DIGITALIZATION OF REGIONAL ECONOMIC SYSTEMS IN CONDITIONS OF GLOBALIZATION CHALLENGES

MARTA DERHALIUK [1], OLENA AREFIEVA [2], VIKTORIIA CHOBITOK [3],

OLENA KOSTIUNIK[4], TETIANA SHCHEPINA[5], INNA SHOSTAK[6]

[1]Department of Economics and Entrepreneurship, National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine
[2]Department of Air Transport Economics, National Aviation University, Kyiv, Ukraine
[3]Department of Marketing and Trade Entrepreneurship, V. N. Karazin Kharkiv National University,
Kharkiv, Ukraine
[4]Department of Economics and Entrepreneurship, National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine
[5]Department of Economics and Entrepreneurship, National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine
[6]Department of Economic Cybernetics, National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute", , Kyiv, Ukraine
E-mail: [1]Marta17.06@ukr.net; [2]lena-2009-19@ukr.net; [3] viktoriia.chobitok@karazin.ua;
[4]elena_kostynik@ukr.net; [5]supertanuta@gmail.com; [6] ShostakInna@ukr.net

ABSTRACT

Relevance of the study is due to increasing role of digitalization in development of regional economic systems, which are increasingly important in the international market in modern conditions. The purpose of the study is to develop and substantiate the methodological approach to assess digitalization of regional economic systems. Methodological basis of the study is digital paradigm, under which generally defined social goals of sustainable development are achieved directed to ensure equal opportunities for all regional subjects in obtaining knowledge and information, access to high-quality services, expanding opportunities to reveal potential of all economic subjects, including households, increasing their safety of life and creating comfort due to digital technologies in everyday life. In the article, the methodological approach to assess digitalization of regional economic systems is proposed, which includes substantiation of principles on choice of evaluation indicators for sub-indices digitalization of regional economic systems (complexity, reliability, strategicity and accuracy, which provides for validity of further calculations of sub-indices and comprehensive index of digitalization of regional economic systems). The methodological approach involves calculating comprehensive index of digitalization of regional economic systems using logic of system analysis in accordance with the "cause and effect constraints" principle; definitions of sub-indices digitalization of regional economic systems based on the weighted geometric mean using the approach on determination of absolute values of the numerical ratios "more"/"less" when comparing corresponding component of sub-indices through the matrix of numerical pairwise comparisons. The typology of regional economic systems is proposed according to values of the complex digitalization index under the adapted Harrington scale into regions with a high, stable, medium and low level of digitalization. The proposed methodological approach to assess digitalization of regional economic systems is tested on the example of regions of Ukraine.

Keywords: *Digitalization, Digital Economy, Digital Technologies, Digital Paradigm, Regional Economic System, Globalization, Region, Economic Entities.*

1. INTRODUCTION

Modern possibilities of using information and communication technologies simplify, activate, improve and accelerate relationships between economic entities at all levels. The impetus for rapid development of digitalization and its implementation in public life was general reasons, including:

- emerged need to search for new opportunities in international and local markets to meet social needs of humanity;
- search for new approaches to integrating regions and countries, new capital, labor and sales markets to ensure ways of economic growth and

increase competitiveness of entities at different levels;

- increasing disparities between regions, cities and rural settlements in terms of economic development, standard of living of the population and level of public services' provision, etc.

The issue of regional economic systems' digitalization is in the direction of public administration, since for the development of digitalization it is necessary to overcome institutional and legislative barriers to digital transformation, the state must promote the attraction of investment resources to stimulate the development of digital infrastructure at both the state and regional levels.

At the same time, there is steady increase in the role and influence of regions on macroeconomic state of national economies and the global economy as a whole, in which regions become full-fledged actors. There is a general trend towards increasing capabilities of the regional economic level directed to more effective and optimal solutions to problems of local and regional scale, including through digitalization. The above-mentioned actualizes further scientific research directed to the improved methodological approach to assess digitalization of regional economic systems.

Modern trends in socio-economic development influence formation of a new paradigm, namely the digitalization paradigm. Digitalization contributes to creation of cyber-physical space by filling physical world with electronic-digital devices, spread of electronic communication information exchange systems, which affect interpenetration of physical and virtual space. The impact of digitalization extends to political, economic, social and other spheres of public life and becomes a catalyst for its development by generating positive synergistic effect. Due to its unique capabilities, digitalization makes it possible to generate new knowledge and innovations, accelerates their dissemination. Digitalization provides an opportunity to look at established processes from a new perspective and, due to this, make more effective management decisions. Information and communication technologies and their platforms are no longer the only technical means, but also means of new culture of thinking and systems management at different levels, including regional ones.

