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Digital transformation of Ukraine: challenges of theory and practice in implementation of digital quality of life

Abstract
Introduction. The complexity of predicting the digitalisation processes with regard to all existing challenges and potentials of digital transformation raises the relevance of both theoretical and empirical studies related to the indicators development that allow analysing the current level of digitalisation of the socio-economic development of the territory, the transformational potential, the digital quality of life and the creation of methods for its evaluation, as well as determining the perspective directions in the digitalisation policy.
The purpose of the article is to develop methodological approaches to the evaluation of the digital quality of life.
Methods. The methods of formalisation, hypothetical assumption, system approach and scientific abstraction were used in the study. The Pareto principle and the ABC analysis method were used while determining the transformational potential (the significance of the digital space components tendency). In the developing of the indicators for assessing the digital quality of life in terms of the digital space components the process approach and the EFQM excellence model were used. The basis for calculating each indicator is the method of linear scaling.
Results. The paper proposes a conceptual model of the digital transformation in the economy and society which is represented both from the position of three digital spaces: business, education and science, state and society and from the viewpoint of process-industrial and technological approaches. In this model, the functions of business, education and science, the state and society are mutually complementary. It is suggested to monitor the development of individual components of the digital space in two directions: 1) the readiness of each component to digital transformations; 2) the use of information and communication technologies and their impact on the development of the specific component of the digital space and the quality of digital life. This approach to monitoring allows us to assess the digital quality of life. A methodology for assessing digital quality has been developed and indicators for its evaluation have been proposed. The assessment of the digital quality of life on average in the European Union (EU) and Ukraine by components of the territory's digital space for 2015 showed that the EU requires progress in the dissemination of digital public services (0.39) and the integration of digital technologies into business activities (0.48), Ukraine is far behind the EU in terms of the digital quality of life.
Conclusions. In comparison with similar studies, the proposed methodology for assessing the digital quality of life allows us to identify problem areas and competitive advantages of digitalisation of the economy and society, and provides the ability to model the development the level of the digital quality of life in view of changing conditions.
Keywords: Digital Space; Digital Economy; Transformation Potential; Digital Quality of Life; Indicators of Digital Quality of Life
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Цифрова трансформація України: виклики теорії і практики реалізації цифрової якості життя
Анотація. У статті запропоновано концептуальну модель цифрової трансформації економіки і суспільства, яка представлена як з позиції трьох цифрових просторів (бізнес, освіта й наука, держава й суспільство), так і з позиції процесно-галузевого і технологічного підходів. Обґрунтовано необхідність проведення моніторингу розвитку окремих компонентів цифрових просторів як за готовністю кожного компонента до цифрового розвитку, так й за впливом інформаційно-комунікаційних технологій (ІКТ) на розвиток конкретного компонента цифрового простору території і якості цифрового життя. Даний підхід до проведення моніторингу дозволяє оцінити результативність цифровізації економіки і суспільства. Розроблено методику оцінки й систему показників для оцінки цифрової якості життя.
Ключеві слова: цифровий простір; цифрова економіка; трансформаційний потенціал; цифрова якість життя; показники цифрової якості життя.

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Цифровая трансформация Украины: вызовы теории и практики реализации цифрового качества жизни
Аннотация. В статье предложена концептуальная модель цифровой трансформации экономики и общества, которая представлена как с позиции трех цифровых пространств (бизнес, образование и наука, государство и общество), так и с позиции процессно-отраслевого и технологического подходов. Обоснован поход к проведению мониторинга развития отдельных компонентов цифровых пространств, позволяющий оценивать результативность цифровизации экономики и общества. Разработана методика оценки цифрового качества жизни и предложена система показателей для оценки цифрового качества жизни.
Ключевые слова: цифровое пространство; цифровая экономика; трансформационный потенциал; цифровое качество жизни; показатели цифрового качества жизни.

