

The Impact of Artificial Intelligence and Digitalization On Development of Regional Socio-Economic Systems in The Globalization Context

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Abstract

In current conditions of global development, digitalization is a key factor in innovative development, strengthening competitiveness of regional economic systems. Given rapid pace of digital transformation, it is especially relevant to study the potential of regions in this area. The article is aimed at substantiating the methodological approach to assessing the impact of artificial intelligence and digitalization on development of RSES's in the globalization context. Justification of methodological foundations of the methodological approach is based on considering the principles as follows: consistency, reliability, coherence, sufficiency, accuracy and hierarchy. The methodical approach involves the definition of evaluation indices and their constituent subindices as part of the integral index based on the weighted geometric mean and determining their relative value using the matrix of pairwise comparisons in accordance with the system of their grouping. The integral index is proposed to be determined using multiplicative and additive convolutions. The impact of the AI and digitalization on the integral index and transformation of the sub-index of the AI and digitalization is calculated based on the relative magnitude of dynamics. The resulting calculations can serve as analytical basis for managers on the introduction of the AI and digitalization at the regional management level.

Keywords: Artificial Intelligence; Digitalization, Digital Technologies, Digital Economy, Region, Socio-Economic System, Globalization, Intellectual Property, Innovation, Industrial Enterprises.

Introduction

Globalization, technoglobalism, ecologization, digitalization, formation of the knowledge economy, open innovations and other concepts and scientific approaches inherent in current stage of development of post-industrial society describe modern development of the world. This determines that advantages of socio-economic systems (SES's) of different levels in one of the sectors or spheres of the economy, without considering the impact of others, neutralize their efforts and throw them back in the struggle for resources and leadership

in the market. Rapid development of the artificial intelligence and digital technologies is causing the increase in the impact of digital tools on development of RSES's. At the same time, as with any process, digitalization and mass introduction of the artificial intelligence also have negative manifestations, for example, including possible reduce of employment due to replacement of certain categories of employees with jobs and the AI, however, at the same time, digitalization opens up new opportunities and markets for business entities, which can neutralize negative processes by intensifying their own initiatives. Rapid development of the AI and digitalization affect efficiency of business, regions, and the state.

The article is aimed at substantiating the methodological approach to assessing the impact of the artificial intelligence and digitalization on development of RSES's in the globalization context.

Literature review

Wang Q. et al. (2025) believe that the AI plays a significant role in improving efficiency of the green economy. The study Muhammad Shahbaz et al. (2025) argues that developing investment strategies based on the circular economy is vital for socio-economic development of the country.

Jiapei Wei et al. (2025), Karen Matamoros et al. (2025), Varona Gonzalo Ricardo Alegría et al. (2025) analyze the technological challenge of the AI and its impact on the production mode and new socio-economic model of sustainable human development. S. Biriescu et al. (2025), Masoud N. (2025) demonstrate significant promise by positioning the AI. Vdovichena O. et al. (2025) substantiated importance of strategic implementation of the AI.

Ronald E. Rice et al. (2025) analyze characteristics of the public opinion formation regarding the artificial intelligence (AI) in 20 countries based on the analysis of demographics, public trust, support for science, use of scientific news, and differences in the level of the economy. Shanshan Wang et al. (2025), Ahmad V. et al. (2025) are convinced that Industry 4.0 contributes to reformatting perception of the changing world to occupy high-competitive positions.

Jain Ankita et al. (2025) analyze relationship between the circular economy, the artificial intelligence, and healthcare efficiency. Muduva M. et al. (2025), Salvatore Schinello (2025) analyze the transformative role of the AI in revolutionizing green marketing strategies to support the circular economy.

Andrea Lagna (2025) argues that the artificial intelligence represents next technological frontier in the asset management. The authors Popelo O. et al. (2025), Jakúbek P. et al. (2023), Marhasova V. et al. (2024), Derhaliuk M et al. (2021) analyzed features of public administration and legal support for economic modernization of society.

According to the authors Varun Kesavan K., Sakthi Srinivasan (2024), the artificial intelligence has become an important and influential factor that can significantly impact sustainable development efforts in several industries in the digital economy era. Sayyed Mudassar et al. (2024) are convinced that the artificial intelligence plays a significant role in the digital economy. Neirou M. et al. (2025) analyze the impact of the artificial intelligence on the virtual economy of the Metaverse.

Garafonova O. et al. (2021), Cosmulese C. (2019), Abramova A. (2021) developed the methodological approach to economic analysis in transformation of economic systems. Linde N. et al. (2024), Hong Z. et al. (2024) examine the role of the blockchain and AI, incentivizing recycling, and implementing circular business models.

However, despite a significant number of considerable efforts by scientists who are interested in the impact of AI on various spheres, the issue of determining the impact of the AI and digitalization on development of RSES's in the globalization context remains extremely relevant and requires further in-depth research.

