The Improvement of the Assessment of Digital Transformations in Socioeconomic Systems Using AI[1]

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Abstract. *This article aims to improve the methods of assessing digital transformations in socioeconomic systems. The relevance of the research topic is driven by the rapid development of digital technologies and their impact on the economy and society, which contributes to sustainable development. Research methods include analysing statistical data, expert methods, and modelling the dynamics of digital transformations. The results show that throughout the study period of 2017–2021, six out of eight dynamic indicators reflect that digital transformations in socioeconomic systems meet installed criteria besides the involvement of government institutions in providing access to electronic democracy tools and the percentage of the adult population subscribed to mobile phones. Six out of eight dynamic indicators show a trend, suggesting an increase in these specific indicators over time. Additionally, the consolidated dynamic indicator of digital transformations in socioeconomic systems meets the criteria, pointing towards an overall improvement over*

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time for indicators of digital transformations in socioeconomic systems. It is important to note that this does not necessarily imply a simultaneous improvement in all individual indicators. Consequently, enhancing the indicators experiencing deterioration over time is crucial to improve the overall situation. This emphasises the need to make managerial decisions regarding the correction of digital transformations in socioeconomic systems in those areas, the indicators of which decreased during 2017–2021. Identifying key aspects of these problems allows for defining directions to improve the digital transformations. The practical value of the study lies in the potential use of refined scientific and methodological approaches to obtaining information necessary for making managerial decisions to promote digital transformations.

Keywords: *digital transformations, socioeconomic systems, indicators, sustainable development, methodological approaches, artificial intelligence (AI).*

JEL Classification: *O33, Q01*

1 Introduction

Digital transformations in socioeconomic systems represent a crucial aspect of contemporary society, influencing all areas of life, from business and economics to social relations. However, there is currently a lack of methodologies to assess these transformations' spread in socioeconomic systems adequately. The problem statement revolves around the necessity to develop an effective and universal methodology that would enable researchers, business analysts, and decision-makers to systematically evaluate the degree of integration of digital technologies into economic and social processes. The development of such methodologies is a pressing task as it will not only enhance our understanding of the impact of digital transformations on socioeconomic systems but also contribute to formulating strategies and policies geared towards supporting sustainable development. Applying these practices helps countries and organisations better understand and evaluate the influence of digital technologies, contributing to developing an innovative and effective society.

The recent research in the assessment of the impact of digital transformation shows that there are numerous approaches and initiatives. The assessment of the impact of digital transformations on socioeconomic systems revealed that methodologies have the potential for refinement (Sotnyk, Voronenko, Maslii, Nikulina, Xing, 2023). Kramarenko I. et al. studied socioeconomic development in the conditions of digital transformations and proposed methodological approaches for calculating the economic potential of the IT sector's development. Analysis, evaluation, and monitoring are crucial in formulating appropriate development plans, efficiently managing their implementation, assessing their efficacy, and gauging their outcomes (Popa, 2022). The digital transformation process cannot be universally deemed entirely positive, as it exerts diverse effects on various facets, including the economy, the environment, society, technology, and institutions, as well as their intricate interconnections (Parra-López et al., 2021; Behera, 2021; Rijswijk et al., 2021). In evaluating digital transformations, researchers employ new models, and new methodologies for assessing digital transformations are continually emerging (Koblianska et al., 2020; Bin, Hui, Qifeng, Ke, 2021). Digital transformations have the potential to surmount economic, societal, and environmental challenges, leading to the achievement of sustainable development goals (Dayıoğlu, Turker, 2021; Melnyk, Dehtyarova, 2022; Bieser, Hilty, 2018; Prokhin, 2020; Moroz, Dyma, 2020; Larios-Hernandez, 2023).

However, there are several unresolved aspects of the overarching issue, including defining clear methodologies and criteria for systematically measuring the level of digital transformations in socioeconomic systems. Additionally, it is crucial to develop generalised approaches to account the dynamic impact of digital transformations on social and economic aspects, which remain underrepresented in existing scientific research. Therefore, addressing these questions requires further refinement and development of the methodological framework for studying digital transformations in socioeconomic systems, as presented in this article.

2 Formulation of the article's aims

This article aims to enhance existing methodologies for assessing digital transformations in socioeconomic systems. The research tasks include identifying new indicators for systematic measurement of the level of digital transformation and developing generalised approaches and criteria for evaluating dynamic changes in digital transformation over time and its impact on social and economic aspects. Another objective is to advance the methodological foundation of

the research to provide an effective toolkit for analysing and determining the influence of digital transformations on socioeconomic systems.