1. Introduction

Nowadays, the formation of knowledge-based and information-based society is taking place, in the context of which the innovative economy is dynamically developing as a global information system. The development of high-throughput computing (HTC), new architectures and the principles of high performance computing (HPC), on the one hand, have triggered the industrial revolution 4.0 and created the new *economy ionosphere* - a digital economy that leads to the emergence of the new *digital quality of life*, in which information and communication technologies (ICT)[1] are the key drivers of economic growth. On the other hand, simultaneously with the development of ICT new risks there also appear:

1) the digital inequality between those who fit in technological progress and who do not keep up with it [2], leading to social stratification that extends to new industries[2], regions and professional groups; in connection with this, the elimination of jobs and the polarization of the labour market is a matter of concern;
2) the decline in the quality of education, the new communication networks themselves do not produce new knowledge, their formation and development, first of all, depends on human individuals, their skills and competences, whose effective formalisation in education (on the basis of the new professional skills of the company reorganise the work, which requires changes in education profiles and the development of new approaches to learning);
3) the complexity of predicting digitalisation processes taking into account all existing challenges and potentials of digital transformation, since most of the indicators are short-term oriented are not expressed financially and do not reflect the value they create, the sets of rating indicators do not have a functional orientation Thus, based on the new opportunities that digitalisation brings and the new risks that arise, the relevance of both theoretical and empirical studies related to digital transformation and the emergence of the information society as one of the stages of the society knowledge is topical.

2. Brief Literature Review

The necessity to research information processes in modern society is justified by R. Atkinson and D. Castro (2008) [4], who demonstrate how information technology becomes a key factor in many if not most key innovations and improvements in the life of society, starting with the improvement of education and health to a cleaner and more energy-efficient environment. D. Castro (2008) [5-6] explores information technology and civic engagement, as well as the use of information technologies by the government to solve many problems. D. Lupton (2015) [7] reviews digital health care technologies and discusses the implications for the economics of digital knowledge, data security and confidentiality, social inequality and civil rights. M. Constantinescu and G. Marinescu (2016) [8] focus on the smart economy, the smart city and the smart citizen, pointing out that these are new concepts that allow foreseeing the transformation of human civilization in the near future. M. Stucke and A. Ezrachi (2017) [9] explore social, political and economic problems and emerging threats for the life digitalisation. While investigating the problems and opportunities of business digital technologies in enterprises and small business sectors in Canada, F. Faisal (2017) [10] comes to the conclusion that the usage of various digital technologies in these enterprises significantly increased their potential market opportunities and enabled them to attract customers all over the whole world. S. Murina (2009) [11] suggests a structural and logical model for studying the quality of life while investigating the problems of the improving life quality and various methods for assessing it. Having analyzed the international indices which are used to assess the development of the information society, A. N. Lazarev (2011) [12] offered new indices for determining the level of information development for countries. M. A. Simakina (2012) [13] reveals the foundations for the formation of the new quality of life in the conditions for the establishing of the information society. O. N. Andreeva (2013) [14] attempted to develop methodological requirements for

[1] By 2020, according to the forecasts of the Boston Consulting Group (BCG), the share in the global GDP of the ICT sector will reach 8.7% [1].
[2] According to data provided by experts from the World Economic Forum and McKinsey, only 29% of the industrial companies surveyed during the preparation of the profile report have started commercialise the «Internet of things». 41% of the companies still conduct only «pilot» tests, while 30% have not even begun to test the appropriate technologies [3].

the content of methods assessing the level and quality of life. E. V. Kurushina, A. S. Nikonova, D. A. Luzin and N. P. Sheveleva (2017) [15] study the process of the formation of digital economy by means of a comparative analysis of the dynamics of the development of the information and communication technologies index and the network readiness index.

Based on the fact that digital technologies are an important lever for improving the digital quality of life there is a need to evaluate it. Existing techniques do not allow identifying problem zones of structural components in the digital space of the territory and do not evaluate either the transformation potential or the digital quality of life in the territory.

3. The purpose of the article is the development of methodological approaches to the evaluation of the digital quality of life.