Methodology

The analysis of recent publications on determining the impact of AI and digitalization on development of RSES's in the globalization context makes it possible to note that issues related to assessment of the impact of digitalization processes on development of RSES's require further scientific research. When evaluating in the methodological

approach, it is important to adhere to the following principles:

- systematic, since regions are an open system, and also, in accordance with principles of systematicity, act as a subsystem of higher levels of systems in the globalization context;
- reliability, which implies availability of the empirical base of all indicators for assessing development of RSES's in accordance with their publication;
- connectivity, which implies available relationship between development of RSES's in the globalization context and development of the AI and digitalization;
- sufficiency, which is manifested in determining the number of indicators that make it possible to reliably and simultaneously fully assess the impact of the AI and digitalization on development of RSES's, while the estimated indicators should not be duplicated and overloaded with excessive arrays of statistical data calculations;
- accuracy, which provides for maximum reduction of errors in calculations using various special programs in calculations;
- hierarchy, which is based on the definition of scoring indices, which act as data for calculating subindices, based on which the integral index of the impact of AI and digitalization on development of RSES's in the globalization context is calculated.

These principles serve as the methodological basis for assessing the impact of the AI and digitalization on development of RSES's in the globalization context, and their observance makes it possible to obtain the most accurate results in accordance with the selected estimates.

The methodological approach is based on the definition of integral indices and their constituent subindices, which are a system of grouping indicators and calculations, which has the following form:

$$I_{AID} = \begin{cases} I_I = \langle I_1, I_2, I_3, I_4 \rangle \\ I_{II} = \langle I_5, I_6, I_7, I_8 \rangle \\ I_{III} = \langle I_9, I_{10}, I_{11} \rangle \\ I_{IV} = \langle I_{12}, I_{13}, I_{14}, I_{15} \rangle \\ I_V = \langle I_{16}, I_{17}, I_{18}, I_{19} \rangle \end{cases} \quad (1)$$

where *I_{AID}* is the integral index of development of RSES's in the globalization context, taking into account the AI and digitalization (most indices are calculated relative to the average value for the current year for the country);

I_I – sub-index of production activity of RSES's, calculated according to the component evaluation indices:

I₁ – estimated index of the volume of industrial products sold per capita of the region;

I₂ – estimated indicator for energy, gas and water per capita of the region;

I₃ – estimated index of the volume of agricultural products per capita of the region;

I₄ – estimated index of the volume of investments per capita of the region;

I_{II} – sub-index of budgetary and financial activity of RSES's, calculated according to the component evaluation indices;

I₅ – estimated index of local budget revenues per capita of the region;

I₆ – estimated index of expenditures of local budgets per capita of the region;

I₇ – estimated index of the volume of subsidies of the region per capita of the region;

I₈ – estimated index of the number of enterprises in the region that have a website;

I_{III} – sub-index of human development of regional economic systems, which is calculated according to the component evaluation indices:

I₉ – estimated index of the population of the region with higher education;

I₁₀ – estimated index of life expectancy of the population;

I₁₁ – estimated index of the number of enterprises in the region using social media;

I_{IV} – sub-index of innovative development of regional economic systems, calculated according to the component evaluation indices:

I₁₂ – estimated index of issued intellectual property rights per 10 thousand residents of the region;

I_{13} – estimated index of the production volume of innovative goods and services per 1 capita of the region;

I_{14} – estimated index of the volume of innovative goods and services sold per capita of the region;

I_{15} – estimated index of the number of innovatively active enterprises;

I_V – sub-index of the AI and digitalization of regional economic systems, calculated according to the component indices:

I_{16} – estimated index of the number of enterprises in the region using ERP software;

I_{17} – estimated index of the number of enterprises in the region that exchange data electronically with suppliers or customers in the supply chain;

I_{18} – estimated index of the number of enterprises in the region that purchase cloud computing services;

I_{19} – estimated index of the number of enterprises in the region using the AI technology services.

The identified evaluation indices and sub-indices in accordance with the cause-and-effect approach serve as a basis for further calculations of integral indices of the impact of the AI and digitalization on development of RSES's in the globalization context.

Subindices that are included in the integral indices calculation system are determined based on the weighted geometric mean according to the formula:

$$I_{I-V}^{sub} = \sqrt[n]{\prod_{j=1}^n (I_{ij})^{w_j}} \quad (2)$$

where I_{I-V}^{sub} is the corresponding subindex (I_I , I_{II} , I_{III} , I_{IV} , I_V);

I_{ij} – evaluation indices as part of the sub-index;

j – number of evaluation indices included in the sub-index; $j = \overline{1, n}$

w_j – relative value of the j -th evaluation index in the sub-index structure.

The important aspect in calculations is determination of the relative value of the estimated indices as part of the subindex, for which the authors of the study recommend using

the matrix of pairwise comparisons by the following formula:

$$a_i = \begin{pmatrix} 1 & I_{i1}/I_{i2} & I_{i1}/I_{ij} & I_{i1}/I_{in} \\ I_{i2}/I_{i1} & 1 & I_{i2}/I_{ij} & I_{i2}/I_{in} \\ I_{ij}/I_{i1} & I_{ij}/I_{i2} & 1 & I_{ij}/I_{in} \\ I_{in}/I_{i1} & I_{in}/I_{i2} & I_{in}/I_{i(n-1)} & 1 \end{pmatrix} \quad (3)$$

where a_i is the matrix for determining the relative weight of evaluation indices as part of the sub-index;

I_{ij} - scoring indices included in the sub-index calculation.

