ISSN-L 2664-9969; E-ISSN 2706-5448

UDC [005.6:35+005.6:37+005.6:33]:(004:502.131.1)
JEL Classification: O33, H83, Q01, I28, L86
DOI: 10.15587/2706-5448.2025.348540

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DEVELOPMENT OF AN INTEGRATED QUALITY MANAGEMENT MODEL IN THE CONTEXT OF DIGITAL TRANSFORMATION: PUBLIC ADMINISTRATION, EDUCATION, ECONOMY

The object of research is the processes of ensuring the quality of electronic services and developing human capital competencies in public administration, education and economic systems in the context of digital transformation.

The problem being solved is the operational gap between the strategic goals of digital modernization and their practical implementation. This gap is manifested in the fragmentation of processes, the lack of effective tools for monitoring the quality of electronic services, and the inconsistency of educational programs with the real needs of the digital economy.

To solve the problem, an integrated model of electronic service quality management and a comprehensive matrix of key performance indicators for educational outcomes and service provision were developed. This model was empirically tested on the case of "Issuing a certificate".

The testing revealed significant discrepancies between target and actual indicators. This is explained by "bottlenecks" at the "input" of the process: mostly e-identification errors and an incomplete set of documents.

The scientific novelty lies in the architectural integration of quality engineering and risk management tools in the organization of public e-services. This creates a single measurable "language" for managers, IT specialists and financiers, which allows solving the problem of operational fragmentation.

The research results can be used to form policies for digital inclusion and modernization of educational programs. In the field of economics, they should ensure the improvement of business conditions and increase its competitiveness by harmonizing educational standards with market needs, improving the quality of public electronic services for state entities. The developed model is designed to assess the quality of various types of electronic services and various regions.

Keywords: *digital competencies, electronic public services, integrated quality management model, matrix of key performance indicators, modernization of the economy, ensuring sustainable development.*

Received: 26.10.2025
Received in revised form: 15.12.2025
Accepted: 27.12.2025
Published: 29.12.2025

How to cite
Kovalenko, M., Sikalo, M., Kovalova, T., Radchenko, O., Velychko, L., Nakisko, O., Grybko, O., Maistro, S., Ryzhikova, N. (2025). Development of an integrated quality management model in the context of digital transformation: public administration, education, economy. Technology Audit and Production Reserves, 6 (4 (86)), 46–61. https://doi.org/10.15587/2706-5448.2025.348540

1. Introduction

Digital technologies today are one of the determining factors in the transformation of society, changing communication channels, interaction models and mechanisms of social governance. The development of digital platforms, social networks and online communities creates additional opportunities for global cooperation and integration, which, in turn, contributes to the emergence of new formats of social coordination and public governance. Digitalization not only shapes new social practices, but also significantly affects the functioning of educational systems and economic institutions. That is why digital transformation is considered a fundamental component of modernization, in which education and the economy interact within the framework of the knowledge economy. The education system is the institutional basis of digital transformation, ensuring the adaptation of human capital to new technological requirements.

It is proceeded from the belief that through specific educational practices, digital tools are systematically implemented in the life of society – from working with information to career planning. As a result, the prerequisites are being formed for more flexible and, at least partially, individualized learning, which at the same time retains a mass character and covers both formal and non-formal education. The deployment of educational platforms, hybrid formats and blended learning models, which is observed both in Ukraine and in other

countries, makes it possible to better coordinate the organization of the educational process with the real educational trajectories of applicants. This is not only about adjusting the content of courses to the "average profile" of a student or trainee, but also about supporting long-term, sometimes uneven, but continuous professional development throughout life. In a globalized economy, the ability to update knowledge and build the necessary competencies in accordance with changes in the labor market ceases to be an additional advantage and actually turns into a basic condition for maintaining the competitiveness of a specialist, including in the public sector. There is a need to update government strategies to maximize the potential of digital transformation, given its importance for achieving the Sustainable Development Goals [1].

The OECD (2024) report highlights the key role of digital initiatives in modernizing public services and achieving the Sustainable Development Goals [2]. The information and communications technology (ICT) sector in OECD countries serves as a major catalyst for economic development. Between 2013 and 2023, ICT grew on average three times faster than the economy as a whole, with a growth rate of approximately 7.6% in 2023, making it the most promising catalyst for development prospects. A recent OECD report on digital transformation highlights the growing role of a number of technologies, including artificial intelligence, 5G networks and virtual and augmented reality. If earlier they were considered more like a "superstructure" on top of the existing infrastructure, now they are increasingly at the center of the formation of state digital policy. Their role is no longer limited to increasing productivity or updating infrastructure. It is about technologies that affect the very structure of markets, the ways in which the state, business and citizens interact. It is important that the report focuses not on "technological optimism", but on the analysis of the complex social consequences of digitalization. Separately, it emphasizes the impact of digitalization on sensitive areas – mental health, feelings of vulnerability and unequal opportunities for different groups of the population to join the online environment. The authors of the document emphasize that without a holistic policy and updated regulatory approaches, the digital economy tends not to reduce, but, on the contrary, to increase existing social and economic gaps. This implies the need for targeted measures to overcome the digital divide and to create mechanisms that would ensure, as far as possible, a fairer distribution of the benefits of the introduction of digital solutions. In other words, digitalization cannot be considered a neutral process. If the state removes itself from regulation, the main benefits of digital solutions are concentrated in the hands of a limited number of actors.

Domestic scientists pay considerable attention to the study of the transformation of economic relations under the influence of digital technologies. The digital economy is considered a subject of state regulation and a significant factor in the reconfiguration of economic relations in Ukraine [3, 4]. Recent studies emphasize. Barriers to the integration of digital innovations in the business model are separately analyzed [5], as well as the features of the digitalization of public services and the consequences of accelerated digital transformation in the public sector [6, 7].

Of particular relevance is the analysis of the role of digitalization in the development of public services as an element of building the digital economy of post-war Ukraine, in particular in the context of its contribution to the restoration and modernization of state institutions [8]. These studies show that strengthening the quality of electronic services contributes to the trust of citizens and the sustainable development of regions, which confirms the relevance of our study.

Studying the impact of digitalization and foreign direct investment on economic growth in developed countries allows to understand how digital changes can contribute to increasing social welfare [9]. The theory of "green" digital transformation is gaining ground, which claims that digital factors (high-tech manufacturing, e-participation, big data analytics, information and communication technology infrastructure) contribute to environmentally sustainable business practices [10]. Of particular importance is the introduction of a methodological approach to assess the effectiveness of the infrastructure component in combating money laundering in the context of increasing digitalization [11].

The World Bank emphasizes that digital technologies play an important role in overcoming the global digital divide and promoting economic and social development. It claims that digital technologies have the ability to significantly increase global GDP, create new economic prospects and contribute to the implementation of the UN Sustainable Development Goals. Among the goals are poverty eradication, improved access to health and education, and environmental sustainability. To optimize the benefits of digital transformation for government, business, and civil society, fruitful cooperation in ensuring inclusive access to digital technologies and the associated benefits for all players is an important issue [12].

The McKinsey Global Institute predicts that by 2030, 400 million to 800 million workers could be displaced from their current jobs due to automation, while 75 million to 375 million people will need to retrain and reskill. New job opportunities are expected to arise from rising incomes, increased spending on healthcare and education, investments in infrastructure and energy, and advances in technology and construction [13].

China's rapid digitalization is having a significant impact on both the economy as a whole and the education sector, creating new avenues for innovation and growth. With over 900 million active Internet users, China is building a strong foundation for expanding its digital services footprint, which already accounts for over 45% of the global e-commerce market. In the field of finance and new technologies, more than 80% of all transactions are already carried out through mobile applications, which strengthens social integration and the dynamics of the country's economic development. Digital educational platforms have provided millions of people with access to education. This process has significantly accelerated during the pandemic, equipping the workforce with the knowledge and skills to meet the needs of the digital economy, which has created the basis for building a competitive innovative model of social and economic development [14]. If to consistently develop this logic, it is advisable to consider effective management of digital transformation processes not as a purely technical task, but as a complex management process. This requires a coordinated approach between the main policy sectors and stable institutional support from the state. It is such support, as the experience of recent years shows, that is one of the key prerequisites for sustainable development and maintaining the competitiveness of national economies in a changing global environment [15, 16].

The modern scientific community is moving away from perceiving digital transformations as a secondary phenomenon, recognizing their systemic nature. Today, they are defined as one of the key dimensions of the modernization of society, covering the spheres of public services, education and the labor market. Although the scientific positions of researchers differ in detail, the thesis that digital transformation is a complex and structurally heterogeneous phenomenon dominates in general. It is difficult to fully describe it within the framework of a single discipline, therefore, an interdisciplinary toolkit is increasingly used, combining approaches from economics, educational studies, sociology, political science and, ultimately, public administration. Digitalization, on the one hand, opens up additional opportunities for economic growth, diversification of educational trajectories and the emergence of new formats of learning and work. On the other hand, it creates new risks and challenges: from increasing inequality of access to digital resources and services to rethinking the roles of educational institutions and the state as a whole.

ISSN-L 2664-9969; E-ISSN 2706-5448

Analysis of other sources shows that attention is focused mainly on two levels. First, this is the regulatory and strategic level, represented by government documents [17, 18], which define political goals and the general framework of digitalization, but do not contain operational mechanisms for their achievement. Second, this is the scientific and theoretical level, where researchers focus on issues of macroeconomic regulation [4], implementation of public policies [19] or general technological trends [12].

At the same time, there is a lack of applied research that would offer an engineering methodology for transforming these strategic intentions into effective processes and form a toolbox for managing the quality of electronic services. There is an urgent need to implement integrated models that can combine user needs with the context of the process, ensure continuous improvement, minimize the risks of failures and carry out statistical control of processes. Therefore, the current complex task is to create a unified approach to decision-making, which will serve as a common basis for government officials, IT specialists and financiers in matters of ensuring the quality of electronic services.

The implementation of the principles of good governance through the application of quality engineering and risk management methodologies is of particular relevance, which will allow forming a reproducible basis for diagnosing and improving the services provided, ensuring the quality of electronic services and developing human capital.

The unresolved problem considered in this article is overcoming the operational gap between the strategic intentions of digital transformation and their practical implementation. In particular, there is a lack of a controlled, reproducible and measurable methodology for designing and improving the quality of digital services and harmonizing educational standards with them.

The object of research is the processes of ensuring the quality of electronic services and developing human capital competencies in public administration, education and economic systems in the context of digital transformation.

The aim of research is to develop an integrated model of quality management in public administration, education and economy as an imperative of sustainable development in the context of digital transformation.

To achieve the aim, it is necessary to solve the following tasks:

1. To form a value-conceptual basis for the development of an integrated model of quality management of electronic services.

2. To confirm the practical applicability of the integrated model of quality management of electronic services using an empirical case study.

3. To formalize the declarative priorities of digital education through a system of key performance indicators (KPIs) necessary for the full functioning of the integrated model of quality management.