4. Results

All countries in the world are developing towards digitalisation of their economies and society, there is a rethinking of the ICT importance, their consequences for innovation [16] and new models of social development are being formed. The recognition of the importance of this process for Ukraine is reflected in the «Concept for the Development of the Digital Economy and Society of Ukraine for 2018-2020» and «Digital Partners of Ukraine 2020», which identified the tasks and key priority areas, initiatives and projects for the digitalisation of Ukraine, namely the development of digital infrastructure; digitalisation of educational processes and stimulation of digital transformations in the system of education, medicine, ecology, non-cash economy, infrastructure, transport, public security and other areas [17-18]. In order to realise the tasks, it is necessary to carry out a comprehensive monitoring of the transformation processes in the digitalisation of the economy and society, which we propose to carry out on the basis of the developed conceptual model of digital transformation (Figure 1).

This model is presented on the basis of the model of four spirals (business, education and science, state, and civil society) using process-industrial and technological

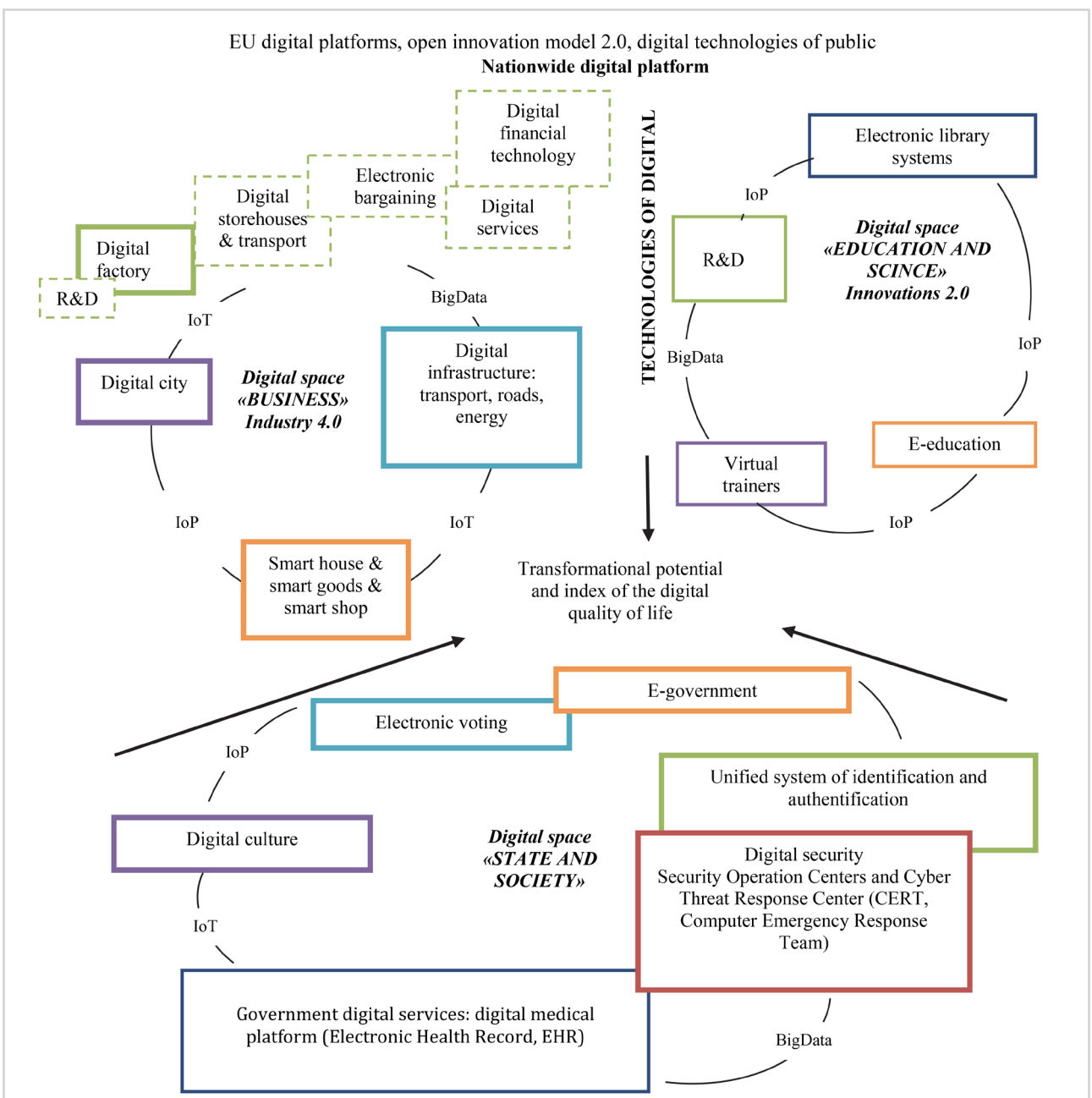

Fig. 1: **Conceptual model of digital transformation based on the model of four spirals (state, education and science, business, and civil society): process-industrial and technological approach**
Source: Compiled by the authors based on [17-18]