Therefore, development of socio-economic regional systems today is under influence of the digital paradigm, which affects all economic processes and phenomena.

The aim of the study is to outline the methodological approach to assess digitalization of regional economic systems. To achieve this goal, the authors solved a number of tasks, including:

- proving relevance and timeliness of the study to substantiate the methodological approach to assess digitalization of regional economic systems;

- definition of the digital paradigm as a methodological basis for research;

- research into scientific and applied developments on methodological approaches to assess digitalization of regional economic systems;

- development of the methodological approach to assess digitalization of regional economic systems, which includes substantiation of principles of selecting evaluation indicators for sub-indices of digitalization of regional economic systems; calculation of a complex index of digitalization of regional economic systems by applying logic of the system analysis under the "cause and effect constraints" principle; definitions of sub-indices of digitalization of regional economic systems based on the weighted geometric mean using the approach on determination of absolute values of numerical ratios "more"/"less" when comparing corresponding components of sub-indices through a matrix of numerical pairwise comparisons;

- gradation of regional economic systems according to values of the complex digitalization index according to the adapted Harrington scale into regions with high, stable, medium and low levels of digitalization;

- testing the proposed methodological approach to assess digitalization of regional economic systems using the example of regions of Ukraine

2. LITERATURE REVIEW

The digitalization paradigm has influenced relations of subjects of socio-economic development on the global scale, revealing new opportunities for them. Scientists from all over the world are investigating various aspects of digitalization of regions, underlining extreme relevance and comprehensiveness of the research conducted.

Scholars [1] state that today there are notable differences between access to and use of information and communication technologies (ICT) and the Internet for a wide range of activities by individuals in regions of Italy and Spain. Results of the authors' research show interconnection between the variables of access and use of ICT by households and individuals and variables of deprivation in regions of Spain and Italy. The authors [2] constructed the digitization index and established links with multifactor environmental productivity. Scientists have proven that introduction of digital innovations in industries and creation of sustainable securities

play a crucial role in explaining ecological growth of developing countries.

In the research [3], relationship between digitalization and political participation in three Middle Eastern countries: Egypt, Kuwait, and Tunisia, is studied. Results of the analysis show that Egypt and Kuwait are characterized by advanced stages of digitalization with wide access to the Internet, while Tunisia's progress is uneven. Articles [4], [5], [6], [7] are also devoted to various aspects of innovative and digital development of regions, use of digital technologies in the state administration system.

The purpose of article [8] is to analyze technological tools that contribute to development of business in the regions, making them consider their digital transformation, digitalization and digital marketing extremely important. The authors investigated possibilities of Greek SMEs to implement various digital marketing strategies and achieve high results of digital growth, and also analyzed dependence of digital literacy and knowledge on the region where the enterprise is located. The issue of infrastructural development of regions and administrative aspects in the conditions of innovative and digital economy is studied in the paper [9], [10].

Pelucha Martin et al. (2023) [11] analyzed potentially possible changes in business behavior of agricultural holdings and farmers in the region after digitization and ICT use. The results of the authors' research showed that in the selected rural microregion, digitalization was very marginal in functioning models of relevant agricultural subjects. Triki Rabob et al. (2023) [12] investigated the impact of digitalization on ensuring regional competitiveness in the context of implementation of sustainable development goals. In the course of the study, it was proven that digitalization contributes to acceleration of sustainable development in the studied region of Khail.

The impact of digitization on financial behavior of households in different regions, as well as the issue of the development of digital currency and digital finance, is disclosed in publications [13], [14], [15]. Scientists [16] analyzed the most significant initiatives related to digitalization of tangible and intangible cultural heritage of the Burgas region, Bulgaria. Scientists present results related to digital promotion, presentation and preservation of the cultural heritage of the region in global and long-term perspectives, which proves effective fruitful cooperation at the national and international levels of digitalization experts.

Of practical importance is article [17], within which existing literature on digitization and spatial regional development is considered, namely a wide list of opportunities and risks due to digitization in the areas of mobility, economy, tourism, environment, social infrastructure, local governance and planning. The authors [18] analyze different views and opinions of general insurance agents on how regional digitization affects their general behavior.

Current trends and impact of digitalization on innovative development of business and society are disclosed in articles [19], [20], [21]. Dhanamalar M. et al. (2020) [22] analyzed digitalization features used by women in rural and urban regions. The study is based on the analysis of basic Internet centers and trainings and their provision for effective training and use by rural women to help them master Internet facilities.