The formula for determining the relative value (w_j) of the j -th evaluation index in the subindex structure is as follows:

$$w_j = \frac{\sqrt[n]{\prod_{j=1}^n a_{jn}}}{\sum_j \left(\sqrt[n]{\prod_{j=1}^n a_{jn}} \right)} \quad (4)$$

where $\sqrt[n]{\prod_{j=1}^n a_{jn}}$ are the geometric average values of the corresponding rows of the matrix of pairwise numerical comparisons according to the formula (3);

a_{jn} – result of the numerical pairwise comparison of the j -th and n -th components of evaluation indices;

$\sum_j \left(\sqrt[n]{\prod_{j=1}^n a_{jn}} \right)$ - sum of the geometric mean for the rows of the matrix pairwise numerical comparisons calculated according to the formula (3).

The Integral Index for development of RSES's in the globalization context taking into account the AI and digitalization (I_{AID}) is determined by the components, which are the obtained values of subindices.

$$I_{AID}^{mult} = \sqrt[n]{\prod_{i=1}^N (I_{I-V}^{sub})^{w_i}} \quad (5)$$

$$I_{AID}^{addit} = \sqrt[n]{\sum_{i=1}^N (I_{I-V}^{sub})^{w_i}} \quad (6)$$

where I_{I-V}^{sub} – sub-indices of the integral index of development of regional economic systems in the globalization context taking into account the AI and digitalization;

wI – relative value of the j-th subindex in the structure of this integral index, which is calculated according to formulas (3) and (4).

Using multiplicative and adaptive convolutions makes it possible to verify and confirm the veracity of the obtained calculation results, which is important given the use of many inputs of statistical data in calculations.

To determine the impact of the AI and digitalization on the integral index of development of RSES's in the globalization context, it is proposed to determine by calculating the relative value of dynamics for the integral index, which makes it possible to assess transformation of the integral index. The relative value of the dynamics of the integral index is determined by the formula:

$$DI_{AID} = \frac{I_{AID}^{2023}}{I_{AID}^{2020}} \quad (7)$$

We will also calculate transformations of the AI sub-index and digitalization of regional economic systems using the formula:

$$DI_V = \frac{I_V^{2023}}{I_V^{2020}} \quad (8)$$

For calculations of the impact of the AI and digitalization on development of regional economic systems, as well as transformation of the AI sub-index and digitalization, two periods appear in calculations. It can be any years, depending on the task of determining the impact of the AI and digitalization on development of regional economic systems in the globalization context.

Results

To test this methods for assessing the impact of the AI and digitalization on development of RSES's in the globalization context, regional economic systems of Ukraine were selected in accordance with the statistics of the State Statistics Service of Ukraine for 2020 and 2023 obtained according to the proposed methodological approach to assessing the impact of the artificial intelligence and digitalization on development of RSES's in the globalization context.

As a result of calculations according to the formula (2) in Table 1 for 2020 and in Table 2 for 2023, values of sub-indices of regional economic systems are given: II – sub-index of production activity; III – sub-index of budget and financial activity; IIII – sub-index of human development; IIV – sub-index of innovative development; IV – sub-index of the AI and digitalization.

Table 1. Results of calculations of sub-indices of the integral index of development of RSES's in the globalization context considering the AI and digitalization for 2020

Regions	Sub-indices					Rank by sub-indices				
	I_I	I_{II}	I_{III}	I_{IV}	I_V	I_I	I_{II}	I_{III}	I_{IV}	I_V
Vinnitsia	0.882	0.348	0.652	0.617	0.649	7	17	20	13	22
Volyn	0.514	0.256	0.623	0.397	0.636	23	25	22	25	23
Dnipropetrovsk	0.900	0.775	0.961	0.971	0.881	5	2	1	1	3
Donetsk	0.751	0.526	0.872	0.820	0.837	17	5	6	7	5
Zhytomyr	0.724	0.333	0.780	0.714	0.693	20	19	15	12	18
Transcarpathian	0.350	0.351	0.457	0.466	0.734	25	16	25	23	11
Zaporizhzhia	0.759	0.400	0.856	0.804	0.729	15	12	8	8	13
Ivano-Frankivsk	0.725	0.283	0.914	0.745	0.763	19	22	3	10	8
Kiev	0.953	0.507	0.892	0.902	0.716	1	6	5	4	15

Regions	Sub-indices					Rank by sub-indices				
	I_I	I_{II}	I_{III}	I_{IV}	I_V	I_I	I_{II}	I_{III}	I_{IV}	I_V
Kirovohrad	0.777	0.369	0.722	0.786	0.706	12	14	18	9	16
Luhansk	0.718	0.460	0.848	0.569	0.782	21	8	10	18	6
Lviv	0.702	0.387	0.866	0.883	0.682	22	13	7	5	20
Mykolaiv	0.840	0.419	0.805	0.563	0.863	9	10	12	20	4
Odesa	0.884	0.466	0.760	0.957	0.891	6	7	17	3	2
Poltava	0.818	0.615	0.905	0.584	0.776	10	4	4	15	7
Rivne	0.771	0.300	0.484	0.443	0.490	13	21	23	24	25
Sumy	0.765	0.422	0.697	0.737	0.670	14	9	19	11	21
Ternopil	0.753	0.263	0.778	0.578	0.750	16	24	16	17	9
Kharkiv	0.878	0.629	0.851	0.970	0.690	8	3	9	2	19
Kherson	0.745	0.337	0.821	0.579	0.719	18	18	11	16	14
Khmelnyskyi	0.902	0.326	0.786	0.566	0.731	4	20	14	19	12
Cherkasy	0.940	0.406	0.803	0.520	0.735	2	11	13	21	10
Chernivtsi	0.507	0.277	0.482	0.520	0.620	24	23	24	22	24
Chernihiv	0.787	0.353	0.632	0.599	0.706	11	15	21	14	17
Kyiv	0.936	0.777	0.955	0.879	0.938	3	1	2	6	1
Average	0.771	0.423	0.771	0.687	0.736	-	-	-	-	-