4. To identify the main areas of application of the developed model for the modernization of the national economy.

2. Materials and Methods

The work uses a systemic approach as a key tool for studying digital transformation processes from the perspective of ensuring the improvement of quality management in public administration, education and the economy.

The methodology for assessing the quality of digital services is based on several complementary process and risk management tools, in particular:

1. *PDCA (Plan-Do-Check-Act)* – a cycle of continuous improvement, within which the service goes through successive stages: planning changes, implementing planned solutions, checking results and corrective actions aimed at eliminating identified deviations and consolidating successful practices.

2. *SIPOC (Suppliers-Inputs-Process-Outputs-Customers)* is used when it is necessary to quickly describe the process at one level. This is a high-level process description tool that allows to outline key suppliers, identify input resources, record the main stages of the process, expected outputs and target user groups, creating a holistic view of the context of providing a digital service.

3. *CTQ/QFD (Critical to Quality/Quality Function Deployment)* – a methodological approach by which user expectations and needs are consistently translated into measurable quality indicators and specific functional characteristics of the service, helping to transform the "voice of the user" into requirements.

4. *SERVQUAL (Service Quality – gap model)* – an assessment method that captures the difference between the expected and actually perceived quality of the service. The assessment is carried out according to five dimensions: reliability of performance, efficiency and willingness to help, professional confidence of staff, ability to empathy and material/technical aspects of the service.

5. *FMEA (Failure Modes and Effects Analysis)* – a preliminary risk analysis technique that is able to identify possible facts of failures when working with data, assess possible results and consequences, and also determine priority areas for the use of organizational or technical measures aimed at minimizing risks.

6. *SPC (Statistical Process Control)* – a method of statistical process control, which allows to confirm the stability and effectiveness of the process based on the analysis of actual data.

Thus, the KPI model combines technological parameters, foresees possible risks and improves the quality of the adopted management decisions. It is clearly recorded who is responsible for what, which indicators are of primary importance, what needs to be adjusted, where it is advisable to concentrate resources. The model takes into account precisely those technological and risk-oriented indicators that are carefully detailed in analytical tables.

During the development and testing of the integrated model for assessing the quality of e-services, it was possible to take into account the strategic goals of digital transformation. For this purpose, special indicators were used that characterize the effectiveness of public governance mechanisms and are aimed at ensuring inclusiveness, sustainability and adherence to the principles of good governance (Good Governance). To achieve the set aim of research, the following actions were performed:

– synthesis of theoretical approaches to digital transformation in public administration, education and the economy;
– construction of an integrated PDCA-SIPOC-CTQ/QFD-FMEA-SPC model with a comprehensive KPI grid for services and educational policies;
– experimental testing of the model on the example of the case "Issuance of a certificate" by comparing actual and target threshold values (execution time, P90, FCR, DPMO, CSAT, proactivity);
– identification of "bottlenecks" and gaps in quality and formulation of management interventions;
– development of political and managerial recommendations for scaling the model in the system of public e-services and the education sector (lifelong learning, digital competencies).

At the first stage, a thorough analysis of scientific works, articles, monographs and other literary sources related to the topic of digital transformation was carried out. An analysis of reports of international organizations and regulatory documents (OECD data bank, World Bank reports, MES/Ministry of Digitalization Norms) was carried out, which allowed to identify key trends in digitalization from 2000 to 2025. Scenario modeling was used to interpret the results, which made it possible to assess the dynamics of processes taking into account possible changes. This analysis allowed to determine the main approaches to studying digitalization, identify key trends and, using content analysis, reveal gaps in existing research.

The methodological basis of research is based on the use of analytical-synthetic and logical methods, which ensured the reconstruction of the scientific discourse on the dynamics of social and economic relations in the context of digital technology.

The research used empirical data aggregation procedures, which made it possible to identify and empirically confirm the characteristic patterns and trends of the impact of digital transformation on the sphere of social relations. The information base of the research is made up of World Bank data, reports of international organizations, research by analytical companies, as well as regulatory and legal acts of relevant ministries, in particular the Ministry of Education and Science and the Ministry of Digital Transformation. The covered period of study of various scientific studies for the period from 2000 to 2025 allowed to trace the key trends in the development of digitalization processes and propose an integrated model of quality management in public administration, education and the economy.

At the final stage of interpreting the results, scenario modeling tools were used. This approach provided an in-depth analysis of key dimensions of digital transformation, taking into account current trends and conditions. The use of scenario modeling not only detailed the course of digitalization processes, but also became the basis for developing practical recommendations for the further development of educational and economic systems, as well as improving their regulatory mechanisms within public administration.

3. Results and Discussion

3.1. Human-centricity as a key driver of digital transformation

Digital transformation is considered one of the fundamental dimensions of modern economic and educational progress. Scientific publications in this field reflect the multifaceted nature of the process, in particular the consequences of digital changes on social, cultural and economic infrastructure. International studies have paid considerable attention to how digital media shape the value orientation of young people and the processes of socialization, emphasizing both potential risks and opportunities caused by digital transformations [20, 21].

Digital technologies have become a systemic factor of economic development, ensuring increased efficiency, the implementation of innovative business models and the personalization of service offerings. In view of this, digital transformation involves not only the integration of digital technologies into production and management processes, but also structural changes in the system of socio-economic relations.

Digital transformation is understood as "the process of using digital technologies to create new or modify existing business processes, culture and customer experience in order to meet changing business and market requirements" [22]. Modern digital transformation creates the prerequisites for a consistent increase in the effectiveness of management processes, the implementation of modern business models, more precise targeting of customers, as well as the implementation of innovative solutions that are limited or economically unjustified within the framework of traditional operational approaches.

In this chain, public administration plays a key role in shaping the regulatory architecture of information platforms and the platform economy, acting on the side of protecting public interests. Public administration provides legal and regulatory supervision, consumer protection, supporting balanced competition and restraining monopolistic practices. Public policy should move away from a narrow model focused only on maintaining competition. Instead, it should be based on a broader framework focused on the goals of socio-economic development and increasing the well-being of market participants. In the field of public administration, this means strengthening institutional mechanisms for transparency, accountability and adherence to the principles of good governance through clearly organized interaction between platforms, users and authorities. Achieving socially significant goals in the face of rapid technological change requires a review of existing institutional approaches and updating regulations. This is about the state's ability to adapt rules and procedures to new digital practices in a timely manner. Without such updating, it gradually loses its real influence on how digital services and markets function.

The impact of digital technologies on the development of society can be described in at least several interrelated areas:

First, digital transformation enhances inclusion, as it expands access to information resources and services for people with different needs, regardless of their place of residence. This is particularly relevant for residents of remote communities and vulnerable groups who previously had limited access to such services.

Secondly, the nature of management processes is changing. Digital tools increase the transparency of both government and corporate decisions, enable more accurate tracking of resource use, and reduce the role of purely intuitive management decisions.

Finally, basic services (healthcare, education, financial services, etc.) are becoming more accessible and user-friendly. The digitization of public services reduces the time and costs of citizens and businesses to interact with authorities, reduces the number of offline visits and duplication of paper procedures. Digital platforms create additional formats of cooperation, joint learning and collective initiatives. In parallel, the development of e-commerce expands the choice for consumers and intensifies competition between suppliers: it becomes easier to compare offers, conditions and pricing models, and therefore to demand better quality of goods and services.

Recent experience shows that those actors who ignore digital transformation gradually lose their influence on institutional and structural changes. Available empirical studies [23] consistently but irreversibly record a positive relationship between digitalization, the effectiveness of management decisions and the activity of innovations in different sectors of the economy. Digital technologies are changing not only the formats of work organization and interaction between key stakeholders, they are gradually restructuring the usual socio-economic configuration, forcing key players to look for other models of growth and interaction. The COVID-19 pandemic has become not just another "challenge" for institutions and organizations, but a severe stress test of their capabilities. In a very short time, it became clear which organizations have effective digital tools, and which have been postponing relevant decisions "for later" for years. Where the digital infrastructure was at least minimally formed, it was possible to support economic activity, not stop basic public services, and maintain relative manageability of social systems. On the other hand, in structures that relied mostly on paper document flow and manual procedures, the result was management failures, delays, a drop in trust and productivity. The pandemic has simultaneously tested the strength of the state, business, and other sectors of the economy; after such an experience, it is difficult to describe digital transformation as a temporary "fad" or a purely rhetorical priority – without it, further development becomes virtually impossible. This is not about individual IT solutions, but about changing the way work is organized in general – from managerial thinking and setting priorities to building a management vertical. As a result, individual industries are forced to restructure, traditional business models lose their stability, and new opportunities for reducing costs and increasing the competitiveness of products are being formed. At the same time, such a transformation creates conditions for faster development of society, a gradual improvement in the quality of life of the population.

Digital transformation affects not only dry macroeconomic indicators, but also everyday issues, the way people work and communicate with each other every day. As a result, the very idea of work is being reshaped: it is no longer important to "work" a certain number of hours, but to have space for flexible decisions, collaboration, and clear, achievable results.

ISSN-L 2664-9969; E-ISSN 2706-5448

Digital tools are gradually being introduced into production, marketing, and human resources management, changing established cost patterns and forcing managers to organize areas of responsibility, division of duties, delegation, and control processes differently. The traditional centralized management model is gradually losing its dominance, giving way to approaches based on transparent rules and data analytics. The decision-making process is increasingly decentralized and delegated to executives, instead of being excessively concentrated at the higher levels of the hierarchy. The introduction of electronic document management provides automation of routine procedures and a significant reduction in transactional and administrative costs (in particular, on logistics and archiving), which directly increases operational efficiency.

This, relatively speaking, human-centric trajectory of digital development is significantly different from approaches where technology is viewed primarily as a tool for controlling data and user behavior. Some studies have even emphasized that such practices increase the asymmetry of power between digital service providers and citizens who use these services [19]. Practice proves that the use of digital technologies correlates with higher rates of economic growth and noticeable shifts in the social structure. For individual enterprises, this means strengthening their positions in the market, for national economies – the opportunity to expand the participation of different groups of the population in economic and social activity thanks to digital services [24]. The effectiveness of these processes is directly influenced by how the state maintains a balance between stimulating innovation and protecting social stability. If this balance is ignored, digital growth can easily turn into a catalyst for inequality. The formation and implementation of effective public governance mechanisms in the context of digitalization is becoming a key prerequisite for achieving sustainable development goals and reducing the risks of increasing inequality [25]. Without clear regulatory and institutional mechanisms for public governance in the context of digitalization, sustainable development goals remain declarations. It is through these mechanisms that the state can either reduce the risks of increasing inequality or consolidate them at a new technological level.

