in the technoglobalism context, differentiation between the leader and the regions that are at the last stage of the rating is 2.2 times. The greatest differentiation is observed for the production and investment activity sub-index, namely 176.6 times, the smallest for the value of the digital transformation sub-index – 1.5 times.

The scientific novelty lies in development of the methodological approach to assessing the role of digitalization in RESdevelopment in the technoglobalism context, which includes methodological principles of systematicity, coherence, formalization, and sufficiency and provides for:

first, calculation of the integral index of development of RES in the technoglobalism contect using multiplicative convolution, which consists of five sub-indices (production

and investment activity, budget efficiency, human potential development, innovative development, digital transformation), which are calculated using nineteen indices and represent a system of tuples;

second, determining subindices using the weighted geometric mean, taking into account the weights of pairwise numerical comparisons of the corresponding rows of the matrix;

third, calculating the value of the weight of sub-indices in the formation of an integral index of RESdevelopment in the conditions of technoglobalism.

Further scientific research is required on issues related to development of strategies for RESdevelopmentin the technoglobalism context, considering the obtained values of the calculated sub-indices and the integral index of evelopment of RESin the technoglobalism context, which will make it possible to activate digital transformation of regions.

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