The result of research [23] is digitization of geographic regions, which will help the user comment effectively without prior training, providing an overall accuracy of 84% of the placement of vertices. The authors [24] present a set of proven methodologies suitable for application to the specific problem of restoration and digitization of archival films of the ORWO region.

The analysis of existing current scientific works in the field of the digitalization of regional economic systems in the context of globalization challenges demonstrated that these issues are relevant and timely, which is confirmed by the activity of scientific developments on this object of study. Paying tribute to scientists from different countries who conducted active scientific and methodological research in the direction of studying diverse aspects of the digitalization of regions in the context of globalization, it should be noted that the issues of assessing the digitalization of regional economic systems and substantiating the appropriate methodological tools for this require further improvements and research.

It should also be noted that in the published developments there is almost no assessment of the digitalization of regional economic systems of Ukraine, this is due to the current situation in this country, but this is one of the impetuses for active scientific exploration and testing specifically for Ukraine, which will affect the further socio-economic development of regional economic systems, taking into account digitalization processes.

However, without diminishing the work of scientists, it is appropriate to note that the issue of developing a methodology to assess digitalization

level of regional economic systems requires further research and testing.

3. METHODOLOGY

To assess digitalization of regional economic systems, it is proposed to use the methodological approach in which, to determine evaluation components, it is important to adhere to the following principle:

- comprehensiveness, which involves comprehensive assessment of digitalization of regional economic systems, taking into account multi-vector factors of influence;

- reliability, which means that all assessment indicators must have empirical basis, be substantiated, and have reliable statistical disclosure;

- strategicity, according to which calculations are carried out not only to determine results that illustrate facts and patterns of digitalization of regional economic systems, but also for possible further strategic planning based on them for development of regional economic systems;

- accuracy, the essence of which is that during calculations it is important to maintain accuracy to reduce possible errors when operating with a certain array of empirical data, including using special software to obtain reliable results that become basis for further management decisions.

Adherence to the outlined principles of developing the methodological approach to digitalization of regional economic systems, namely: comprehensiveness, reliability, strategicity, and accuracy, makes it possible to ensure validity of further calculations of sub-indices and the comprehensive index of digitalization of regional economic systems.

To calculate the complex index of digitalization of regional economic systems, the approach based on the detailed analysis of components of the complex index - sub-indices and their structure - is proposed.

By definition, the complex index I c includes calculation of indicators for four subindices and can be defined as a multidimensional function of four variables - a linear superposition of multidimensional functions of the form:

$$Id = F_1(I_1, I_2, I_3, I_4), \qquad (1)$$

where I_1 is index that characterizes the number of Internet subscribers by region and economic system in relation to average value for the country for current period;

I_2 – index characterizing share of households that have access to Internet services at home, as a percentage of the total number of households in current period;

I_3 – index that characterizes population by access to the Internet by region as a % of the total population for the current period;

I_4 – index that characterizes revenues from sale of postal and communication services by type of communication and region in relation to average value for the country for the current period.

From the point of view of the system analysis, the study of the complex digitalization index of regional economic systems, which is presented as the formula (1), should be carried out based on the analysis of its structural components of sub-indices. The analysis is step-by-step and satisfies basic principles of systems research - cause-and-effect constraints, conservation and hierarchy.

The specified principle of "causal and consequential constraints" is implemented by evaluating indices I_1 - I_4 based on economic indicators; the "conservation" principle is implemented by including evaluation indices in sub-indices; the hierarchy principle is implemented by determining the complex digitalization index of regional economic systems I ц (system level) based on the superposition of its structural and elemental components (Fig. 1).
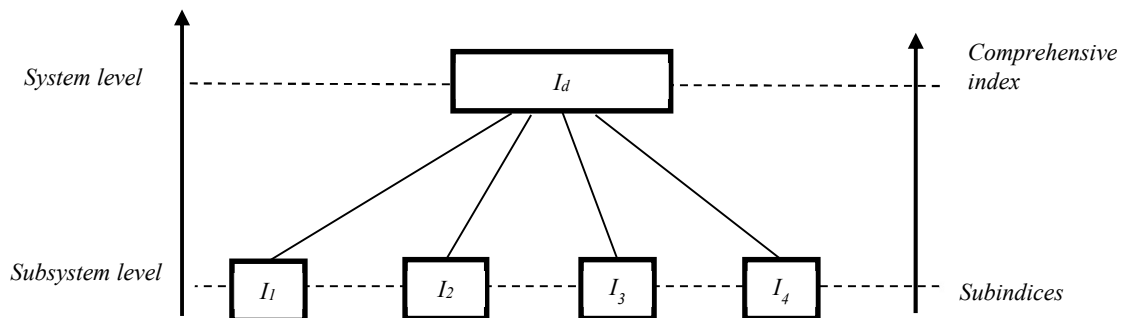