One of the defining processes associated with digital transformation is the "digital socialization" of youth. In scientific research, it is considered an important factor in the entry of new generations into the digital society. It is not only about mastering technical skills for working with digital media and the Internet. It is important that young people are able to critically read information content, understand the social consequences of online interactions, and form sustainable models of responsible behavior [20, 21]. The educational environment sets the institutional basis for the development of digital competencies and a culture of safe online presence. At the same time, unequal access to digital resources and different levels of digital literacy easily translate into deeper social and economic gaps, especially at the stage of youth transition to adulthood and entry into the labor market [26]. Therefore, it is advisable to consider digital socialization not only as a pedagogical or cultural phenomenon, but as a strategic factor in ensuring social justice, mobility, and economic development in the context of the digital transformation of society in the broad sense of the term.

Previous discussions around digitalization were largely associated with an underestimation of its systemic, rather than local, nature. The COVID-19 pandemic demonstrated the fundamental importance of the digital dimension of government activities: there was an urgent need to quickly provide citizens with access to basic and specialized services through digital platforms. This led to the expansion of the practice of providing hybrid services (combining online and offline formats). It also stimulated a review of the quality standards of public services and became an impetus to increase their convenience, speed, and orientation to user needs, which was not the case before.

Under such conditions, the development of digital competencies of civil servants from a secondary issue turns into one of the priorities of public policy. Governing bodies consider not only the technical aspects related to the implementation of digital solutions, but also the strategic management of innovative transformations. This requires a review of approaches to the organization of administrative work, decision-making procedures and internal communication. Ensuring the proper quality of service to citizens involves a significant increase in the accessibility, convenience and effectiveness of public services; these parameters directly depend on the level of digital literacy of public sector employees. Indeed, digital literacy is transformed from an "auxiliary" competence into a fundamental criterion of professional competence of civil servants, serving as an important prerequisite for effective involvement in the digital environment. The digital transformation of public administration is becoming a key element in increasing the efficiency, transparency and accountability of management processes. It is thanks to these transformational initiatives that it is possible to strengthen trust in public institutions, thereby contributing to the implementation of the declared sustainable development goals.

3.2. Applied aspects and testing of an integrated model of quality management of electronic services

Digital transformation has gained the status of a key driver of modernization of the public sector, the education system and the economy; it fundamentally changes the forms of interaction between the state and citizens, the logic of production and consumption of services, as well as the requirements for human capital competencies. In the context of the challenges of wartime and post-war reconstruction in Ukraine, the issues of quality, security and sustainability of e-services, inclusiveness of access and consistency of educational outcomes with the needs of the digital economy are transformed from purely technical into political and managerial problems. It is at the intersection of public administration, education and the economy that the demand for controlled, reproducible and measurable approaches to the design and improvement of e-services is formed.

Despite the intensive implementation of digital platforms, the gaps between strategic intentions and their operational implementation are not disappearing anywhere. These gaps include the fragmentation of processes and data. There are also different levels of digital competences among users and staff. Other problems include limited interoperability. Preventive risk management and systematic quality monitoring are also underestimated.

Practice shows that without a systematic assessment of the quality of digital services provided by public authorities at the national, regional and local levels, there can be no consistent strategic planning of digital transformation. This also applies to a transparent allocation of resources and responsibilities between the stakeholders involved, as well as evidence-based monitoring of the effectiveness and social value of such services. For such an assessment, it is advisable to use an integrated model that actually combines analytical understanding of challenges and real management practice. The model forms a common conceptual space for politicians, IT specialists and financial managers, ensuring transparent prioritization, managed implementation of solutions and evidence-based monitoring of the effectiveness of electronic services. In essence, the point is that the general principles of digital governance should cease to be slogans and become practices that can be planned, measured and replicated.

An integrated model for assessing the quality of e-services can be used to solve the following applied tasks:

1. The model allows for the implementation of declared values (transparency, accountability, security) in everyday management work. These values are combined with specific tools, regulations and typical situations. As a result, the general questions "what, why and how" are gradually reformatted into a clearly defined set of roles, procedures, deadlines, control mechanisms and areas of responsibility.

2. The model systematically organizes key risk groups (digital inequality, cyber threats, etc.) and selects adequate response formats: from digital inclusion programs to the implementation of appropriate cybersecurity measures. A separate block provides risk management. The use of DPIA (Data Protection Impact Assessment) and the Privacy by Design approach creates conditions for a more informed allocation of resources according to priority areas.

3. For each identified managerial or organizational problem, the model allows to identify responsible employees (based on the RACI matrix), as well as ensure compliance with relevant regulatory requirements and standards (GDPR, ISO/IEC 27001, NIST SP 800-53/CSF). Additionally, expected results and key performance indicators (KPIs) are set, which allows not only to formally determine the area of responsibility, but also to track actual progress in implementing control. In general, this simplifies both external and internal control, increases audit efficiency.

4. The model ensures the recording of solutions that have proven successful and how they were adapted to specific managerial, organizational, economic, and regional conditions. As a result, a base of standards and typical solutions is formed, and subsequently norms that can be extended to other services and regions without loss of quality.

5. The model provides an opportunity to integrate a portfolio of digital projects with a system of performance indicators:

– customer satisfaction index;
– coverage of target groups in terms of inclusion;
– service availability (Uptime – the proportion of time during which the system works correctly);
– solving the problem on the first call (P90 – 90th percentile – a time threshold that only 10% of requests exceed);
– the number of defects per million potential points of failure;
– the proportion of tested or confirmed algorithms, etc.

Taken together, this allows to embed a continuous PDCA cycle into the practical – operational activities of government bodies, and not leave it at the level of methodological recommendations.

The methodology for assessing the quality of digital services is described in the corresponding section of the article.

The integrated model for assessing the quality of e-services was tested during the provision of the conditional e-service "Issuance of a certificate". The following indicators were used to assess the effectiveness of the e-service provision: data coverage period, number of requests, number and share of defects, cycle time, share of proactive services, level of user satisfaction, number of errors per one million potential failures.

SIPOC was also tested – to outline the process as a whole, its stages, input data and roles of stakeholders. The CTQ/QFD approach made it possible to link user expectations with specific characteristics of service quality. FMEA was used to identify critical points of potential failures. SPC – to monitor the stability of the process and assess the variability of its indicators over time.

Transaction logs, user satisfaction survey results, and formalized process regulations were used as additional data sources. Measurements were conducted over ten calendar days, during which 181 requests for the hypothetical e-service "Issuance of a certificate" were processed.

The following is an extended mini-case that demonstrates the detailed application of the PDCA–SIPOC–CTQ/QFD–FMEA–SPC link:

1. *Objectives and boundaries of the experiment.* The object of the analysis is the e-service "Issuance of a certificate". The main goal of the case is to show how the PDCA–SIPOC–CTQ/QFD–FMEA–SPC link works in practice to consistently improve the quality of services based on reproducible and comparable metrics.

2. *SIPOC – Process description.* Using the SIPOC model, the process contour is defined through five basic components: Suppliers, Inputs, Process, Outputs and Customers, which is structurally reflected in Table 1.

Table 1

Process description

Component	Component description
S (Suppliers)	Registers, payment provider, ACTION/Portal, issuing authority
I (Inputs)	E-Application, E-Identification, data from registers, payments, electronic applications
P (Process)	Reception → validation → processing → signature → delivery of E-document
O (Outputs)	E-certificate, status, notifications
C (Customers)	Citizens, business, related agencies
Constraints	Identification, data completeness, load, support windows

3. *CTQ/QFD: from "voice of the customer" to requirements and metrics.* Within this approach, user expectations ("Voice of the Customer") are consistently translated into measurable quality requirements (CTQ, Critical to Quality), and then into specific operational metrics. This chain of "expectations – requirements – metrics" is systematized in Table 2.

Table 2

Reflection of user needs into CTQ attributes and operational metrics for the e-service "Issuance of a certificate"

User Need	CTQ attribute	Operational Metrics	Target
Quickly get help	Lead time	Average/median time, P90	≤2.0 days; P90 ≤3.5 days
No extra calls	First contact ratio (FCR)	FCR = first success/all	≥85%
No errors or failures	Process reliability	DPMO; defective rate	≤3000 DPMO
Convenient and affordable	Availability/ convenience	Uptime; CSAT; proactive rate	≥99,8%; CSAT ≥4.6/5; ≥35%

4. *Definition of metrics and formulas in a mini-case.* Lead Time is calculated as the difference between the moments of submitting a request and its execution. The average, median and 90th percentile were used for fixation. The indicators were calculated using the following formulas:

$FCR = \text{Number of resolved requests} / \text{Total number of requests};$

$DPMO = \text{Number of defects} / (\text{Number of resolved requests} \times \text{Number of rejected and unresolved requests}) \times 1000000;$

$\text{Availability} = 1 - (\text{Total downtime} / \text{Total service operating time});$

$\text{SPC (p-map)}: \bar{p} = \Sigma \text{Defects} / \Sigma \text{Requests};$

$UCL/LCL = \bar{p} \pm 3 \times \sqrt{\bar{p}(1-\bar{p})/n},$

where n – the sample size of the period.

5. *Final results of the experiment.* Table 3 summarizes the main results of the experiment:

– number of processed requests; defect level;
– indicators of the speed of processing successful requests;
– the proportion of requests resolved on the first attempt;
– the level of proactivity of the service;
– average user satisfaction values and the final defect rate (DPMO).

Such calculations allow to simultaneously assess the operational efficiency of the management process, and also highlight the level of satisfaction of the service user.

ISSN-L 2664-9969; E-ISSN 2706-5448

Within the framework of the conditional experiment, 181 requests were processed for the period from 01.09.2025 to 09.09.2025, 48 of them had recorded defects. This corresponds to a share of defective cases $\bar{p}$ at the level of 26.52%. In other words, approximately every fourth request contained errors, which for a basic e-service can be considered as too high a level and as a signal to review the process. The average duration of processing successful requests was 0.94 days, the median was 0.9 days, and the P90 value was 2.08 days. The share of requests resolved on the first attempt was 73.5%, the share of proactive issues was also 73.5%, and the average user satisfaction index was 4.83. According to the DPMO methodology, the total process defect rate was estimated at about 53,274 defects per million opportunities.

6. *KPI: comparison of actual results with target benchmarks.* For the model to be used in management practice, it is important to regularly compare the actual values of the indicators with the agreed targets. Table 4 compares the actual values with the threshold parameters for key quality indicators (speed of processing, first-time resolution, defect rate, proactivity, satisfaction), which allows for a substantive assessment of where the goals have been achieved and where gaps remain.

The obtained comparison clearly shows which goals have been met and where significant gaps remain. The average processing time P90 is within acceptable thresholds, which indicates an acceptable efficiency of the typical service provision scenario. Despite this, the failure to achieve the target values of FCR and the increased level of DPMO indicate the presence of a "process", it is these areas that generate repeat requests and additional rework. Empirical observations confirm that the basic speed of processing requests is consistent with user expectations (the average time and P90 correspond to the established thresholds). The level of satisfaction remains high; despite a noticeable share of defects (CSAT and the share of proactive services demonstrate high values). At the same time, it is the discrepancy between FCR and DPMO targets that focuses attention on the need to eliminate the root causes of repeat requests and errors.