3 The main research material

The defining methods for assessing of digital transformations to ensure sustainable development are possible through expert approaches, which may involve periodic updates of these approaches to reflect new trends and challenges in the dynamics of digital transformations as they evolve over time.

The digital transformations in socioeconomic systems can significantly impact and yield various effects. Let's list the key effects that can be evaluated:

Economic Growth. Adopting digital transformations contributes to economic growth by increasing productivity, reducing production costs, streamlining processes, and enhancing the competitiveness of businesses. This can lead to increased production, higher income levels, new jobs, and attracting investments.

Innovative Development. Digital transformations stimulate the innovation potential in socioeconomic systems. They encourage research and the development of new products, processes, and services, which leads to the emergence of new markets and opportunities for businesses.

Social Changes. Adopting digital transformations can impact social aspects, including changes in lifestyle, improved quality of life, and access to new services. For example, digital technologies can facilitate access to education, healthcare, electronic payments, and other social services.

Environmental Sustainability. Digital transformations can reduce the negative environmental impact by developing environmentally friendly alternatives, optimising resource utilisation, and reducing emissions. For example, developing renewable energy sources and efficient energy-saving technologies helps reduce greenhouse gas emissions and improves environmental sustainability.

Global Impact. The dissemination of digital transformations can have a global impact by promoting the exchange of knowledge, technologies, and innovations among different countries. This stimulates international cooperation, trade, and the development of global networks, contributing to economic growth and an improved quality of life.

Evaluating the effects of the dissemination of digital transformations in socioeconomic systems is a complex task that requires a comprehensive approach and the analysis of various factors. When assessing the effects of the spread of such technologies, it is important to consider their impact on various aspects of the system, including economic development, social changes, environmental sustainability, and innovation activity.

Evaluating the effects of digital transformations in socioeconomic systems requires a comprehensive analysis of various economic, social, and environmental indicators to understand and assess their impact and potential for development and changes in these systems.

Assessing the effects of digital transformations in socioeconomic systems is paramount for ensuring the efficient utilisation of resources, stimulating innovation, and achieving sustainable development. This helps make informed decisions and formulate strategies that align with the needs of contemporary society. It is a crucial task for several reasons:

Clear Understanding of Impact. The assessment allows us better to understand the impact of digital transformations on socioeconomic systems. This enables us to evaluate better the benefits and challenges arising from their adoption and make informed decisions regarding investments, policies, and development strategies.

Forecasting and Planning. Effective evaluation enables us to forecast and plan the consequences of implementing digital transformations. This helps reduce risks and maximise opportunities, ensuring a more efficient use of resources, time, and effort.

Stimulating Innovation. The evaluation serves as an incentive for further development and implementation of new digital transformations. Understanding their impact allows us to identify the innovation potential and promote the attraction of investments and resources for further development.

Rational Resource Utilization. Evaluating the effects of digital transformation helps determine the optimal use of resources. This may involve identifying potential issues, risks, and constraints, allowing measures to overcome them and ensure efficient resource utilisation.

Sustainable Development. Evaluation allows for considering environmental, social, and economic aspects in implementing digital transformations. This contributes to sustainable development, balancing societal needs and environmental preservation.

Given the specific research context, some work has been carried out to define the methodology for assessing the effects of digital transformations in socioeconomic systems using an improved system of relevant indicators and criteria developed by experts. These indicators and criteria complement the existing set of indicators and criteria and can also be used to assess the dynamics of digital

transformations in socioeconomic systems. Considering the variability of data in these systems, they can also aid in evaluating the dynamics of digital transformations. Based on the obtained results, recommendations for managing the digital transformations of systems can be developed.

It is proposed to define the methodology for evaluating the effects of digital transformations in socioeconomic systems by incorporating additional annual indicators. These include relative indicators:

1. P_g – part of government institutions that provide access to electronic democracy tools, %.
2. P_i – part of enterprises with internet access, %.
3. P_c – part of enterprises that use computers, %.
4. P_{inv} – part of enterprises that provide electronic invoices or billing statements, %.
5. P_{ba} – part of enterprises that use broadband internet access, un.
6. P_{dt} – part of investments in digital transformation, including the information technology sector, %.
7. P_{pi} – part of the adult population with internet access, %.
8. P_{pm} – part of the adult population subscribers of mobile communication, %.

For further development of additional annual indicators, it is also proposed to include the following indicators: part of enterprises that use artificial intelligence technologies in their operations; and part of the adult population that are users of artificial intelligence technologies. But now, the data for such indicators do not exist.