Source: calculated by the authors

Values of the sub-indices of the integral index of development of RSES's in the globalization context are calculated, which are given in Table 1 make it possible to note that no region has the same ranks among all regions in all sub-indices. At the same time, there are regions in which ranks by sub-indices do not change significantly, for example, the Volyn region (22-25th place in rank), and there are regions in which there is a large range in ranks according to various sub-indices, for example, the Kyiv region (from 1 to 15 places in the ranking).

The highest average value for 2020 has the sub-index of production activities $I_{I_{avr}} = 0.771$, the second sub-index of the AI and digitalization $I_{V_{avr}} = 0.736$, and the smallest value of the sub-index of fiscal activities $I_{II_{avr}} = 0.423$.

According to the sub-index of production activity, the 1-3rd places in terms of the rank of regions are occupied by Kyiv ($I_I = 0.953$), Cherkasy ($I_I = 0.940$) and the city of Kyiv ($I_I = 0.936$), and the lowest three places according to the rating are occupied by Volyn ($I_I = 0.514$), Chernivtsi ($I_I = 0.507$), Zakarpattian ($I_I = 0.350$) regional economic systems. At the same time, according to the sub-index of budgetary and financial activity, the leader is the city of Kyiv ($I_{II_{avr}} = 0.777$) and Dnipropetrovsk ($I_{II_{avr}} = 0.775$) and Kharkiv ($I_{II_{avr}} =$

0.629) regions, the lowest rank is occupied by the Volyn region ($I_{II_{avr}} = 0.256$). The Dnipropetrovsk region ranks first in rank in terms of sub-indices of human ($I_{III} = 0.961$) and innovative ($I_{IV} = 0.971$) development and third in terms of sub-index of the AI and digitalization ($I_V = 0.881$).

According to the sub-index of the AI and digitalization by rank of regions in 2020, the first place is occupied by the city of Kyiv ($I_V = 0.938$), the second by the Odesa region ($I_V = 0.891$), and the last three regions by rank are: Volyn ($I_V = 0.636$), Chernivtsi ($I_V = 0.620$), Rivne ($I_V = 0.490$) regions. Between the leader and the outsider in terms of the rank of the AI sub-index and digitalization, the difference in sub-index values is 0.448, that is, almost 2 times, but compared to other sub-indices, this is not a great differentiation, which makes it possible to conclude that digital development is possible and gives its results in regions with different conditions, development of production and agriculture, etc.

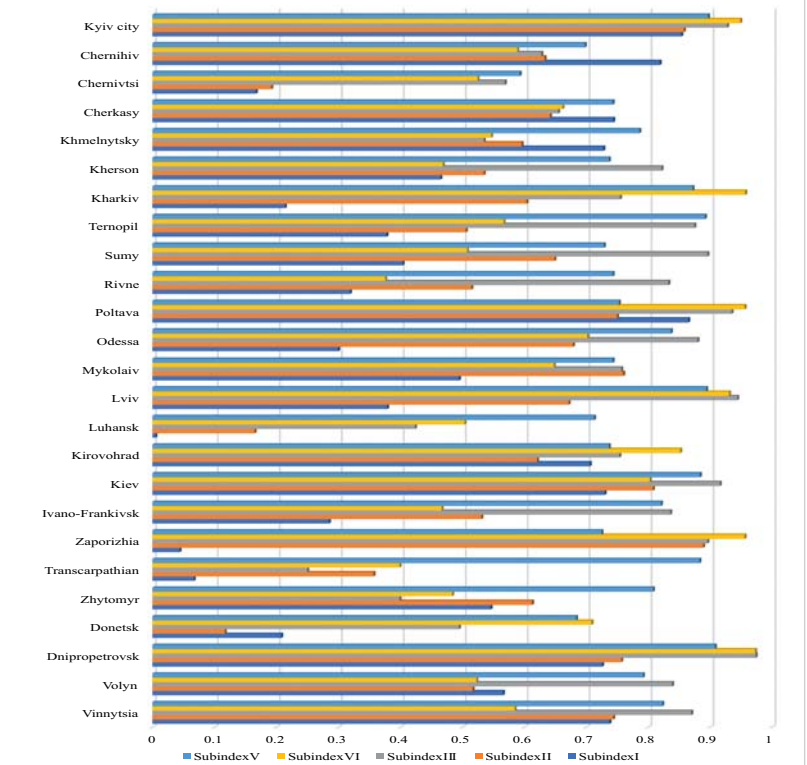
In Table 2, Fig. 1, calculations are given according to the proposed methodological approach of sub-indices according to the data of 2023.