Figure 1: Visualization of the system approach in determining comprehensive digitalization index of regional economic systems

Source: built by the authors

Considering the fact that the structurally complex index is superposition of corresponding groups subindices $Isub\ I_1 \div I_4$, that form it, it is proposed to determine subindices based on the weighted geometric mean:

$$I_i^{sub} = \sqrt[m]{\Pi_{j=1}^m (I_i j)^{w_j}} \,, \qquad (2)$$

where $i = \overline{1, N}$– number of subindices included in the complex digitalization index, N = 4;

$j = \overline{1, m}$– number of component indices in corresponding subindex;

w_j – relative value, i.e. the "weight" of the jth index in the structure of the ith subindex.

The weight estimate of the corresponding j -th subindex based on the Saati hierarchy analysis method, but not using traditional scale of expert pairwise comparisons, but by determining absolute values of numerical ratios "more"/"less" when comparing corresponding subindexes included in the complex digitalization index of regional economic systems. Due to determining the ratios between the corresponding components I ij within the complex digitalization index of regional economic systems I ц, we obtain a matrix of numerical pairwise comparisons of the form:

$$Ai = \begin{pmatrix} 1 & I_{i1}/I_{i2} & I_{i1}/I_{ij} & I_{i1}/I_{im} \\ I_{i2}/I_{i1} & 1 & I_{i2}/I_{ij} & I_{i2}/I_{im} \\ I_{ij}/I_{i1} & I_{ij}/I_{i2} & 1 & I_{ij}/I_{im} \\ I_{im}/I_{i1} & I_{im}/I_{i2} & I_{im}/I_{i(m-1)} & 1 \end{pmatrix}, \qquad (3)$$

Based on the matrix, weights of the component Ai subindices are determined I_{ij} within the given complex index Id:

$$w_j = \frac{\sqrt[m]{\Pi_{j=1}^m a_j m}}{\sum_j^m \left(\sqrt[m]{\Pi_{j=1}^m a_j m} \right)}\,, \qquad (4)$$

where wj is relative value, i.e. the "weight" of the jth component subindex;

$\sqrt[m]{\Pi_{j=1}^m a_j m}$ - geometric mean values of the corresponding rows of the matrix of pairwise numerical comparisons, which is represented by formula 3;

a_{jm}– result of numerical pairwise comparison of the jth and mth component subindices;

$\sum_j^m \left(\sqrt[m]{\Pi_{j=1}^m a_j m} \right)$ –sum of geometric means for rows of the matrix of pairwise numerical comparisons, which is represented by formula 3.

To classify regional economic systems by values of complex digitalization index, it is necessary to use a scale of measurement of calculated values of the complex index. To do this, it is proposed to adapt the Harrington scale according to appropriate data distribution criteria (Table 1).

Table 1 – Harrington Scale For Forming Typologies Of Regional Economic Systems Based On Values Of The Complex Digitalization Index

Meaningful description of gradations	Numerical value	Meaningful description gradations of zones of regional development typologies	Numerical value of the subindex
Traditional scale		Modified scale (author's approach)	
Very high	0.8 – 1.0	Regions with a high digitalization level	Over 100% of the national average (coefficient more than 0.8)
High	0.64 – 0.8	Regions with stable, above-average digitalization level	≤ 80% of the national average, but ≥ 0.64% of the national average (0.64-0.80)
Medium	0.37 – 0.64	Regions with average digitalization level	≤ 64% of the national average, but ≥ 37% of the national average (0.37-0.64)
Low	0.2 – 0.37	Regions with low digitalization level, which is critical in relation to the overall level	≤ 37% of the national average, but ≥ 20% of the national average (0.2-0.37)

Source: proposed by the authors based on the Harrington scale

To determine the type of regional economic system, the scale provided numerical values of parameters of the typology of regions according to values of the complex digitalization index, namely, four groups were identified: regions with high, stable, medium and low digitalization levels.