Key gaps are concentrated in the FCR and DPMO indicators: the main sources of problems are, on the one hand, errors at the "input" (for example, the lack of necessary applications), on the other hand, vulnerabilities in electronic identification procedures. For public policy, this means the need to increase the emphasis on "quality at the input" (in accordance with the logic of SIPOC/CTQ/QFD processes), the introduction of standardized checks, ensuring interoperability and fault tolerance of integration solutions.

7. *Process stability: statistical control based on p-map.* To separate the usual (background) variability from anomalous deviations (special causes), a *p*-map is used. Table 5 presents the weekly sample sizes, the number of defects and the calculated proportion *p*. For each week, the lower and upper control limits (LCL and UCL) are determined, calculated relative to the integral proportion of defects for the entire observation period. Points exceeding these limits or the appearance of suspicious trends are interpreted as a signal to start RCA/FMEA procedures.

Fig. 1 shows a weekly visualization of the p-map of defects; the control limits are indicated by dotted lines.

Table 3

Summary of the experiment results and key performance indicators

Indicator	Value	Comment/formula
Data coverage period	2025-09-01-2025-09-09	–
Number of requests (total)	181	–
Number of defects (total)	48	–
Defective rate $\bar{p}$, %	26.52	defects/cases, integral over period
FCR (first-time success rate), %	73.5	successful & first_contact = 1/all cases
Lead time, average (days)	0.94	successful transactions; negative values are truncated to 0
Lead time, median (days)	0.9	–
Lead time, P90 (days)	2.08	90% of successful ones close faster than this limit
Proactive rate, %	73.5	–
CSAT, 1–5	4.83	–
Average number of opportunities, pcs/request	4.98	–
DPMO	53274	defects/(cases × opportunities) × 1e6

Table 4

Performance indicators: actual and target values

Metric	Actual	Target	Status
Average lead time, days	0.94	2.0	Achieved
P90 lead time, days	2.08	3.5	Achieved
FCR (from first contact), %	73.5	85.0	No
DPMO	53274.0	3000.0	No
Proactive deliverables ratio, %	73.5	35.0	Achieved
CSAT (1–5), score	4.83	4.6	Achieved

Table 5

Data for *p*-map: weekly defect rates and control limits

Week (start, Mon)	Requests (n)	Defects	Defective rate (p)	*sigma_p*	*UCL*	*LCL*
2025-09-01	145	37	25.52	0.03665927427333287	37.52	15.52
2025-09-08	36	11	30.56	0.0735726863920375	48.59	4.45

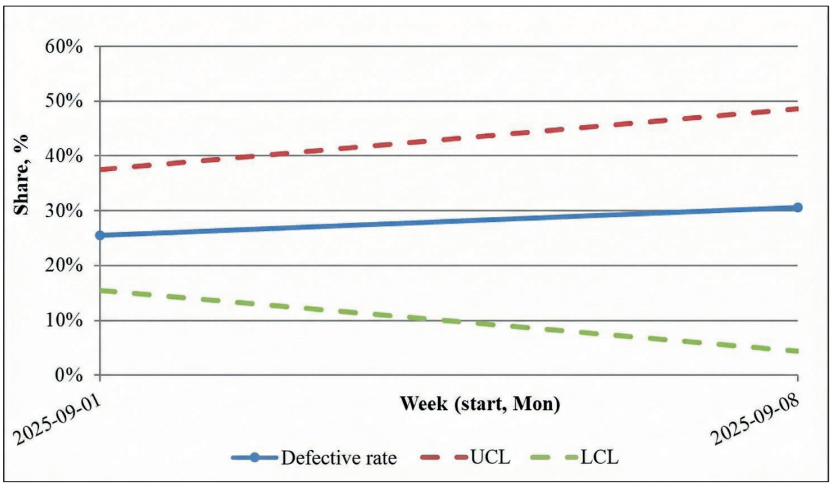

Fig. 1. Defect control chart (SPC)

The analysis of the defect level within the statistical process control was carried out using the *p*-chart. Control limits were built on the basis of the total proportion of defects for the entire period, after which weekly values were compared with these thresholds to assess the controllability of the process. If all indicators remained within the LCL-UCL range, the process was considered statistically stable. Exceeding the upper control limit or constantly approaching it, especially with small weekly samples, signaled the need for a detailed analysis of the root causes of the relevant deviations. At the same time, it is emphasized that the two-week observation horizon allows for only very approximate preliminary, and in this case, theoretical conclusions regarding the stability of the process. For a more reliable assessment, a much larger data set (approximately 4,000 requests) and a longer analysis period (at least four weeks) are required.

8. *Defect/failure classification by type.* For the correct planning of targeted interventions, it is of fundamental importance to understand which factors generate defects. The appropriate classification of failures by type allows to outline the "zones of the greatest contribution" to the overall defect level and concentrate efforts there. Table 6 shows the share of each category of errors in the total volume of defects, which creates the basis for prioritizing error reduction measures (UX prompts in the interface, mandatory fields, technical repetition mechanisms, etc.).

Table 6

Defect classification by type

Error/Fault Type	Number	Share of all, %
E-Identification (eid_error)	17	9.39
Missing attachments (missing_attachment)	25	13.81
Registry error (registry_error)	3	1.66
Payment error (payment_error)	1	0.55
E-document delivery error (delivery_error)	1	0.55
Status (summary indicator)	26	14.36

A separate analysis of the distribution of defects by type allows to identify the most common categories of failures (take experimental values as a basis). The dominance of certain types of errors usually indicates either problems at the "input" of the process (incomplete or incorrect attachments to the application), or weaknesses in critical integration nodes (identification, payment, electronic document delivery procedures, etc.). It is these areas of the process that should be considered as priority areas for improvement. If do not dwell on the consequences, but calmly "disassemble into pieces" the very causes of failures at the input, the picture becomes quite simple. There will be fewer repeated requests, people in support will stop putting out the same fires, and the process will "breathe out" a little. If to limit ourselves to cosmetics – tighten secondary indicators without changing anything in the input data and integrations, the effect will be appropriate: better in the report, but not in the work. Therefore, it is important to carry out a preliminary check of the data before submitting the application and eliminate the shortcomings in order to exclude the possibility of their transfer to external registers and services.

9. *Comparison of actual data of key performance indicators with the necessary benchmarks.*

Fig. 2 shows a comparison of actual KPI data with the specified benchmarks, which allows to visualize problem areas. All indices are reduced to a single scale (100% corresponds to achieving the goal, higher – exceeding, lower – below the norm).

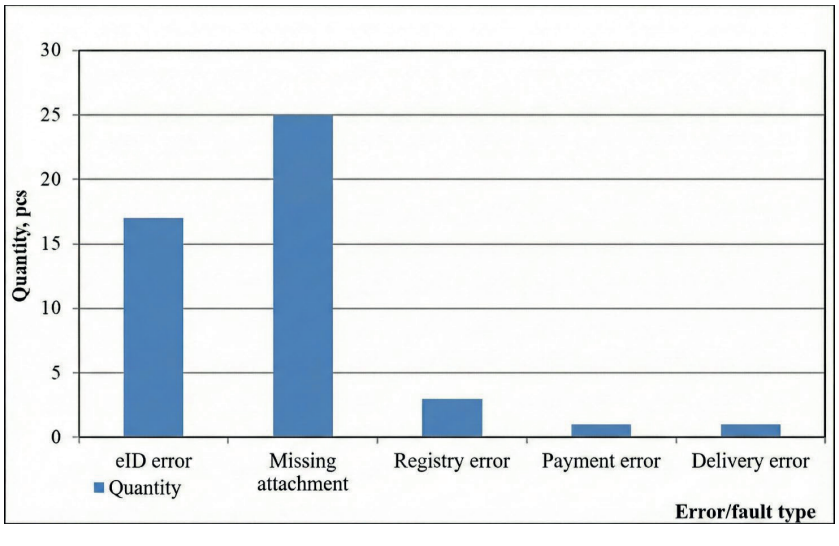

Fig. 2. Key performance indicators

If the "plus" indicators do not reach 100%, and the "minus" (for example, DPMO) exceed the threshold, this indicates not a random coincidence, but a direct management signal. In such cases, the process itself requires changes, and not just explanations of the reasons for non-fulfillment of regulatory indicators. In the example considered, weaknesses are clearly visible – these are FCR and DPMO. At the same time, the processing speed, proactivity and CSAT are at the level of target indicators and do not form a pronounced problem area. For making management decisions, the signal is clear: "bottlenecks" identified due to indicators that do not meet the standards require intervention.

10. *General conclusions and practical recommendations.* According to the main indicators, the process looks manageable: the average processing time of applications is within the regulatory framework, the satisfaction level is stably high. At the same time, there are a number of problematic points – this is primarily the cumulative level of defects

ISSN-L 2664-9969; E-ISSN 2706-5448

and the proportion of requests that are not resolved on the first attempt. In practice, in everyday work, this does not translate into rework, duplication of requests, instability of weekly indicators within the SPC. If these indicators are left at the current level, employees will continue to spend time repeating routine operations instead of developing the service.

This leads to the following priority tasks:

– strengthen electronic identification and data completeness verification;

– increase the fault tolerance of key external iterations (through retry mechanisms, error codes and texts);

– expand the scenario of proactive service provision, when the available data is sufficient to make decisions without additional actions on the part of the applicant.

At the management level, this should occur in a constant cyclical mode – regulatory PDCA iterations, *p*-map monitoring, periodic analysis of anomalies, use of FMEA to identify critical failure points. In the future, these approaches should become part of the rules. They should be enshrined in official regulations, integrated into training programs, reflected in the KPI system as standards for designing e-services. It is about the principles of "confidentiality by design", "security by design", data interoperability and other parameters that in practice determine the level of user trust.

The empirical results obtained during the testing allowed to identify typical "bottlenecks" at the stage of process initiation (completeness of the application, e-identification) and their impact on repeat applications, the level of defects and user satisfaction. The use of this data will allow to directly link output metrics to management actions, namely: standardizing entry checks, improving the fault tolerance of integrations, implementing the principles of "privacy and security by design" (Privacy/Security by Design), and regular monitoring.

3.3. Improving education policy in the context of digital transformation: from strategic declarations to key performance indicators

Education directly affects employment, incomes and quality of life, therefore, in the context of digital transformation, it is it that sets the boundaries for economic growth and social mobility. People with better education are more likely to find work, have better health, lead a healthier lifestyle and participate more actively in public life. A higher level of education improves adaptability in society and reduces the likelihood of criminal behavior.