Table 2. Results of calculations of sub-indices of the integral index of development of RSES's in the globalization context considering the AI and digitalization, 2023

Regions	Sub-indices					Rank by sub-indices				
	<i>I_I</i>	<i>I_{II}</i>	<i>I_{III}</i>	<i>I_{IV}</i>	<i>I_V</i>	<i>I_I</i>	<i>I_{II}</i>	<i>I_{III}</i>	<i>I_{IV}</i>	<i>I_V</i>
Vinnitsia	0.738	0.744	0.870	0.585	0.823	5	7	10	14	9
Volyn	0.566	0.517	0.839	0.523	0.792	10	19	11	18	12
Dnipropetrovsk	0.726	0.757	0.974	0.973	0.908	8	5	1	1	1
Donetsk	0.208	0.117	0.495	0.709	0.684	21	25	22	9	24
Zhytomyr	0.546	0.613	0.399	0.484	0.808	11	14	24	21	11
Transcarpathian	0.067	0.357	0.250	0.399	0.883	23	22	25	24	6
Zaporizhzhia	0.044	0.889	0.896	0.956	0.725	24	1	6	3	21
Ivano-Frankivsk	0.285	0.531	0.836	0.467	0.821	19	18	12	23	10
Kiev	0.730	0.808	0.916	0.803	0.884	6	3	5	8	5
Kirovohrad	0.706	0.621	0.754	0.852	0.737	9	13	17	7	18
Luhansk	0.005	0.165	0.424	0.504	0.713	25	24	23	20	22
Lviv	0.379	0.672	0.944	0.931	0.894	15	9	2	6	3
Mykolaiv	0.495	0.760	0.757	0.648	0.743	12	4	15	12	15
Odessa	0.300	0.679	0.880	0.702	0.837	18	8	8	10	8
Poltava	0.865	0.750	0.935	0.956	0.753	1	6	3	4	25
Rivne	0.319	0.515	0.833	0.376	0.743	17	20	13	25	14
Sumy	0.404	0.649	0.896	0.508	0.729	14	10	7	19	16
Ternopil	0.378	0.506	0.875	0.567	0.892	16	21	9	15	20
Kharkiv	0.214	0.604	0.755	0.957	0.872	20	15	16	2	4
Kherson	0.465	0.535	0.822	0.469	0.737	13	17	14	22	7
Khmelnyskyi	0.728	0.596	0.535	0.547	0.786	7	16	21	16	19
Cherkasy	0.744	0.642	0.655	0.662	0.743	4	11	18	11	13
Chernivtsi	0.167	0.192	0.569	0.525	0.593	22	23	20	17	17
Chernihiv	0.819	0.633	0.628	0.589	0.698	3	12	19	13	23
Kyiv	0.854	0.858	0.928	0.949	0.897	5	2	4	5	2
Average	0.470	0.588	0.747	0.665	0.788	-	-	-	-	-

Source: calculated by the authors

Fig. 1. Regional breakdown of sub-indices of the integral index of RSES's development in the globalization context, 2023

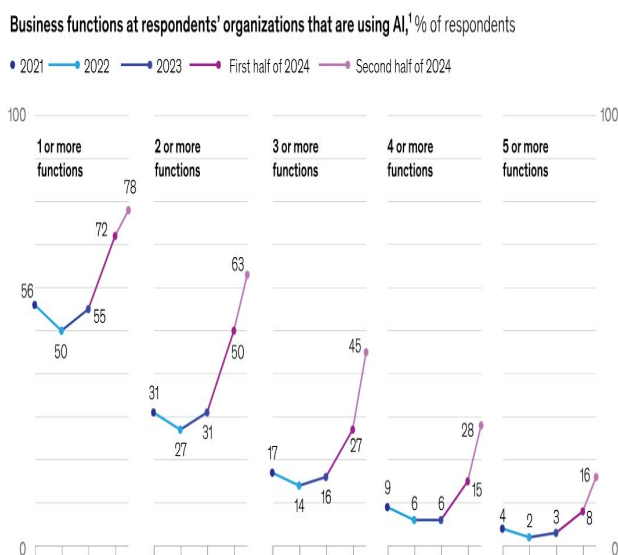


Source: built by the authors based on calculations

Results of calculations of the arithmetic mean values of sub-indices in 2023 in relation to 2020 show that the average value of the sub-index of production activity (II) has significantly decreased from 0.771 in 2020 to 0.470 in 2023. In this case, one of the areas of the AI increase can serve as a sub-index of production activities, since introduction of the AI in enterprises can give positive impetus to their development, as well as reduce costs, which generally has positive effect on business.

According to survey results, global trends prove that enterprises are using the AI in most business functions. Since the beginning of 2024, it has been established that enterprises are using the AI in an average of three business functions, which proves relevance of these technologies (Fig. 2).

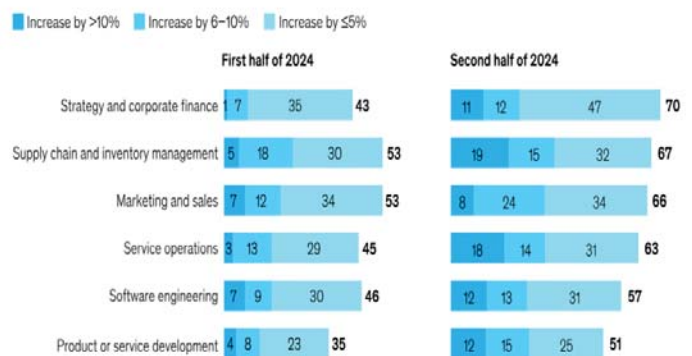
Fig. 2. Use of the AI by organizations across functional areas



Source: McKinsey (2025).