Applying this approach to typology of regions allows us to identify weaknesses and strengths in digitalization of regional economic systems. Also, this typology is appropriate to use for developing a matrix of strategies for digitalization of regional economic systems

4. RESULTS

Using the digitalization paradigm, generally defined social goals of sustainable development are achieved directed to ensuring equal opportunities for all subjects of regions to obtain knowledge and information, access to high-quality services, expanding opportunities to reveal potential of all economic subjects, including households, increasing their safety of life and creating comfort through digital technologies in everyday life. The digital paradigm contributes to ecological safety, environmental protection and prevention of technological disasters, increases efficient use of natural resources. It als expands possible entrepreneurial activity and creates new jobs, which contributes to overcoming poverty. In addition, the digital paradigm contributes to intensified international activity of regions, which encourages improvement of efficient functioning of regional economic systems and their competitiveness in the international market through a more new and effective use of existing potential, obtaining synergistic effect from combining local regional potential opportunities and resources with foreign capital and resources. It has positive effect on education of the population and cultural development of regions, etc.

To test the proposed methodological approach, the authors propose to take regions of Ukraine. For greater clarity of changes that occur in the regional context under digitalization, data for 2013 and 2022 are used. However, it should be noted that the research interval can be chosen any, depending on further actions with the obtained results of the values of the complex digitalization index of regional economic systems.

The value of subindices I1 – I4 for 2013 and 2022 are given in Table 2, which are calculated based on estimated indicators of statistical data of Ukraine. They are the basis for determining the complex digitalization index of regional economic systems.

Table 2 – Sub-index data for calculating the comprehensive digitalization index of regional economic systems

Regions	2013				2022			
	I_1	I_2	I_3	I_4	I_1	I_2	I_3	I_4
Vinnytsia	0.0243	0.5103	0.0237	0.5272	0.0352	0.6234	0.0211	0.7503
Volyn	0.0120	0.2291	0.0100	0.6617	0.0202	0.7321	0.0122	0.7065
Dnipropetrovsk	0.4072	0.8285	0.4613	0.8375	0.0626	0.9190	0.6133	1.0155
Donetsk	0.3042	0.8013	0.0898	0.7794	0.0783	0.3239	0.0397	0.3625
Zhytomyr	0.0098	0.6257	0.0099	0.6848	0.0271	0.8214	0.0142	0.6211
Transcarpathian	0.0102	0.8283	0.0135	0.8786	0.0186	0.9190	0.0137	0.9771
Zaporizhzhia	0.0279	0.6991	0.0296	0.8283	0.0371	0.7668	0.0248	0.7004
Ivano- Frankivsk	0.0102	0.3980	0.0107	0.4261	0.0209	0.8165	0.0161	0.6154
Kiev	0.0217	0.9029	0.0185	0.5253	0.5547	0.7503	0.5334	0.8205
Kirovohrad	0.0080	0.6760	0.0086	0.6765	0.0153	0.6666	0.0105	0.7536
Luhansk	0.0246	0.8285	0.0214	0.9303	0.0306	0.6895	0.0157	0.6492
Lviv	0.0446	0.7560	0.0530	0.6620	0.0638	0.9425	0.0457	0.956
Mykolaiv	0.3235	0.8002	0.3195	0.7968	0.0206	0.8173	0.0185	0.6244
Odessa	0.8362	0.7127	0.1140	0.8325	0.1269	0.9322	0.1270	0.7170
Poltava	0.1183	0.5492	0.0179	0.8062	0.0251	0.7194	0.0209	0.7277
Rivne	0.0085	0.1189	0.0103	0.2256	0.0200	0.8044	0.0125	0.6711
Sumy	0.0105	0.4169	0.0120	0.7004	0.0182	0.6638	0.0122	0.7389
Ternopil	0.0149	0.6531	0.1157	0.6773	0.0168	0.7642	0.0144	0.7470
Kharkiv	0.0351	0.8299	0.0528	0.5962	0.0578	0.8495	0.6461	0.9986
Kherson	0.0122	0.6560	0.0133	0.7657	0.0185	0.6741	0.0157	0.7810
Khmelnytskyi	0.0134	0.7245	0.0139	0.7599	0.0629	0.6149	0.0960	0.7753
Cherkasy	0.0115	0.6271	0.0162	0.8698	0.0290	0.8057	0.0138	0.6606
Chernivtsi	0.0108	0.5433	0.0116	0.4589	0.0132	0.3305	0.0104	0.3922
Chernihiv	0.0143	0.6531	0.0140	0.7033	0.0269	0.4955	0.0144	0.7129
Kyiv	0.8386	0.9305	0.8525	0.8018	0.1602	0.8596	0.4426	0.9666

Source: calculated based on estimated indicators of statistical data of Ukraine and, accordingly, formulas (1)-(2)

There is no region in which all sub-indices would have approximately the same values of all components of the complex digitalization index of regional economic systems.