In 2021, the Minister of Education and Science of Ukraine Serhii Shkarlet identified digital transformation as one of the priority areas for improving the quality of education [27], Ukraine has already formally recorded digital competencies as a priority ("Action.Digital Education"). In today's conditions, the rapid development of digital technologies and innovations in all spheres of life requires immediate modernization of the personnel training system; the education system must adapt programs, infrastructure and retraining mechanisms. This aspect is crucial for the successful modernization of the national economy and the response to modern global requirements.

The digital transformation of the labor market is fundamentally changing the requirements for specialists. This necessitates the transition from fragmentary changes in curricula to a systematic update of the logic of vocational education. New technologies affect both the content and organization of work in traditional professions, changing the list of required skills and the level of responsibility of the employee. This trend is clearly visible in traditional specialties, where digital tools are transformed from auxiliary elements into a necessary condition for professional activity. Professional profiles related to computer technologies, artificial intelligence and robotics are losing their highly specialized nature, becoming a structural factor in demand on the labor market. The corresponding competencies are transformed into a standard qualification requirement, losing the status of an additional advantage. Under such conditions, educational programs should focus on the current needs of the digital economy, and not on formalized theoretical models of the graduate. As digital competence becomes a mandatory element of professional suitability, this necessitates systemic changes in the approaches of both educational institutions and employers.

When the state underfinances digital education, this quickly affects its ability to ensure sustainable development. Under such conditions, mastering modern approaches in education and public administration ceases to be a purely theoretical component and becomes a necessary prerequisite for the long-term socio-economic development of Ukraine. The modern economy requires specialists who are able not only to use ready-made digital services, but also to design, test, implement and maintain new digital platforms in various sectors of the economy and spheres of social life.

Updating the national training system taking into account the role of digital technologies and innovations should not be reduced to the implementation of individual digital projects against the background of loud declarations. It requires a well-thought-out system of measures.

One of the key areas is the formation of a modern educational infrastructure that allows training specialists who are able to work with digital technologies at an interdisciplinary level and integrate them into real business processes and management practices. And of course, this is not just a demonstration of mastery of basic office programs. Today, educational programs must be constantly improved in accordance with the new challenges of the digital environment, combining basic skills in working with ICT and special courses aimed at mastering innovative digital systems and services. Otherwise, modernization may remain a fashionable political slogan rather than a real update of the content of education. The development of digital competencies of citizens is now becoming a priority task of state policy, and this requires a shift in priorities in both strategies and individual government initiatives. In the era of digital transformation, mastery of digital skills has a strong impact on the prospects for socio-economic development and can create conditions for social harmony and the functioning of social elevators.

To ensure a more systematic approach to training personnel for the digital economy and supporting social transformations, the Cabinet of Ministers of Ukraine approved the "Concept for the Development of Digital Competencies by 2025" on March 3, 2021 [17]. The document outlines the strategic development of a high-tech educational space and the establishment of digital competence standards at all levels of education. Particular attention is paid to the inclusion of digital technologies in educational methodologies, the improvement of e-learning platforms, and the improvement of digital skills in society.

According to the Concept, one of the central elements of the digital transformation of the educational space is the creation of the Unified State Web Portal "Action.Digital Education", which should become a key tool for increasing digital literacy. The portal provides access to various educational programs, online courses, and training materials aimed at the formation and improvement of digital skills.

In general terms, the Concept offers a fairly broad understanding of digital competence: it is not only the ability to work at a computer, but also the ability to effectively use digital tools in professional, private and public life. Its content, along with basic skills in using the Internet and mobile devices, also includes more complex skills: working with large data sets, their interpretation and evaluation, developing digital products, and applying individual elements of artificial intelligence. Digital competence is considered as a multidimensional characteristic that combines technical, analytical and communicative components and is manifested not only in "technical skill", but also in the ability to act consciously and responsibly in the digital environment.

Among the main areas of implementation of the Concept, several blocks can be distinguished, which in practice set the framework for state policy in the field of digital skills:

1. *Digital education at all levels.* Implementation of digital education programs in all types of educational institutions – from schools

to universities – with proper technical support and broadband access to the Internet. Already today, the platform "Diia.Digital Education" is actively working in this field, as well as a number of specialized courses: the interdisciplinary course "Robotics. Grades 7–9", digital courses and modules for students in grades 10–12 and other similar initiatives.

2. *Training a new generation of educators and civil servants.* Special emphasis is placed on training and improving the qualifications of teachers, lecturers and civil servants to ensure their real, rather than formal, competence in the application of modern digital technologies in education and management. This includes, in particular, "Digital Grammar for Teachers", "Digital Technologies in Education", "E-learning", "Media Literacy", "Digital Skills of Educators", "Cloud Services in Education", etc.

3. *Lifelong Learning.* Expanding people's opportunities to improve their digital experience using e-learning platforms and self-education tools (Prometheus, eDerA, Diia Digital Education). This is the basis for personal improvement and acquiring new skills throughout life.

4. *Supporting digital entrepreneurship and small businesses.* Promoting the growth of digital startups and small business development through programs focused on mastering digital tools and their practical use in business processes – from organizing production processes to marketing (Diia.Business with online academies and e-commerce courses, SME digital maturity framework, Google for Startups Ukraine Support Fund grant program, EU4Digital and EU4Business training and consulting initiatives).

5. *Legal awareness and security in the digital economy.* Increasing digital awareness of citizens regarding the legal aspects of the functioning of the digital economy, issues of personal data protection and basic cybersecurity rules, so that users understand not only "how the service works", but also the risks it carries ("Diia.Digital Education", course "Personal Data Protection", courses and tests from the NBU on the "Garazd" platform, online courses on cybersecurity and media literacy from the Center for Safe Internet of Ukraine).

6. *Digital competence certification system.* Creation of a mechanism for formal recognition of digital competence levels, which could confirm the presence of digital skills both in Ukraine and abroad. Reduces the gap between actual skills and their institutional recognition (cipher-gram tests, teacher training programs within the framework of DigComp/DigCompEdu, SELFIE online tool).

In the development of digital skills, the issues of personal data protection and respect for privacy require special attention. Without this, any talk about "digital transformation" again risks remaining declarations, rather than changes in practices. If educational programs lack meaningful modules on cybersecurity and data work, such "digital education" actually performs a decorative function. The same applies to the development of critical thinking and media literacy. Today, this is no longer an optional but a necessary element, in particular to counter fake news, information manipulation and disinformation in the online space. The focus is also on distracting the population from economic and social problems, which is especially acute in the context of the spread of corporatocracy. The concept focuses on promoting digital entrepreneurship. It is not just about vague calls to stimulate innovation, but about creating the necessary conditions for small and medium-sized domestic companies to confidently feel themselves in both domestic and foreign markets.

Leading world experience shows that where there is targeted investment in digital competencies, new business models emerge faster, labor productivity increases, and additional jobs are created. For our country, this means, among other things, a chance to reduce the outflow of young specialists. In fact, through the implementation of the Concept and development of the "Action.Digital Education" platform, Ukraine is gradually bringing its own requirements for digital competencies closer to the European Digital Competence Framework DigComp. This process can be interpreted not only as an internal reform of the educational space, but also as one of the practical tools for implementing the Association Agreement with the EU. The DigComp framework serves as a basic guideline for developing national standards and approaches to assessing digital skills, which makes it possible to correlate Ukrainian educational results with European criteria. This is important at least because it reduces the gap between formal and real recognition of competencies: a diploma or certificate issued in Ukraine must confirm skills that can be correctly measured and compared in an international context. Thus, the implementation of the measures set out in the Concept is aimed not only at increasing the level of digital literacy of the population, but also at forming the basis for an innovative economy and sustainable socio-economic development in the face of global challenges.

In the educational context, it is also important to take into account the concept of "lifelong learning", which was formally recognized at the Lisbon Summit of the European Council in March 2000. In Ukrainian realities, it is gradually ceasing to be just a declaration and is increasingly being used as a framework for rethinking the relationship between formal, non-formal and informal education, in particular in terms of developing digital competencies of the adult population. The adopted "Memorandum on Lifelong Learning" [28] defines such education as a key principle in ensuring a comprehensive continuum of learning. Its main principles include:

– guaranteeing comprehensive and continuous access to learning, which provides everyone with the opportunity to acquire and update the knowledge necessary for active participation in society throughout their lives;

– ensuring unlimited access to high-quality information and learning opportunities, creating a single European educational space where people can access educational resources anytime and anywhere;

– providing opportunities for lifelong learning to the widest possible range of people, ensuring accessibility regardless of age, place of residence, social status or other factors.

The implementation of these principles contributes to raising the level of education and professional qualifications, greater accessibility and flexibility of education. Also relevant are the alignment of people's skills and knowledge with the needs of the labor market, personal and professional development throughout life, strengthening social cohesion and active civic participation. For Ukraine today, this is no longer a general declaration, but a rather mundane task. Updating the education system and human capital management policy should be among several priorities on the state agenda. This is extremely important, since without this it is difficult to talk about post-war reconstruction, and about the competitiveness of the economy, and about meaningful, rather than purely formal, European integration.

The events of recent years – forced isolation during the COVID-19 pandemic, mass population movements caused by various crises and war – have given this concept an additional, quite practical dimension. The system of public administration in education is forced to change rapidly. New formats, communication channels, other requirements for the flexibility and responsibility of educational institutions have appeared. Some of the solutions were implemented experimentally, but they set a new "normality" to which both schools, universities, and the participants in the educational process themselves had to adapt. The adaptability of students and teachers to distance learning formats has become a mandatory characteristic of modern education, even if not everyone was ready for it. The constant updating of digital competencies, the emergence of new online courses that take into account the specifics of distance interaction, have ceased to be an "additional option" and have become an integral element of educational policy [29]. Analysis of current policies and practices in the field of digital competence development and lifelong learning shows that the integration of digital skills into educational programs should be considered as a structural part of adult education.

ISSN-L 2664-9969; E-ISSN 2706-5448

It is no longer an auxiliary module for individual enthusiasts or one-time projects. In modern conditions, there is a problem of inconsistency between strategic goals and the results of their implementation. Most educational programs in Ukraine are still based on the industrial logic of personnel training, although the labor market has been demanding a different set of competencies related to digitalization for several years in a row. In these circumstances, the question arises about the architecture of educational trajectories themselves – do they really train a specialist capable of working in a digital environment, or rather recreate an outdated production model with minor superficial adjustments. This primarily concerns educational programs in economics, management, accounting, finance, engineering and technical specialties (mechanical engineering, production technology), public administration, marketing and law. Typically, such programs often retain the structure of the 1990s–2000s and consider digital competencies as additional rather than basic skills.

The next step is to translate general principles into measurable, management practices. This is where the need arises to apply a comprehensive KPI model. On the one hand, the model ensures comparability of results, and on the other hand, it allows for targeted adjustments to the PDCA cycle and provides guidelines for investments in the development of certain skills and modern educational technologies. This approach functions as a kind of monitoring system that demonstrates the compliance or non-compliance of political declarations with specific management decisions regarding socio-economic changes, economic modernization, employment growth, increasing citizens' incomes, quality of life, etc. (Table 7).