It is worth noting that enterprises note creation of value in business units that use the AI generation. The use of the AI in various business units has increased their performance and contributed to the increase in revenues, which justifies the need for the comprehensive approach to introduction of the AI in enterprises (Fig. 3).

Revenue increase within business units from gen AI use, past 12 months, by function, % of respondents



Source: McKinsey (2025).

Returning to the sub-indices of the integral index for development of RSES's in globalization context in 2023, it should be noted that the average value of such sub-indices as fiscal activities ($III_{avr} = 0.588$) and the sub-index of the AI and digitalization ($IV_{avr} = 0.788$).

In terms of the value of the AI and digitalization sub-index in 2023, such regions as Dnipropetrovsk ($IV = 0.908$), Lviv ($IV = 0.894$) and Kiev regions ($IV = 0.897$) were the worst. The worst positions in the morning of this subindex were occupied by Chernihiv ($IV = 0.698$), Donetsk ($IV = 0.684$), Poltava ($IV = 0.753$) regions. On the positive side, the difference between the leading regions and the outsider decreased in 2023 compared to 2020 and amounted to 1.3 times.

The next step of the proposed methodological approach is calculation of relative values (w_j) of subindices in the integral index of development of RSES's in the globalization context using the method of matrix numerical pairwise comparisons (formula 4, Table 3).

The data on the calculation of the relative values of sub-indices in the integral index of development of RSES's in the globalization context, which are given in Table 3, make it possible to note that each region has its own sub-index, which has the highest relative value. In 2020, the AI and digital transformation sub-index had the greatest relative value for the integral index of Volyn, Zakarpattia, Mykolaiv and Chernivtsi regions. In 2023, the number of regions increased and they include Zhytomyr, Transcarpatian, Ternopil, Khmelnytskyi, Cherkasy and Chernivtsi regions.

Table 3. Results of calculations of relative values of sub-indices in the integral index of development of RSES's in the globalization context considering the AI and digitalization in 2020 and 2023

Regions	Relative values of sub-indices ???, 2020					Relative values of wj sub-indices, 2023				
	wI _I	wI _{II}	wI _{III}	wI _{IV}	wI _V	wI _I	wI _{II}	wI _{III}	wI _{IV}	wI _V
<i>I</i>	2	3	4	5	6	7	8	9	10	11
Vinnitsia	0.274	0.109	0.203	0.192	0.202	0.192	0.194	0.227	0.152	0.215
Volyn	0.208	0.103	0.252	0.161	0.257	0.172	0.157	0.254	0.159	0.240
Dnipropetrovsk	0.196	0.170	0.210	0.212	0.192	0.164	0.171	0.220	0.220	0.205
Donetsk	0.193	0.135	0.224	0.211	0.216	0.092	0.052	0.220	0.314	0.303
Zhytomyr	0.219	0.101	0.235	0.216	0.210	0.188	0.211	0.137	0.167	0.277
Transcarpathian	0.146	0.146	0.190	0.193	0.306	0.043	0.136	0.162	0.070	0.569
Zaporizhzhia	0.210	0.111	0.236	0.222	0.202	0.017	0.250	0.343	0.184	0.187
Ivano-Frankivsk	0.207	0.081	0.262	0.213	0.219	0.095	0.177	0.278	0.156	0.273
Kiev	0.235	0.125	0.221	0.222	0.176	0.172	0.191	0.217	0.190	0.210
Kirovohrad	0.226	0.108	0.211	0.229	0.206	0.188	0.166	0.201	0.227	0.197
Luhansk	0.209	0.133	0.246	0.166	0.227	0.006	0.196	0.310	0.208	0.261
Lviv	0.195	0.108	0.241	0.246	0.190	0.097	0.172	0.242	0.239	0.229
Mykolaiv	0.236	0.118	0.226	0.158	0.242	0.142	0.219	0.218	0.186	0.214
Odesa	0.219	0.116	0.188	0.237	0.221	0.086	0.196	0.254	0.203	0.241
Poltava	0.217	0.163	0.240	0.155	0.206	0.199	0.172	0.216	0.220	0.173
Rivne	0.304	0.118	0.190	0.174	0.193	0.112	0.181	0.293	0.132	0.261
Sumy	0.228	0.125	0.208	0.220	0.200	0.124	0.200	0.275	0.157	0.224
Ternopil	0.236	0.082	0.244	0.181	0.235	0.115	0.154	0.267	0.172	0.271
Kharkiv	0.215	0.154	0.208	0.236	0.169	0.062	0.173	0.218	0.276	0.251
Kherson	0.228	0.103	0.252	0.177	0.221	0.151	0.173	0.266	0.152	0.238
Khmelnitskyi	0.267	0.097	0.232	0.168	0.217	0.223	0.183	0.165	0.168	0.241
Cherkasy	0.270	0.117	0.231	0.150	0.212	0.212	0.182	0.186	0.188	0.212
Chernivtsi	0.206	0.113	0.196	0.212	0.253	0.079	0.092	0.272	0.252	0.284
Chernihiv	0.251	0.113	0.202	0.191	0.224	0.238	0.184	0.183	0.172	0.203
Kyiv	0.205	0.170	0.209	0.192	0.205	0.186	0.187	0.203	0.208	0.196

Source: calculated by the authors

Calculation of the integral index for development of RSES's in the globalization context (IAID) for 2020 and 2023 was carried out according to multiplicative (see formula 5) and additive convolutions (see formula 6) to reduce the error in calculations and identify possible errors.