To assess how the dynamics of digital transformations in socioeconomic systems are changing, it is proposed to calculate a developed dynamic indicator of digital transformations in socioeconomic systems, which is a specific dynamic indicator for each of the additional relative indicators. The optimal direction of change for the relative indicators is growth.

The criterion for evaluating the dynamics of digital transformations in socioeconomic systems is a dynamic indicator value greater than 1. The dynamic indicator is calculated based on the relative increments of additional annual relative indicators using the formula:

$$D_{ei} = \sqrt[N-1]{\prod_{n=1}^{N-1}\left(\frac{P_{ei\{n+1\}}}{P_{ei\{n\}}}\right)},$$

where D_{ei} – the dynamic indicator of digital transformations in socioeconomic systems for additional annual relative indicators;

P_{ei} – i-th additional annual relative indicator;

N – number of years over which the analysis is conducted;

n – year number designation.

Since a dynamic indicator will be calculated for each additional annual relative indicator, there will be eight dynamic indicators. These can be consolidated into a single dynamic indicator.

Consolidation can be achieved with weighted coefficients. The approach to finding the weighted coefficients is the expert method. It is applied as one of the approaches to weighting the assessment indicators of the effects of digital transformation in socioeconomic systems. This method relies on involving experts with significant experience and knowledge in the relevant field or issue to determine the relevance and importance of each indicator. The expert method considers the knowledge and expertise of specialists to assign weighted coefficients, which helps provide a more objective assessment of the indicators for assessing the effects of digital transformation in socioeconomic systems.

In this study, artificial intelligence (AI) based on ChatGPT 3.5 version [15] will act as a hundred experts. The request made to the ChatGPT 3.5 version had the following form: "Calculate the weighting coefficients for the evaluation indicators of digital transformations in socioeconomic systems based on the opinion of a hundred experts in this field, and the opinion of each of the hundred experts must be generated by you yourself separately and independently. This should happen in the following way: each expert scores each indicator on a four-point scale, where the most significant indicator from the expert's point of view receives the highest score. The weighting coefficients are calculated according to the formula v/n, where v is the sum of the ratings each indicator received from one hundred experts, and n is the total amount of ratings given by experts to all indicators. The sum of the weighting coefficients should be 1".

The weighted coefficients, according to the expert version from ChatGPT 3.5 version, are:

For P_g (part of government institutions that provide access to electronic democracy tools) = 0.1068.

For P_i (part of enterprises with internet access) = 0.1428.

For P_c (part of enterprises that use computers) = 0.1246.

For P_{inv} (part of enterprises that provide electronic invoices or billing statements) = 0.0997.

For P_{ba} (part of enterprises that use broadband internet access) = 0.1138.

For P_{dt} (part of investments in digital transformation, including the information technology sector) = 0.1347.

For P_{pi} (part of the adult population with internet access) = 0.1318.

For P_{pm} (part of the adult population who are mobile communication subscribers) = 0.1461.

In that case, the formula for finding the consolidated dynamic indicator is:

$$D_e=0.1068\cdot D_{e1}+0.1428\cdot D_{e2}+0.1246\cdot D_{e3}+ \\ + 0.0997\cdot D_{e4}+0.1138\cdot D_{e5}+0.1347\cdot D_{e6}+ \\ +0.1318\cdot D_{e7}+0.1461\cdot D_{e8},$$

where D_e – is the consolidated dynamic indicator of digital transformations in socioeconomic systems for additional annual relative indicators, calculated using weighted coefficients determined by the expert method.

Criteria for evaluating the dynamics of digital transformations in socioeconomic systems for the consolidated dynamic indicator:

$$D_e > 1.$$

The fulfilment of this condition indicates that the dissemination of digital transformations in socioeconomic systems is moving in the right direction and reflects a positive trend, i.e., a change over time.

The evaluation methodology was applied to Ukraine for the years 2017–2021. The results of dynamic indicator calculations are presented in Table 1. Graphs of dynamic indicator variations are also provided in Figure 1. The calculations were based on data from the State Statistics Service of Ukraine [16].

As observed in Table 1, over the entire study period (2017–2021), the dynamic indicators of digital transformations in socioeconomic systems do not meet the criteria for the share of government institutions providing access to electronic democracy tools and the part of the adult population subscribers of mobile communication. The values of these listed dynamic indicators are less than 1, which does not align with the criteria and indicates a negative trend, signifying a deterioration over time in these specific indicators. On the other hand, the aggregated dynamic indicator of digital transformations in socioeconomic systems meets the criteria, indicating an overall decline over time for the entire group of additional indicators. However, this doesn't necessarily imply an increase in all individual indicators simultaneously. Therefore, improving the deteriorating indicators over time is crucial to enhance the overall situation within this group.