Table 7

Key performance indicators (KPIs) for digital competence and lifelong learning initiatives*

Category	Indicators	Assessment methods	Assessment frequency
Technological readiness	Level of digital infrastructure coverage, percentage of service availability	Indices, surveys	Annually
Service use	Number of active users, share of population coverage	Data analytics, statistics	Monthly
Citizen satisfaction	Index of satisfaction with service quality, loyalty level	Surveys, reviews	Quarterly
Economic performance	Amount of savings, time saved	Financial analysis	Annually
Social impact	Level of digital inclusion, trust index	Sociological research	Every 2 years
Innovation	Number of new services implemented, level of process automation	Expert evaluation	Annually
Cyber resilience	Number of security incidents, average recovery time	Security monitoring	Ongoing
Digital skills	Literacy level of the population	Testing, certification	Annually

Note: * – developed by the author based on international assessment methodologies

The developed integrated system of indicators transforms the digitalization of education from a set of disparate initiatives into a managed process with clearly defined accountability, regular feedback and responsibility. This, in turn, makes it possible not only to record "successful cases", but also to substantively discuss the content of educational programs, professional development mechanisms and formats of cooperation between educational institutions and employers. In other words, the discussion moves from "whether digitalization is needed at all" to the question of "what kind of digital education does a specific sector of the economy need".

3.4. Using the developed model as a tool for economic modernization and sustainable development

Investments in the modernization of the training system for the digital economy determine whether Ukraine will be able to restore and increase its economic potential after the war. It is not only about responding to current challenges, but also about building a development model where added value is created within the country, and not lost along with the working population.

The National Economic Strategy of Ukraine for the period up to 2030 pays significant attention to digitalization as one of the key guidelines of economic policy [18]:

1. Creating a favorable environment for the digital economy, digitalization of public services, development of digital infrastructures and support for digital innovations (in practice, this is already being implemented through the "Diia" ecosystem, eID tools, eHealth, state electronic registers and a number of related platforms).

2. Taking into account technological, social, economic and institutional aspects, which in general should ensure not only the socio-economic development of the country, but also the sustainability and inclusiveness of digital transformations.

3. Strengthening the interaction of government, business and civil society, when the spread of digitalization becomes the result not only of the actions of the authorities, but also of real demand from all stakeholders.

4. Determining priority areas for investments in the field of digitalization, which will allow more rational use of limited resources and direct them to stimulate long-term socio-economic development.

5. Implementing systematic monitoring and evaluation, which will allow recording actual results, adjusting the goals and tools of strategy implementation and identifying "bottlenecks" that require additional response.

Thus, the National Economic Strategy of Ukraine for the period until 2030 is an indicative document that sets the general trajectory of the digital transformation of the economy. However, actual results may differ significantly from those declared due to the inconsistency of real actions of the authorities with public interests. The ultimate success will depend on whether these actions turn out to be populism or a real nationwide project for the modernization of the country. At the time of preparation of the research, the Strategy is at the stage of practical implementation, and it is the quality of this process that will largely determine whether the declared priorities will be transformed into tangible changes for citizens and businesses.

The rapid evolution of jobs due to the COVID-19 pandemic and the full-scale war in Ukraine is already having quite tangible consequences for business. Companies are forced to simultaneously adapt to the new conditions of today and form a safety margin in case of future shocks. In such circumstances, digital transformation is not only one of the factors of success of individual enterprises, but also an important driver of economic modernization in general. It opens up opportunities for growth, increased labor productivity, and the construction of new value chains that are no longer rigidly tied to geographical borders.

The nature of the impact of digital transformations on the economy is changing, digital technologies are increasingly used exclusively to increase productivity or automate individual operations; they have begun to determine the ways in which companies organize business, generate costs, and build interaction with customers. In this environment, the role of sectors and forms of employment that were considered highly specialized or experimental a few years ago is gradually increasing.

Their development is accompanied not only by the redistribution of added value, but also by noticeable shifts in the industry and spatial structure of employment (in particular, in favor of IT and service centers) and the emergence of new regulatory risks. The experience of companies in recent years shows that the integration of digital solutions into key business processes is no longer a matter of the "good will" of individual management. Without this, maintaining efficiency and competitive positions, including in foreign markets, is becoming increasingly difficult. In parallel, the importance of cybersecurity, data protection, and the quality of regulation of digital markets is growing. If these components remain unchanged, the digital economy does provide productivity gains, but at the same time it accumulates vulnerabilities that in crisis situations can erase a significant part of the benefits gained.

For Ukrainian business, digitalization has transformed from a popular trend into a basic condition for maintaining competitiveness and development in the long term. It allows to automate routine operations, reduce operating costs, accelerate the entry of products and services into the market, work with a global client, while remaining within the Ukrainian jurisdiction. At the macro level, this leads to a gradual change in the structure of the economy: the share of sectors with high added value is increasing, dependence on raw material exports is decreasing.

A generalized map of technological directions shows that in some cases Ukraine can already rely on relatively mature solutions (working with data, cloud services, individual elements of the Internet of Things). While other areas – artificial intelligence, blockchain, quantum methods – still mostly remain at the stage of pilot projects and experiments. Such a heterogeneous structure allows for a more reasoned approach to investments in digital projects. It is important to avoid the temptation to finance trendy but unproven technologies and at the same time not to be late in entering those niches that, with a high probability, will shape the future potential for development in the next 5–10 years (Table 8).

Table 8

Technological directions of digital transformation and barriers to their implementation

Core technologies	Implementation Level	Where to use	Barriers	Possible development directions
Artificial intelligence	Experimental-Mature	Analytics, automation, personalization	Ethical issues, transparency, algorithmic bias	Autonomous decision-making
Blockchain	Early-Active	Identification, registries, voting	Scalability, power consumption	Decentralized management
Internet of Things	Active	Monitoring, smart cities	Security, privacy	Comprehensive sensorization
Big Data	Mature	Policy analytics, forecasting	Data usability and quality, interpretation	Real-time insights
Cloud computing	Mature	Infrastructure, storage	Security, vendor lock-in	Hybrid and multi-cloud solutions
5G/6G networks	Deployment	Mobile services, IoT	Infrastructure costs	Total connectivity
Quantum computing	Research	Cryptography, modeling	Technological complexity	Revolution in computing

Note: * – developed by the author based on technology reports of leading countries (USA, Germany, Japan, South Korea) [2, 30, 31]

Different rates of development and specific barriers to the implementation of each technological direction determine the need for special measures and incentives. For technologies that already have a sufficient level of testing (Big Data, cloud services, Internet of Things), it is more expedient to focus on scaling and expanding the scope of application. For those technologies that are practically still at the stage of pilot projects (AI, blockchain, quantum computing), preference should be given to balanced and consistent testing with a clear consideration of all risks. The combination of these two approaches will provide not only an applied effect, but also provide a certain potential for the development and implementation of new technologies. Such a strategy will allow maximizing the future socio-economic effect, and determining which regulatory measures are more acceptable for its increase.

Digital transformation affects various aspects of business entities' activities, but the main consequences of these changes can be reduced to several key dimensions:

– *Increased productivity* is a consequence of the automation of operational processes, and therefore the transfer of routine functions to "digital" frees up people for their various improvements and solving more complex tasks in various areas;

– *Increased competitiveness* – companies that do not postpone digital initiatives "for later" respond more quickly to changing conditions, launch new products and services faster, and support higher standards of service for customers;

– *Formation of new market areas* (AI products, data analytics, platform services), where the level of marginality significantly exceeds the indicators of traditional production, which stimulates investments in innovation and creates additional sources of economic growth;

– *Improving the quality of everyday life.* Digital technologies remove some of the household and organizational barriers, provide quick access to services and information, simplify communication between people and institutions, and expand access to education and medicine regardless of place of residence.

There are now few fundamental disputes about the impact of digitalization on the efficiency of management and competitiveness of enterprises [32], this connection has been repeatedly confirmed by empirical studies. At the same time, such an effect does not occur automatically.

Tangible results are observed where technical updates are combined with changes in work organization, decision-making practices, and systematic training of personnel; if these components are ignored, digital investments actually work only partially. That is why when implementing national development strategies, it is advisable to proceed not only from technical capabilities, but also from the existing social and organizational limitations within which these technologies are implemented.

3.5. Discussion

If the developed integrated quality management model is implemented, systemic positive changes will be ensured in three interrelated areas. First, operating costs will be reduced. Second, the quality of electronic services will increase. Third, citizens' trust in the state's digital tools will gradually increase.

As a result, public authorities face several rather specific tasks:

– ensure the continuity and quality of service provision in conditions of dynamic digital changes by timely adaptation of services to new technological requirements, guaranteeing their actual availability and operational capacity;

– expand the list of online services and make them truly convenient – taking into account security, ease of use and real scenarios in which citizens turn to these services, and not only based on formal indicators;

ISSN-L 2664-9969; E-ISSN 2706-5448

– systematically invest in the digital competencies of civil servants: without this, no technology, even the most expensive, will produce the expected effect. Training and professional support of personnel in this logic are transformed from an additional bonus into a basic condition for successful digital transformation.

Solving these tasks will not only help overcome current challenges, but also create opportunities for the development and modernization of the public administration system. This includes creating conditions for innovative growth, improving the quality of services for citizens, and the effective use of digital technologies in public governance (such as reducing manual work, queues, the number of complaints, and increasing trust).

For modern Ukraine, digital transformation can become an important factor in ensuring socio-economic development only if a number of key prerequisites are implemented:

– mutual coordination of the interests of the government, business, regions, and segments of the population on the basis of ensuring public welfare and stability;

– systematic monitoring, which evaluates not only formal indicators, but also the level of real benefit of services for users and determines ways to improve them;

– the priority of investments in human development, which ensure the acquisition of not only digital skills, but also improve their moral, cultural, professional, and general intellectual qualities, and such investments in absolute terms should be greater than investments in equipment or software.

If these factors are not taken into account, then various official strategic documents of the authorities will remain declarations, and the potential of digital technologies will not be fully used.

Under these conditions, digital transformation can no longer be perceived as an ordinary technical element of public policy implementation. It becomes a determining factor of changes that positively affect the pace of socio-economic development and the ability of the state to withstand potential social challenges and risks.

It is methodologically incorrect to reduce digitalization to a purely technical optimization of business processes and the provision of public services, which supposedly guarantees and automatically leads to increased efficiency of business and public administration. Without changing the outdated, inefficient economic and political system, the expected results cannot be obtained.

Therefore, digital technologies can become a lever for increasing efficiency only on the basis of systemic changes. They help to allocate and use resources more accurately, reduce environmental and infrastructural pressure, and at the same time improve the quality of everyday life through simplified access to services, clearer services, and faster feedback from authorities. When digital technologies are combined with the logic of sustainable development, space opens up for new trajectories of progress: niche innovations emerge the rules of the game change in individual markets, and citizens' expectations of the state's capabilities increase. As a result, this strengthens the state's resilience and creates the basis for long-term, not just "cyclical" success.