approaches. In this model the functions of business, education and science, the state and society are mutually complementary. The state based on interworking provides public services (education, healthcare and social protection) using social and technological innovations, supports the development of e-Government. The society relying on the system of public administration based on the interworking between the state-provider of public services and the consumer population provides social stability and support for innovations, which leads to economic growth. Business organised in networked enterprises based on ICT provides economy growth, productivity and competition, and offers high-tech products and services on the market.

Education and science are key areas for the implementation of new digital innovations and they are the most important factors contributing to further development of digital technologies.

We consider that the monitoring of the development of individual components in the digital space must be carried out in terms of both the readiness of each component for digital development (transformation potential - indices-incentives for digital development) and the usage of ICT in view of their impact on the development of a specific component in the digital space area. Such an approach to monitoring will make it possible to assess the effectiveness of the digitalisation of the economy and society, which is conducted basing on two indicators: the evaluation of the transformational potential of the components of the digital space area and the evaluation of the digital quality of life.

Substantiating the methodology for assessing the transformational potential of the components of the digital space area and assessing the digital quality of life we proceeded from the fact that, firstly, the transformation potential of the economy, as well as, society digitalisation is formed by creating conditions for the effective development of digital economy institutions, raising the digital quality of life and creating new opportunities for entrepreneurial and labour activity with the participation of the state, business and civil society and ensuring rapid economic growth due to the use of information and communication technologies; secondly, the digital quality of life is the level of ICT development and the degree of satisfaction for citizens in terms of using ICT; thirdly, the analysis of the digital economy is currently carried out through complex indices [19-27], which demonstrate the rating of countries, but do not identify the problem areas of the structural components of the digital space area and evaluate neither the transformation potential of the area nor the digital quality of life.

On the basis of the foregoing, we propose a technique for assessing the digital quality of life based on a set of needs and interests of people in digitalisation by three components of the digital space: business and technology, education and science, the state, and society. The process approach (ISO 9001: 2015) [28], the quality perfection model EFQM[3] that was developed by the European Fund for Quality Management [29] (at the analysis stage, these models are recommend methods of estimating the indicators at the discretion of the researcher), the indicators included in the calculation of indices for the analysis of the digital economy [19-27, 30], the official statistical data by State Statistics Service of Ukraine (2018) and Eurostat (2018) [31-32] were used while forming the relevant indicators.

The sequence of actions for the assessment of the digital quality of life is presented below.

1. Identification of the key areas that have the greatest importance for the trajectory development of any territory which, on the one hand, sufficiently cover potential sources of calls for the territory and, on the other hand, are compact enough to calculate the composite index. Such spheres are business, education and science, the state, and civil society.

2. Determination of the transformation potential (significant trends) of each of the identified spheres. The significance of each sphere is determined expertly by the degree to which it can change the current state of a given sphere using the Pareto principle and evaluating the contribution and value by the ABC analysis method (Table 1).

Tab. 1: **Significant trends in improving the digital quality of the territory**

Digital space	Significant trends
Potential for the transformation of digital space «BUSINESS and TECHNOLOGY»	1 Development of advanced technologies, automation and robotics 2 Science intensity of production 3 Rational use of natural resources, creation of utilisation and recycling system 4 Creative economics
Potential for the transformation of digital space «EDUCATION AND SCIENCE»	1 Lifelong and mobile education 2 Effectiveness of the contribution to the world science 3 Support for science by the state
Potential for the transformation of digital space «STATE AND SOCIETY»	1 Social equality 2 Level of subjective satisfaction with life 3 Availability of culture products for the population 4 Automated processes for obtaining public services and increased efficiency of the administrative apparatus

Source: Compiled by the authors based on [2; 3; 8; 17-18]

3. Selection of operational indicators for each component of the digital space, which most fully characterise the correspondence or inconsistency of the digital quality of life in the territory to the trends (Table 2) and the determination of actual values of the indicators for the digital quality of life[4].