As shown by calculations given in Table 4, the methodology for determining the integral index of

development of RSES's in the globalization context, based on relative values of subindices according to the proposed methodology, demonstrates a high level of statistical significance (r) according to the Student's t-test and the correlation between the obtained arrays of subindices, namely:

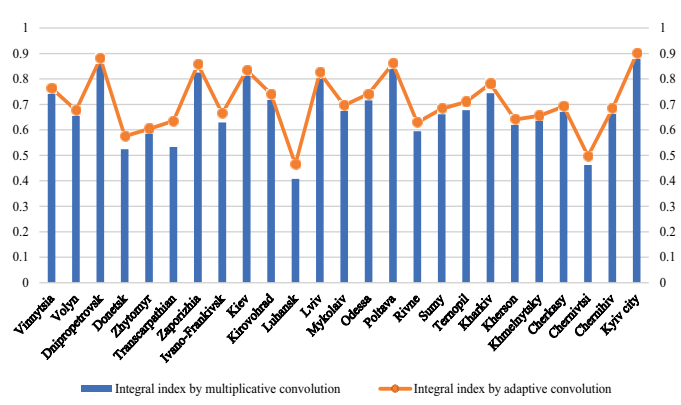
$$r_{I_{AID}^{mult}, I_{AID}^{add}} = 0.998.$$

Table 4. Results of calculations of the integral index of development of RSES's in the globalization context considering the AI and digitalization in 2020 and 2023

Regions	????							
	2020				2023			
	I_{AID}^{mult}	Rank	I_{AID}^{addit}	Rank	I_{AID}^{mult}	Rank	I_{AID}^{addit}	Rank
Vinnitsia	0.655	20	0.675	20	0.759	7	0.764	8
Volyn	0.509	23	0.527	23	0.662	15	0.677	16
Dnipropetrovsk	0.901	1	0.904	1	0.874	2	0.881	2
Donetsk	0.772	6	0.781	6	0.524	23	0.575	23
Zhytomyr	0.672	16	0.689	16	0.587	21	0.604	22
Transcarpathian	0.491	25	0.514	24	0.533	22	0.635	20
Zaporizhzhia	0.730	8	0.746	10	0.825	5	0.858	4
Ivano-Frankivsk	0.726	10	0.752	8	0.629	18	0.664	17
Kiev	0.812	5	0.828	4	0.831	4	0.834	5
Kirovohrad	0.693	14	0.708	14	0.738	9	0.741	9
Luhansk	0.691	15	0.705	15	0.408	25	0.464	25
Lviv	0.729	9	0.749	9	0.800	6	0.825	6
Mykolaiv	0.722	11	0.742	11	0.689	12	0.696	12
Odesa	0.813	3	0.830	3	0.716	10	0.741	10
Poltava	0.750	7	0.760	7	0.857	3	0.860	3
Rivne	0.520	22	0.545	22	0.595	20	0.629	21
Sumy	0.671	17	0.681	19	0.661	16	0.683	14
Ternopil	0.661	19	0.685	18	0.677	14	0.710	11
Kharkiv	0.813	4	0.823	5	0.744	8	0.781	7
Kherson	0.666	18	0.686	17	0.623	19	0.641	19
Khmelnitskyi	0.696	13	0.722	13	0.646	17	0.655	18
Cherkasy	0.710	12	0.735	12	0.690	11	0.692	13
Chernivtsi	0.496	24	0.508	25	0.462	24	0.497	24
Chernihiv	0.634	21	0.650	21	0.678	13	0.683	15
Kyiv	0.900	2	0.902	2	0.898	1	0.899	1

Source: calculated by the authors

Fig. 4. Integral index of regional development in the globalization context considering the AI and digitalization, 2023



Source: calculated by the authors.

In 2020, regions with high value of the integral index for the development of RSES's in the globalization context considering the AI and digitalization by multiplicative and additive convolution include Dnipropetrovsk, Odesa, Kharkiv, Kiev regions and the city of Kyiv. multiplicative and additive convolutions. In 2023, regions with the highest values of the integral index for multiplicative and additive convolutions include the city of Kyiv, as well as Dnipropetrovsk and Poltava. Kiev and Zaporizhzhia regions. And in the last positions in rank are Zhytomyr, Donetsk, Chernivtsi and Luhansk regions. In 2020, the differentiation in the values of the integral index between the leader and the outsider according to the value of the integral index, namely Dnipropetrovsk and Zakarpattia regions, was 1.8 times, in 2023, differentiation between Kiev and Luhansk regions is 2 times.

To determine the impact of the AI and digitalization on the integral index of development of RSES's in the globalization context, it is proposed to determine by calculating the relative value of dynamics for the integral

index (see formula 7), as well as transformation of the AI subindex and digitalization of regional economic systems (see formula 8). Results of calculations in accordance with the proposed methodological approach are presented in Table 5.