The practical significance of the developed integrated model is confirmed by the analysis of the macroeconomic environment. According to the IMD World Competitiveness Center, which conducts a comparative analysis of global competitiveness, Ukraine in 2021 ranked 60th out of 63 countries in the World Digital Competitiveness Ranking (WDCR). As in other rankings, Ukraine showed relatively weak results in the "knowledge" component (40th out of 63), while in "technology" and "future readiness" it took the penultimate places (61st and 62nd, respectively). These rankings assess the ability and readiness of economies to integrate and use digital technologies to achieve economic and social transformation [33]. Such data indicate that fragmented solutions do not provide systemic changes. That is why the KPI matrix for digital education proposed in research is justified. It is aimed at strengthening the "knowledge" component, which remains Ukraine's weak point today. In addition, the correctness of the chosen approach is confirmed by European experience. According to the Comparative Index of Readiness for Digital Lifelong Learning (IRDLL) in the EU, developed by the Center for European Policy Studies (CEPS) in cooperation with "Grow with Google", the Republic of Estonia was recognized as the leader in digitalization in the EU. The report highlights Estonia's lifelong learning policy and its comprehensive approach to digitalization [34]. This is consistent with our findings. The developed model actually allows to adapt the successful Estonian experience to Ukrainian realities by introducing clear performance measurement metrics (KPIs).

Against the background of foreign experience, Ukrainian approaches to the development of digital skills and lifelong learning still remain fragmented and, unfortunately, are often limited to individual projects rather than a holistic strategy. A comparison with the Estonian case in this context demonstrates not so much the "uniqueness" of one example, but rather that the consistency of state policy, the stability of institutions, and investments can radically change the digital profile of a country in a relatively short period of time.

The experience of leading countries in the implementation of digital technologies in education is of practical rather than theoretical importance for Ukraine. It provides an opportunity to see how countries that have achieved significant results in improving the quality of education are building programs, infrastructure, and mechanisms to support educators and students. At the same time, direct copying of such models does not work. Cultural, social, and historical differences determine the specifics of the transfer of practices, and it is important to take them into account if it is about a real, rather than a purely declarative, effect.

For Ukraine, the key task is to consistently and systematically increase the share of the manufacturing sector with high added value. It includes high-tech industries – mechanical engineering, electronics, aerospace, chemical industry and production of complex agricultural products, pharmaceutical industry, biotechnology, etc.

Along with this, it is important to develop such areas as IT, financial services, engineering, consulting. Despite the fact that these areas involve a relatively small part of the workforce, their role in the formation of GDP and filling the budget is disproportionately large. At the same time, the development of such segments allows reducing dependence on raw material exports.

High incomes from the work of the above-mentioned areas can generate additional resources to finance social programs, modernize infrastructure and fulfill the state's basic obligations to citizens. The gradual development of high-tech areas allows to get out of the "raw material trap", when the economy reacts less to short-term fluctuations in external markets and gets the opportunity to develop more evenly and in the long term.

For a country that seeks to secure the potential for rapid socio-economic development, it is important to understand how it is possible to make the most of digital technologies to create incentives for economic revival and improve the quality of life of the population. The introduction of digital technologies in itself does not guarantee anything, a significant result occurs when digital transformation is systematically spread in public administration, education, and the economy. Further expansion of this process requires an active role of public administration in supporting digital transformation – through the formation of a favorable regulatory and legal framework, support for innovative initiatives, and targeted development of digital skills among the population.

The practical significance of research lies in the development of specific tools that allow for the correlation of digital transformation with practice in the educational space and the economy.

It is precisely in order for public administration to effectively manage modernization processes that the developed integrated PDCA-SIPOC-CTQ/QFD-FMEA-SPC model should become a connecting link between analytics and management. It provides a common language for politicians, IT specialists, financial managers and investors, allowing for transparent prioritization of risks (e. g., cyber threats, digital inequality) and evidence-based monitoring of the quality of e-services. Case testing demonstrated how the framework identifies "bottlenecks" (e. g., identification errors or incomplete documents), which allows for the implementation of targeted management interventions: strengthening checks at the "entrance", increasing the fault tolerance of integrations and expanding proactive services.

Based on the results obtained, a number of measures are proposed for the practical implementation of the model. First, to ensure high quality of digital services from the very beginning by standardizing data completeness assessment, clearly defining electronic identification verification protocols and technical means that prevent errors. Second, to increase the reliability of external integrations – primarily with state registers and related information systems, the stability of which directly affects the quality of electronic services. At the regulatory level, in the regulations for the development of e-services, it is advisable to introduce the principles of confidentiality and security, as well as to provide for the regular use of statistical process control for continuous monitoring of key quality indicators. As a result, such measures, adopted based on the results of the quality assessment, will not only reduce the number of errors and repeated applications, but also, in the long term, improve the conditions for doing business and strengthen citizens' trust in digital public administration tools.

The proposed KPI matrix (Table 7) allows moving from general declarations of "lifelong learning" to managed, measurable practice. It allows aligning educational initiatives (e. g., digital competence development) with real labor market needs and public service quality requirements, reducing the gap between education and the digital economy.

The research results also help in shaping technology investment portfolios (Table 8), balancing between "mature" (cloud technologies, Big Data) and "promising" (AI, Blockchain) areas. This is consistent with national strategies (such as the National Economic Strategy-2030) and promotes the development of high-value-added industries, which is key to economic sustainability.

Although the proposed integrated model is methodologically complete, its empirical testing presented in the article has clear limitations that need to be taken into account:

– the sample size is a key factor in this research. The testing was conducted on a sample of 181 requests over 10 calendar days. The authors note that such a short period provides only a preliminary assessment of the stability of the process. For reliable conclusions using statistical process control (SPC), a much larger data set is required (at least 4,000 contacts are recommended) and a longer observation horizon;

– case limitations are also present, as the research examines in detail only one, moreover hypothetical, mini-case ("Issuance of a certificate"). This limits the extrapolation of conclusions about "bottlenecks" to other, potentially more complex, classes of e-services;

– contextual factors should also be considered, as the successful implementation of the research results depends not only on the methodology itself. It also relies on the readiness for "coordinated action by government, business and civil society", as well as on taking into account social, organizational, cultural and historical contexts;

– technological barriers are also limitations. The effectiveness of the model when working with new technologies (Table 8) is limited by their inherent barriers, such as ethical issues and bias of AI algorithms, or scalability and power consumption issues of Blockchain.

Based on the results obtained and the identified limitations, the prospects for further research include:

– systematic scaling, which involves applying the developed quality framework to various classes of real (not hypothetical) e-services and in different regional and operational contexts, as provided by its scalability;

– conducting long-term monitoring (e. g., 6–12 months) using SPC on large data sets to confirm the stability of processes and the reliability of detected defects;

– an integrated system of indicators (Table 7) provides the basis for determining how the targeted implementation of educational programs (e. g., DigComp) affects the measurable quality indicators of e-services (CSAT, FCR, DPMO);

– assessment of the economic effects of implementing the proposed model, in particular, how balancing the technological portfolio (Table 8) affects competitiveness and economic sustainability;

– in-depth analysis of the impact of digitalization on social justice and inclusion, as well as studying the long-term consequences of digital transformation for sustainable development and environmental safety;

– research into models of international cooperation in the field of digital public administration, which will contribute to the formation of uniform standards and best practices.

In the conditions of exponential development of the world, the transition to good governance is becoming a necessary prerequisite for an effective response to global challenges. The implementation of an integrated quality management model in the triad "public administration – education – economy" is becoming an imperative for sustainable development. At the same time, the digital society requires scientists to solve problems that are much deeper than issues of purely technical efficiency. The ethical dimension of digitalization is becoming decisive, which involves focusing technology on public interests and the development of human potential, rather than on the dominance of narrow corporate goals or the manipulation of public opinion. This is a fundamental condition for minimizing algorithmic bias and contributing to building a society where technology serves sustainable development, justice, equality, trust, and freedom.

4. Conclusions

1. It is substantiated that human-centricity should be the determining factor in the implementation of successful digital transformation and a necessary condition for society's adaptation to modern crisis challenges. It is such a value-conceptual foundation that is able to shift the goals of quality management from technical optimization of processes to ensuring social justice, inclusiveness and overcoming digital inequality. Digital transformation in the context of modern challenges is not only a technical tool, but also an indispensable condition for institutional stability and the ability to ensure good governance. An integrated model of quality management of electronic services should take into account the principles of good governance – transparency, accountability, minimization of the asymmetry of power between the state and the citizen. In this context, the digital competence of civil servants and citizens becomes not just a set of technical skills, but a systemic element of ensuring trust in public services and digital platforms, a factor in the high efficiency of providing electronic services.

2. Empirical verification of the model using the example of the electronic service "Issuance of a certificate" revealed rather contradictory data. It is positive that the speed of processing successful requests (on average 0.94 days with a target value of 2.0 days) and the level of user satisfaction (4.83/5 with a target value of 4.6) fully meet the set benchmarks. At the same time, the level of defects for the basic administrative service (DPMO ≈ 53,274 with a target value of 3,000) turned out to be critically high, while the first-time resolution rate (73.5% against the target 85.0%), which means the need for additional management measures at the stage of receiving requests.

ISSN-L 2664-9969; E-ISSN 2706-5448

Analysis of the defect structure showed a concentration of problems already at the initial stage of the process, in particular, these are primarily electronic identification errors (9.39%) and submission of an incomplete package of documents (13.81%). The result of the empirical verification was that the developed integrated model allows not only to ensure an increase in the quality of the provided electronic services, but also to contribute to saving resources and systematically eliminating the causes of defects.

3. An important practical research result was the formalization of declarative priorities of digital education through the development of a KPI matrix, which demonstrates a direct connection between educational initiatives and the level of quality of electronic services. The proposed system of indicators (technological readiness, digital skills, cyber resilience, citizen satisfaction) allowed to operationalize the concept of "lifelong learning", harmonizing the development of competencies with the actual requirements of the labor market. This ensures regular, more effective monitoring and improvement of state educational policy based on real data.

4. The use of the developed integrated model as a tool for systematic monitoring of the implementation of the "National Economic Strategy-2030" is justified, which allows identifying gaps between the declared goals and the actual results of the implementation of digital reforms, ensuring timely adjustment of state policy. It is shown that the model is able to rationalize investments in digitalization by differentiating technologies by maturity level: focusing on scaling proven solutions (Big Data, Cloud Computing) and careful piloting of new technologies (AI, Blockchain) taking into account the barriers to their implementation. The application of the model can contribute to the structural restructuring of the national economy from a raw material type to an economy specializing in the production of products with high added value, where digital transformation is not only a means of automation, but also a key determinant of the emergence of new markets and increasing the competitiveness of domestic enterprises.