Using the obtained values of the sub-indices of the complex digitalization indexof regional economic systems, we determine weights and values of the complex index according to formulas (3)-(4) under the proposed methodological approach to assess digitalization of regional economic systems. The obtained calculation results are given in Table 3.

Table 3 – Results Of Calculations Of The Complex Digitalization Index Of Regional Economic Systems

Regions	2013		2022	
	Id	*Rank by IT*	*Id*	*Rank by IT*
Vinnytsia	0.675	22	0.857	9
Volyn	0.662	23	0.824	12
Dnipropetrovsk	0.917	3	0.946	1
Donetsk	0.871	5	0.712	24
Zhytomyr	0.721	18	0.840	11
Transcarpathian	0.764	11	0.919	6
Zaporizhzhia	0.759	13	0.755	21
Ivano-Frankivsk	0.795	8	0.855	10
Kiev	0.746	15	0.920	5
Kirovohrad	0.734	16	0.767	18
Luhansk	0.814	6	0.743	22
Lviv	0.710	20	0.930	3
Mykolaiv	0.899	4	0.773	15
Odessa	0.927	2	0.871	8
Poltava	0.808	7	0.783	25
Rivne	0.510	25	0.773	14
Sumy	0.698	21	0.759	16
Ternopil	0.780	9	0.928	20
Kharkiv	0.718	19	0.908	4
Kherson	0.749	14	0.767	7
Khmelnytskyi	0.761	12	0.818	19
Cherkasy	0.765	10	0.773	13
Chernivtsi	0.646	24	0.617	17
Chernihiv	0.734	17	0.726	23
Kyiv	0.976	1	0.933	2
Average value	*0.766*	*-*	*0.820*	*-*

Source: calculated based on formulas (3)-(4)

Calculated data on the complex digitalization index of regional economic systems presented in Table 3 make it possible to note that in 2013, among leaders in terms of the complex index were: Kyiv (Id = 0.976), as well as Odessa (Id = 0.927) and Dnipropetrovsk (Id = 0.917) regions, and the lowest values were observed in Volyn (Id = 0.662), Chernivtsi (Id = 0.646) and Rivne (Id = 0.510) regions. Differentiation in the complex index in 2013 between Kiev and Rivne regions was 1.9 times.

It should be noted that in 2022, there were significant changes in average values of sub-indices and the complex digitalization index of regional economic systems compared to 2013. Thus, the average value of the complex digitalization index increased by 1.07 times, respectively, from 0.766 to 0.820 (Fig. 2).
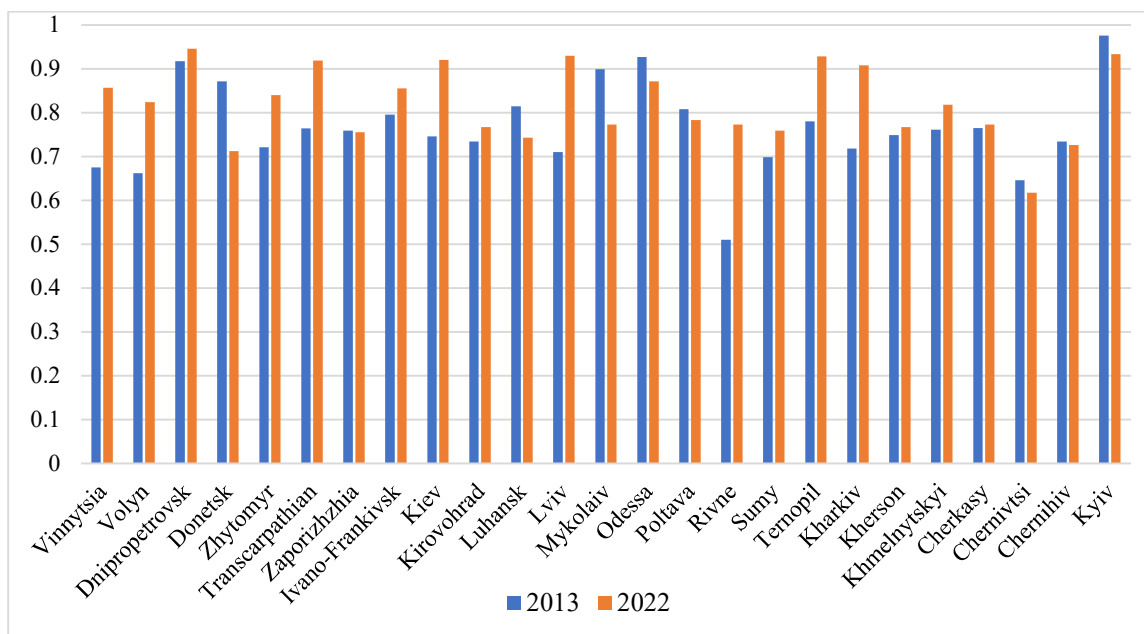
Figure 2: Complex digitalization index of regional economic systems