4. Standardisation of indicator values for each digital space with the purpose of generalising dissimilar indicators. In order to calculate these standardised indicators, the normative indicators (X), which «increase» the population digital quality of life, are applied and defined as the minimum and maximum boundaries of indicators regarding the study area in the selected base period. The calculation is based on the method of linear scaling, which consists in determining the relative distance between its standardised and the normative (minimum or maximum) value. Indicators that «increase» the population digital quality of life (κ_{ij}^{X}) are calculated by relating the difference between the values of the standardised and the minimum regulatory indicators to the difference between the minimum and maximum values of the indicators (X) using formula (1):

$$k_{ij}^{X} = \frac{X_{ij} - \min X_{ij}}{maxX_{ij} - minX_{ij}}, \quad (1)$$

where:

X_{ij} - the actual value of the j-th indicator for the i-th year;

$minX_{ij}$, $maxX_{ij}$ - minimum and maximum values of the j-th indicator from the set of studied structural elements of the digital space for the i-th year.

5. Aggregation of standardised indicators of the digital quality of life in the territory on three selected structural elements of the digital space.

Particular indicators of the digital quality of life by components of the digital space (K_{ij}^{X}) are determined using the arithmetic mean of the indices κ_{ij}^{X} by the formula (2):

$$K_{ij}^{X} = \frac{\sum k_{ij}^{X}}{n}, \quad (2)$$

where:

n - the number of indicators in the j-th private indicator of the digital quality of life.

[3] The EFQM perfection process is based on the «RADAR logic». RADAR (Results - Approaches - Deploy - Assess - Refine) is created on the basis of the PDCA cycle (plan - execute - monitor - act).

[4] The values of indicators used for calculations can be taken from official statistics.

Tab. 2: **Operational indicators of the digital quality of life by components of the territory's digital space**

1 Digital space «BUSINESS and TECHNOLOGY»			
1.1	Development of information and communication technologies (ICT)	1.15	Technology readiness
1.2	Business development level	1.16	GDP growth for an employed person
1.3	High-tech import	1.17	Labour market efficiency
1.4	Share of innovative products (High-tech and medium-high-tech output as a percentage of total manufactures output)	1.18	The level of information technology use in the commercial sphere (Business usage of information technology)
1.5	Electronic document circulation with ERP	1.19	Service sector share in GDP (Services, etc., value added (% of GDP)
1.6	RFD using	1.20	Share of R & D expenditures (Research and Development Expenditure (% of GDP)
1.7	Interaction with customers on social media	1.21	% of electronic banking users
1.8	Use of electronic invoices e-Invoices	1.22	Import of information and communication technologies
1.9	Consumption of cloud services	1.23	Hi-tech exports (% of manufactured exports)
1.10	The share of SMEs trading in the Internet (indicator of online sales)	1.24	Employment in the intellectual fields of knowledge
1.11	Share of average online turnover in trade turnover	1.25	GDP per capita, PPP
1.12	Share of electronic turnover of SMEs with other countries	1.26	Innovation output
1.13	Research and Development Expenditure (% OF GDP))	1.27	Economic complexity
1.14	Quality of logistics functioning	1.28	% of users of online stores
2 Digital space «EDUCATION AND SCIENCE»			
2.1	Accessibility of education	2.11	State expenditures on education
2.2	Duration of schooling	2.12	Graduates in Science and Technology
2.3	Higher education	2.13	National universities in the QS rating
2.4	Scientific Research Source	2.14	R & D expenses
2.5	Higher education and training	2.15	Citation of scientific publications
2.6	Payments for the use of intellectual property	2.16	R & D cooperation between universities and business
2.7	Number of patents	2.17	Number of international patent applications
2.8	Scientific publications	2.18	Gross domestic expenditure on research projects
2.9	Financing of research projects from abroad	2.19	Applications for utility model submitted to the national patent bureau
2.10	Expenses for research projects of private companies		
3 Digital space «STATE AND SOCIETY»			
3.1	Share of cultural institutions with a website	3.8	Share of electronic document circulation between public authorities
3.2	Index of electronic participation	3.10	State online services
3.3	Volume of museums' electronic catalogues	3.11	Open data indicator
3.4	Share of electronic catalogues of the library available on the Internet	3.12	Level of complexity of the electronic government in the country
3.5	Share of health facilities that used the Internet	3.13	Share of the population using the Internet in order to receive public services in electronic form
3.6	Proportion of health facilities with a website	3.14	% of Internet users of e-government services
3.7	Government Effectiveness	3.15	Share of fully realised e-government services