Conflict of interest

The authors declare that they have no conflict of interest in this research, including financial, personal, authorial or other, that could influence the research and its results presented in this article.

Financing

The research was carried out without financial support.

Data availability

The manuscript has no associated data.

Use of artificial intelligence

During the preparation of this article, the authors used ChatGPT 5.2. The tool was used to check grammar, spelling, punctuation and stylistic editing without changing the text of the article. After using this tool, the authors checked the obtained result. Artificial intelligence did not influence the conclusions of the research and was of an auxiliary nature only.

Declaration submitted by: Mykola Kovalenko.

Authors' contributions

Mykola Kovalenko: Conceptualization, Project administration, Writing – review and editing; ***Maksym Sikalo:*** Methodology, Project administration, Visualization, Writing – original draft; ***Tetiana Kovalova:*** Methodology, Investigation, Writing – review and editing; ***Oleksandr Radchenko:*** Formal analysis, Validation; ***Larysa Velychko:*** Investigation, Writing – review and editing; ***Oleksandr Nakisko:*** Formal analysis, Validation; ***Olga Grybko:*** Investigation, Data curation; ***Serhii Maistro:*** Visualization, Writing – review and editing; ***Natalia Ryzhikova:*** Data curation, Writing – review and editing.

References

1. Alojail, M., Khan, S. B. (2023). Impact of Digital Transformation toward Sustainable Development. *Sustainability, 15 (20),* 14697. https://doi.org/10.3390/su152014697
2. *OECD digital economy outlook 2024 (Vol. 1)* (2024). OECD Publishing. Available at: https://www.oecd.org/en/publications/2024/05/oecd-digital-economy-outlook-2024-volume-1_d30a04c9.html
3. Voynarenko, M. P., Skorobohata, L. V. (2015). Network tools for capitalizing on informational and intellectual potential and innovations. *Bulletin of Khmelnytskyi National University. Economic Sciences, 3 (3),* 18–24. Available at: http://nbuv.gov.ua/UJRN/Vchnu_ekon_2015_3%283%29__5
4. Zhukova, L. M. (2017). Digital economy as an object of state regulation. *Economic Bulletin of Zaporizhzhia State Engineering Academy, 5 (11),* 7–14. Available at: http://nbuv.gov.ua/UJRN/evzdia_2017_5%281%29__3
5. Du, M., Qu, X. (2024). Is Digital Transformation a Burden or a Help? From the Perspective of Enterprise Sustainable Development. *Sustainability, 16 (3),* 980. https://doi.org/10.3390/su16030980
6. Latupeirissa, J. J. P., Dewi, N. L. Y., Prayana, I. K. R., Srikandi, M. B., Ramadiansyah, S. A., Pramana, I. B. G. A. Y. (2024). Transforming Public Service Delivery: A Comprehensive Review of Digitization Initiatives. *Sustainability, 16 (7),* 2818. https://doi.org/10.3390/su16072818
7. Ly, B. (2024). Transforming commitment into performance: a study of digital transformation in the Cambodian public sector amidst a pandemic. *Cogent Business & Management, 11 (1).* https://doi.org/10.1080/23311975.2024.2333609
8. Rysin, M., Babych, O. (2025). Digitalisation of Public Administration Services as Part of Digital Economy Development in Post-war Ukraine. *Krakow Review of Economics and Management/Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie, 1 (1007),* 75–86. https://doi.org/10.15678/krem.18640
9. Kusairi, S., Wong, Z. Y., Wahyuningtyas, R., Sukemi, M. N. (2023). Impact of digitalisation and foreign direct investment on economic growth: Learning from developed countries. *Journal of International Studies, 16 (1),* 98–111. https://doi.org/10.14254/2071-8330.2023/16-1/7
10. Kozhakhmetova, A., Tazhiyeva, Z., Zhidebekkyzy, A., Bács, Z. (2025). Effects of digital transformation on green investment: Evidence from developing economies. *Journal of International Studies, 18 (2),* 138–158. https://doi.org/10.14254/2071-8330.2025/18-2/8
11. Lieonov, S., Hlawiczka, R., Boiko, A., Mynenko, S., Garai-Fodor, M. (2022). Structural modelling for assessing the effectiveness of system for countering legalization of illicit money. *Journal of International Studies, 15 (3),* 215–233. https://doi.org/10.14254/2071-8330.2022/15-3/15
12. Clark, J., Marin, G., Ardic Alper, O. P., Galicia Rabadan, G. A. (2025). *Digital Public Infrastructure and Development: A World Bank Group Approach (Digital Transformation White Paper, Vol. 1).* Washington: World Bank Publications, The World Bank, 79. Available at: https://documents1.worldbank.org/curated/en/099031025172027713/pdf/P505739-84c5073b-9d40-4b83-a211-98b2263e87dd.pdf
13. Manyika, J., Lund, S., Chui, M., Bughin, J., Woetzel, J., Batra, P. et al. (2017). *Jobs lost, jobs gained: Workforce transitions in a time of automation. Executive Summary McKinsey Global Institute.* Washington: McKinsey & Company, 28. Available at: https://www.mckinsey.com/~/media/mckinsey/industries/public%20and%20social%20sector/our%20insights/what%20the%20future%20of%20work%20will%20mean%20for%20jobs%20skills%20and%20wages/mgi-jobs-lost-jobs-gained-executive-summary-december-6-2017.pdf
14. Bu, L., Chung, V., Leung, N., Wang, K. W., Xia, B., Xia, C. (2021). *The future of digital innovation in China: Megatrends shaping one of the world's fastest-evolving digital ecosystems.* McKinsey & Company. Available at: https://www.mckinsey.com/featured-insights/china/the-future-of-digital-innovation-in-china-megatrends-shaping-one-of-the-worlds-fastest-evolving-digital-ecosystems
15. Kovalenko, M., Sikalo, M. (2023). The Influence of the Digital Economy onto Social Relations Transformation. *Theory and Practice of Public Administration, 2,* 83–108. https://doi.org/10.26565/1727-6667-2023-2-06
16. Martynenko, N. (2025). *Digitalisation of forensic expert activity in Ukraine: Organisational and legal framework.* Forensic Science International: Synergy, 10, 100578. https://doi.org/10.1016/j.fsisyn.2025.100578
17. *Pro skhvalennia Kontseptsii rozvytku tsyfrovykh kompetentnostei ta zatverdzhennia planu zakhodiv z yii realizatsii* (2021). Rozporiadzhennia Kabinetu Ministriv Ukrainy No. 167-r. 03.03.2021. Available at: https://zakon.rada.gov.ua/laws/show/167-2021-%D1%80#Text

18. *Pro zatverdzhennia Natsionalnoi ekonomichnoi stratehii na period do 2030 roku* (2021). Postanova Kabinetu Ministriv Ukrainy No. 179. Available at: https://www.kmu.gov.ua/npas/pro-zatverdzhennya-nacionalnoyi-eko-a179
19. Nepomnyashchyy, O., Radchenko, O., Marusheva, O., Prav, Y., Shandryk, V. (2022). The Public Policy Implementation Mechanisms in the Context of Digitalization. *Economic Affairs, 67 (4s),* 787–794. https://doi.org/10.46852/0424-2513.4s.2022.12
20. Zizek, B. (2017). Digital Socialization? An Exploratory Sequential Analysis of Anonymous Adolescent Internet-Social Interaction. *Human Development, 60 (5),* 203–232. https://doi.org/10.1159/000479082
21. Smith, J., Hewitt, B., Skrbiš, Z. (2015). Digital socialization: young people's changing value orientations towards internet use between adolescence and early adulthood. *Information, Communication & Society, 18 (9),* 1022–1038. https://doi.org/10.1080/1369118x.2015.1007074
22. Dunayev, I., Kovalenko, M. (2022). New traces of regulation of information platforms and a platform-based economy for the new public good. *Pressing Problems of Public Administration, 2,* 6–24. https://doi.org/10.26565/1684-8489-2022-2-01
23. Shandryk, V., Radchenko, O., Radchenko, O., Koshelenko, A., Deinega, I.; Shchokin, R., Iatsyshyn, A., Kovach, V., Zaporozhets, A. (Eds.) (2024). *Digitalization as a Global Trend of Public Management Systems Modernization. Digital Technologies in Education.* Cham: Springer, 3–16. https://doi.org/10.1007/978-3-031-57422-1_1
24. Livingstone, S., Helsper, E. (2007). Gradations in digital inclusion: children, young people and the digital divide. *New Media & Society, 9 (4),* 671–696. https://doi.org/10.1177/1461444807080335
25. *Improving health and social cohesion through education* (2010). OECD Publishing. https://doi.org/10.1787/9789264086319-en
26. Livingstone, S., Helsper, E. J. (2008). Parental Mediation of Children's Internet Use. *Journal of Broadcasting & Electronic Media, 52 (4),* 581–599. https://doi.org/10.1080/08838150802437396
27. *Tsyfrova transformatsiia osvity i nauky ye odniieiu z kliuchovykh tsilei MON na 2021 rik, – Serhii Shkarlet* (2021). Ministry of Education and Science of Ukraine. Available at: https://mon.gov.ua/news/tsifrova-transformatsiya-osviti-i-nauki-e-odnieyu-z-klyuchovikh-tsiley-mon-na-2021-rik-sergiy-shkarlet
28. *A memorandum on lifelong learning* (2000). Commission of the European Communities. Available at: http://arhiv.acs.si/dokumenti/Memorandum_on_Lifelong_Learning.pdf
29. Oleshko, A., Rovnyagin, A., Godz, V. (2021). Improving distance learning in the context of pandemic restrictions in higher education. *Derzhavne Upravlinnya: Udoskonalennya ta Rozvytok, 1.* https://doi.org/10.32702/2307-2156-2021.1.3
30. *Technology and Innovation Report 2023: Opening Green Windows - Technological Opportunities for a Low-Carbon World* (2023). Geneva: United Nations. Available at: https://unctad.org/system/files/official-document/tir2023_en.pdf
31. *Global Innovation Index 2024: Unlocking the Promise of Social Entrepreneurship* (2024). Geneva: WIPO. Available at: https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2024-en-global-innovation-index-2024.pdf
32. Łasak, P., Wyciślak, S. (2025). *Digital platforms in finance and supply chain management.* London: Routledge. https://doi.org/10.4324/9781003538233
33. Iavorskyi, P., Taran, S., Shepotylo, O. (2021). *Ukraine's integration into the EU's digital single market.* FREE Network. Available at: https://freepolicybriefs.org/2021/02/15/ukraines-integration-single-market
34. Beblavy, M., Baiocco, S., Kilhoffer, Z., Akgüç, M., Jacquot, M. (2019). *Index of readiness for digital lifelong learning: Changing how Europeans upgrade their skills (Final Report).* Brussels: Centre for European Policy Studies. Available at: https://cdn.ceps.eu/wp-content/uploads/2019/11/Index-of-Readiness-for-Digital-Lifelong-Learning.pdf

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