Source: calculated by the authors

If we analyze calculated values of the complex digitalization index of regional economic systems for 2022, we can note positive dynamics in relation to the complex index of 2013. In 2022, the highest values for the complex index were the Dnipropetrovsk region (Id = 0.946), the city of Kyiv (Id = 0.933) and the Lviv region (Id = 0.930), and Chernihiv (Id = 0.617), Donetsk (Id = 0.712) and Poltava (Id = 0.783) regions closed the rating for this complex index. The asymmetry between the Dnipropetrovsk and Poltava regions for the complex digitalization index of regional economic systems was 1.5 times.

In accordance with the proposed typology of regions according to calculated values of the complex digitalization index of regional economic systems, the results obtained are presented in Table 4.

Table 4 – Typology Of Regions According To The Complex Digitalization Index Of Regional Economic Systems In 2013/2022

Type region	2013	2022
Regions with high digitalization level	Kiev, Odessa, Dnipropetrovsk, Mykolaiv, Donetsk, Luhansk, Poltava	Dnipropetrovsk, Kyiv, Lviv, Ternopil, Kiev, Transcarpathian, Kharkiv, Odessa, Vinnytsia, Ivano-Frankivsk, Zhytomyr, Volyn, Khmelnytskyi
Regions with stable digitalization level	Ivano-Frankivsk, Ternopil, Cherkasy, Zakarpattia, Khmelnytskyi, Zaporizhia, Kherson, Kyiv, Kirovohrad, Chernihiv, Zhytomyr, Kharkiv, Lviv, Sumy, Vinnytsia, Volyn, Chernivtsi	Mykolaiv, Rivne, Cherkasy, Kirovohrad, Kherson, Sumy, Zaporizhia, Luhansk, Chernihiv, Donetsk
Regions with average digitalization level	Rivne	Poltava
Regions with low digitalization levels	-	-

Source: generated by the author based on calculations

The presented data make it possible to note that in 2013 and 2022 there is no region that would be classified as regions with low digitalization level. Regions that were classified as regions with average digitalization level have changed. So, in 2013 it was the Rivne region, and in 2022 – the Poltava region. In 2013, most regions were classified as regions with stable digitalizationlevel, and regions with high digitalization level according to the value of the complex digitalization level of regional economic

systems included Kiev, Odessa, Dnipropetrovsk, Mykolaiv and Donetsk regions.

The presented data on the grouping of regions in Table 4 make it possible to note that in 2022, compared to 2013, situation regarding the typology of regions has changed. Thus, in 2022, number of regions that are classified as regions with high digitalization level has significantly increased, their number has reached 13 regions compared to 7 in 2013. However, it should be noted that the Mykolaiv and Donetsk regions, which in 2013 were classified as regions with high digitalization level, have dropped one level below regions with stable digitalization level according to the value of the complex index. The list of regions that were classified as regions with average digitalization level has also changed. In 2013, these were the Chernivtsi and Rivne regions, and in 2022, the Poltava region. Such changes state the fact that during the studied period there were significant changes in the values of the complex digitalization index of regional economic systems, and if a region had high values of the complex digitalization index in a certain period, this does not guarantee it to maintain its leading positions without making additional efforts to carry out digitalization.

The increase in the complex digitalization index of regional economic systems demonstrates changes occurring due to digitalization and enables regions to more effectively use their potential for further regional development. Positive changes in the complex digitalization index as a whole are indicated by the arithmetic mean value (Table 3), which in 2013 was 0.766, and in 2022 – 0.820.

In the digital paradigm, digitalization development significantly affects the ability of business entities of regional economic systems to effectively carry out their activities. Their overall development and development of regions and the as a whole depend on how quickly society and business can adapt to new conditions.

During the period under study, significant changes occurred in the global environment, so the COVID-19 pandemic necessitated changes in the way communication policies are implemented by most business entities of regional economic systems. Digitalization during this period gained particular importance and forced business entities to use digital technologies in their activities in various areas of management and production. Temporary isolation of human communication prompted development, use and implementation of alternative digital sources of support for this communication for social development.