The variations of dynamic indicators for the study periods in Figure 1 contain the necessary information for the temporal analysis of digital transformations in Ukraine's socioeconomic systems.

As seen in Figure 1, for 2017–2021, the aggregated dynamic indicator for digital transformations in socioeconomic systems meets the criteria. When considering the previously analysed values of the aggregated dynamic indicators for individual periods, only the value for 2019–2020 meets the criterion. This is a rather negative fact regarding digital transformations in socioeconomic systems and highlights the need for management decisions to rectify the situation.

4 Conclusions

For 20–17-2021, the dynamic indicators reflecting digital transformation in socioeconomic systems fall short of meeting the criteria related to the part of government institutions that provide access to electronic democracy tools and the part of the adult population who are mobile communication subscribers. This indicates an unfavourable trend, suggesting a decline in these specific indicators over time. In contrast, the consolidated dynamic indicator for digital transformations in socioeconomic systems meets the criteria, indicating an overall increase across the entire set of supplementary indicators over time. However, it is important to note that this doesn't necessarily imply a simultaneous increase in all indicators. Therefore, addressing the deterioration of some indicators over time is essential to improve the overall situation within this group.

Table 1 Dynamic indicators of digital transformations in socioeconomic systems of Ukraine

Indicator	2017–2018	2018–2019	2019–2020	2020–2021	**2017–2021**
D_{e1}	0.927	0.909	0.742	0.885	0.744
D_{e2}	1.013	1.010	1.012	1.006	1.020
D_{e3}	1.011	1.008	1.010	1.010	1.019
D_{e4}	1.018	1.015	1.016	1.017	1.033
D_{e5}	1.012	1.009	1.011	1.011	1.022
D_{e6}	0.896	1.000	1.492	0.621	1.156
D_{e7}	1.139	1.008	1.008	1.005	1.079
D_{e8}	0.973	0.973	0.972	0.971	0.945
D_e	0.999	0.993	1.042	0.938	1.007

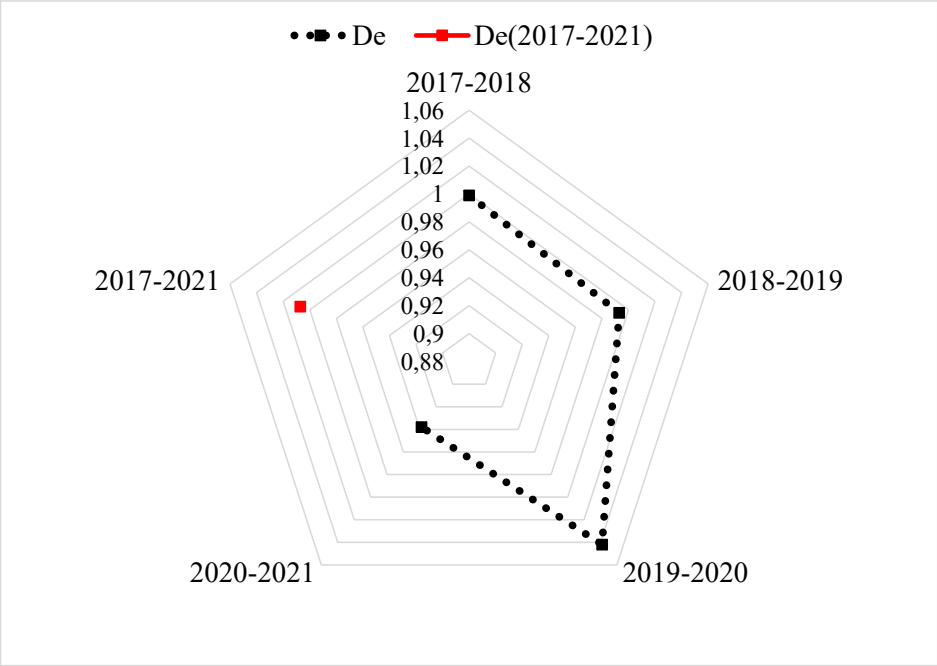

Figure 1 Diagram of aggregated dynamic indicators of digital transformations in the socioeconomic systems of Ukraine

The consolidated dynamic indicators of digital transformations in socioeconomic systems for the separate periods 2017–2018, 2018–2019, and 2020–2021 also fail to meet the criteria. Upon examining the previously analysed values of the consolidated dynamic indicators for specific periods, only the value for 2019–2020 aligns with the criteria. This represents a notably unfavourable aspect concerning the digital transformations in socioeconomic systems, underscoring the imperative for past managerial interventions to address and rectify the situation.

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