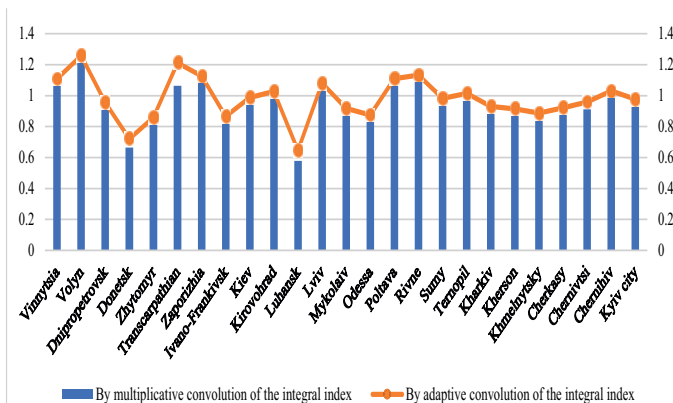
Table 5. Results of calculations of the impact of the AI and digitalization on the integral index of development of RSES's in the context of globalization and transformation of the AI sub-index and digitalization for 2020/2023

Regions	???		DIV
	By multiplicative convolution of the integral index (I_{AID}^{mult})	By adaptive convolution of the integral index (I_{AID}^{addit})	
Vinnitsia	1.136	1.109	1.243
Volyn	1.277	1.258	1.220
Dnipropetrovsk	0.952	0.956	1.010
Donetsk	0.665	0.721	0.802
Zhytomyr	0.856	0.859	1.143
Transcarpathian	1.064	1.212	1.178
Zaporizhzhia	1.107	1.127	0.975
Ivano-Frankivsk	0.850	0.866	1.054
Kiev	1.003	0.987	1.210
Kirovohrad	1.044	1.027	1.025
Luhansk	0.578	0.645	0.894
Lviv	1.074	1.080	1.285
Mykolaiv	0.935	0.918	0.843
Odessa	0.863	0.875	0.921
Poltava	1.119	1.110	0.950
Rivne	1.119	1.133	1.485
Sumy	0.965	0.983	1.066
Ternopil	1.005	1.015	1.165
Kharkiv	0.896	0.930	1.239
Kherson	0.916	0.915	1.004
Khmelnyskyi	0.909	0.887	1.054
Cherkasy	0.954	0.922	0.990
Chernivtsi	0.911	0.959	0.937
Chernihiv	1.048	1.030	0.969
Kyiv	0.978	0.976	0.936

Source: calculated by the authors

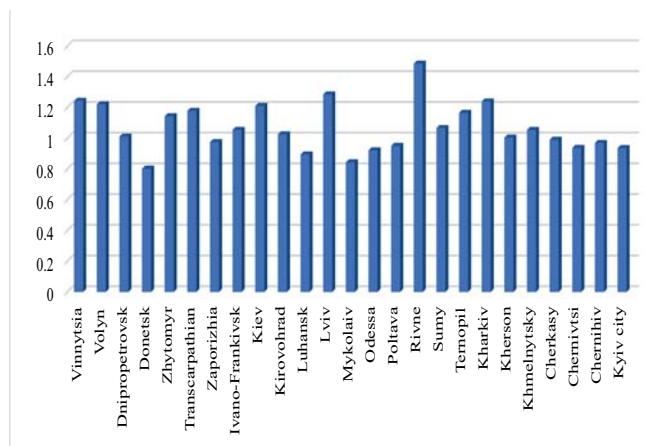
The greatest impact of the AI and digitalization on the integral index according to results of calculations was observed in relation to Vinnytsia, Volyn, Transcarpathian, Zaporizhzhia, Poltava, and Rivne regions (Fig. 5). It should be noted that these regions include those that have both high and low values of the integral index. Transformation of the AI sub-index and digitalization of regional economic systems is presented in Fig. 6.

Fig. 5. Visualization of the impact of the AI and digitalization on the integral index of development of RSES's in the globalization context



Source: calculated by the authors.

Fig. 6. Transformation of the AI and digitalization sub-index



Source: calculated by the authors.

The largest transformation during the study period was experienced by Rivne (Div = 1.485), Lviv (Div = 1.285), Vinnytsia (Div = 1.243), Kharkiv (Div = 1.239) and Volyn (Div = 1.220) regions. The smallest value of the AI sub-index transformation and digitalization was in Donetsk (Div = 0.802), Mykolaiv (Div = 0.843), Luhansk (Div = 0.921) and Odessa (Div = 0.936) regions, as well as the city of Kyiv (Div = 0.936).

Conclusions

The growth of the integral index for development of RSES's in the globalization context considering the AI and digitalization, which was calculated according to multiplicative and additive convolution, reflects the dynamics of changes caused by the AI introduction and digitalization, creating prerequisites for more effective use of regional potential, as well as identifying latent opportunities for further development of RSES's. In the transformation context of the global environment, digitalization plays a key role in improving efficiency of business entities. The adaptation level of society and business to new digital conditions determines not only their competitiveness, but also overall pace of development of the state.

Scientific novelty of the study lies in substantiation of the methodological approach to assessing the impact of AI and digitalization on development of RSES's in the globalization context, which involves by considering principles of the methodological approach; determination of integral indices and their constituent subindices based on the weighted geometric average, which are the system of grouping indicators and calculations; determination of their relative value using the matrix of pairwise comparisons; calculation of the integral index by multiplicative and additive convolutions; determination of the impact of the AI and digitalization on the integral index of RSES's development in the globalization context and transformation of the AI sub-index and digitalization.

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