Depending on the needs, through impact on certain components of the sub-indices, it is possible to adjust strategic goals at all levels of management from state, regional to business entities to obtain the desired result regarding digitalization, implementation and development of information and communication technologies. Implementation of digital processes in regional economic systems contributes to their overall development and formation of appropriate space around them, which has positive impact on investment climate, business reputation, integration and increased competitiveness at the international level.

Thus, the proposed methodological approach to assessing the digitalization of regional economic systems and its testing on the example of regions makes it possible to state its effectiveness and validity. It should be noted that this methodological approach can be applied to regions of other countries, but special attention should be paid to the components of the sub-indices of the complex index of digitalization of regional economic systems, since statistical samples and digitalization indicators in different countries may differ and this will require additional justification of their choice for further calculations.

5. CONCLUSIONS

Scientific novelty of this study is improvement of the methodological approach to assess digitalization of regional economic systems, which is based on the methodological basis of the digital paradigm and includes justification of principles of choosing evaluation indicators for sub-indices of digitalization of regional economic systems; calculation of the complex digitalization index of regional economic systems by applying the logic of the system analysis in accordance with the "cause and effect constraints" principle; definitions of sub-indices of digitalization of regional economic systems based on the weighted geometric mean using the approach of determining absolute values of the numerical ratios "more"/"less" when comparing corresponding components of sub-indices through the matrix of numerical pairwise comparisons; typology of regional economic systems according to the values of the complex digitalization index according to the adapted Harrington scale into regions with high, stable, medium and low digitalization levels.

The proposed methodological approach to assessing the digitalization of regional economic systems includes methodological justification and selection of methodological assessment tools, it is necessary to emphasize that it is important to adhere

to the principles of complexity, reliability, strategy and accuracy, which ensure the validity of further calculations of sub-indices and directly the complex index of digitalization of regional economic systems. Taking into account these principles will ensure the reliability of further calculations according to the proposed algorithm for assessing the digitalization of regional economic systems according to the multidimensional function of four sub-indices, which represent a superposition of multidimensional functions.

Testing of the proposed methodological approach to assess digitalization of regional economic systems on the example of regions of Ukraine for 2013 and 2022 demonstrated significant changes in values of the complex digitalization index of regional economic systems and its overall growth in terms of the arithmetic mean value of the complex digitalization index. There was also a decrease in the asymmetry between regions in terms of their digitalization level from 1.9 times in 2013 to 1.5 times in 2022. According to the proposed typology of regions by values of the complex digitalization index of regional economic systems, significant changes can be observed during the studied period in accordance with the change in the belonging of regions to one or another group.

proposed typology of regions according to the complex digitalization imdex of regional economic systems, taking into account the results obtained, makes it possible to develop strategies for digital transformation of regional economic systems.

The proposed methodological approach to assessing the digitalization of regional economic systems allows us to identify the strengths and weaknesses of the digitalization of regions in the face of globalization challenges, it can serve as a basis for developing a matrix of strategies for the digitalization of regional economic systems, taking into account typology by the value of the complex digitalization index according to the modified Harrington scale, as well as the specific and unique capabilities of specific regional economic systems.

However, in this study they are not applied, taking into account the fact that testing was carried out on the example of digitalization of regions of Ukraine, where hostilities are still ongoing, there are occupied territories and losses of production, infrastructure, social and other facilities continue. In view of this, development and implementation of strategies on the example of regions of Ukraine is inappropriate.

Further research is required on issues related to improving the methodological approach to assess transformational digitalization at the level of regional economic systems to develop a toolkit for the regional digitalization policy.

AUTHOR CONTRIBUTIONS:

Conceptualization: Marta Derhaliuk, Olena Arefieva.

Data curation: Marta Derhaliuk, Tetiana Shchepina, Inna Shostak.

Formal analysis: Olena Arefieva, Viktoriia Chobitok, Olena Kostiunik.

Investigation: Viktoriia Chobitok, Olena Kostiunik.

Methodology: Marta Derhaliuk, Olena Arefieva, Viktoriia Chobitok.

Resources: Olena Kostiunik, Tetiana Shchepina, Inna Shostak.

Supervision: Marta Derhaliuk, Viktoriia Chobitok, Olena Kostiunik.

Validation: Marta Derhaliuk, Olena Arefieva.

Visualization: Olena Kostiunik, Tetiana Shchepina, Inna Shostak.

Writing – original draft: Marta Derhaliuk, Olena Arefieva, Viktoriia Chobitok, Olena Kostiunik, Tetiana Shchepina, Inna Shostak

Writing – review & editing: Marta Derhaliuk, Olena Arefieva, Viktoriia Chobitok.

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