Source: Compiled by the authors based on [19-34]

6. Calculation of the integral index of the digital quality of life (I_{BES}). The calculation is carried out using an average geometric value of three particular indicators, each of which reflects the most important components of the digital spaces «business and technology», «education and science» and «state and society», and determined by the formula (3):

$$I_{BES} = \sqrt[n]{\prod_{j=1}^{n} K_{ij}^{X}}, \quad (3)$$

where:

n - the number of indicators in the j-th indicators of the digital quality of life ($n = 3$).

The comparative calculation of the digital quality of life on average for the EU countries and Ukraine is shown in Figure 2.

7. Determination of the range values of the integral indicator and identification of problem areas for determining the level of digital quality of life in different territories is carried out through expertise. The following levels and ranges of values for each digital space are proposed:

- high level (1-0.8);
- good (0.79-0.5);
- medium (0.49-0.2);
- low (0.19-0).

It will allow us to conduct an objective comparative analysis of the digital quality of life of different territories and to identify problem areas.

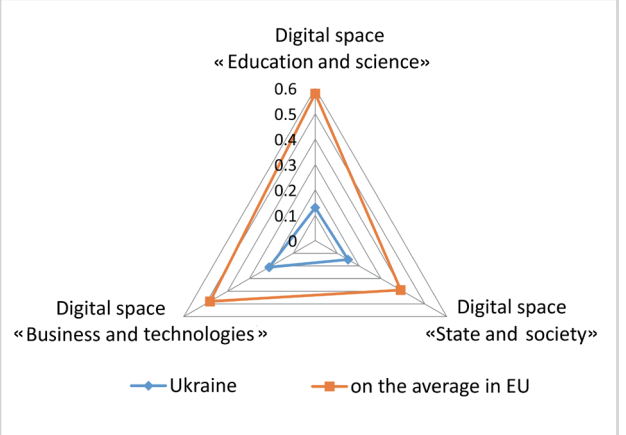

Fig. 2: **Evaluation of the digital quality of life by components of the digital space, 2015**
Source: Compiled by the authors

5. Conclusions

The research shows that digital innovations are the drivers of economic growth, which simplify communication between the state, business and civil society, increasing the digital quality of life, stimulating the active participation of business and civil society in the economic development of the territory. The importance of this process for Ukraine determines

the tasks and priority areas of digitalisation, which are business, education and science, state, and civil society. They sufficiently cover potential sources of calls for the territory and are compact enough to calculate the integral index of the digital quality of life. In order to realise the outlined tasks, it is necessary to select operational indicators for each component of the digital space, which most fully characterises the digital quality of life in the territory and carry out a comprehensive monitoring of the transformation processes in the digitalisation of the economy and society. The monitoring of the structural elements of the digital space can be carried out in two ways:

1) by determining the readiness of each component for digital development;
2) by using of ICT and foreseeing their impact on the development of a specific component in the digital space area.

The proposed approach to monitoring will make it possible to assess the effectiveness of digitalisation in the economy and society basing on the indicator of the digital quality of life. The assessment of the digital quality of life in the European Union (EU) and Ukraine by components of the digital space for 2015 shows that the EU requires progress in the dissemination of digital public services (0.39) and the integration of digital technologies into business activities (0.48). Ukraine is far behind the EU countries in terms of the digital quality of life. Further researches are aimed at identifying the contradictions related to digitalisation, their inclusion in the tools of analytical forecasting and the development of regions' competencies in digitalisation.

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