

Introduction of digital technologies in the enterprise

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Annotation. Digitalization of an enterprise is necessary to increase the efficiency and sustainability of its functioning through dramatic changes in the quality of management, both technological processes and decision-making processes at all levels of management, based on modern methods of production and further use of information about the state and prediction of possible changes in managed elements and subsystems. For the purposes of designing a digital transformation of an enterprise, it is necessary to develop a classification of digital technologies according to the criterion of accessibility and expediency of their implementation in the enterprise. Thus, key digital technologies are grouped into three groups: basic technologies are technologies without which digital transformation of an enterprise is impossible (cloud technologies, wireless technologies, paperless technologies, etc.); critical technologies are technologies that provide a complete digital transformation of the enterprise (big data, cloud computing, unmanned technologies, etc.); breakthrough technologies - technologies that realize the transition from “analog” to a digital enterprise (artificial intelligence, neural networks, distributed data registry, machine learning, etc.)

1 Introduction

In the new paradigm of the development of the world economy, modern digital technologies are considered as the main productive resource that determines the growth of social welfare. The use by organizations and, above all, enterprises of the real sector of the economy of modern computer and information systems is the most significant condition for their effective functioning in the digital economy.

Digitalization of an enterprise is necessary to increase the efficiency and sustainability of its functioning through dramatic changes in the quality of management of both technological processes and decision-making processes at all levels of management, based on modern methods of production and further use of information about the state and prediction of possible changes in managed elements and subsystems. However, modern research for the most part does not sufficiently reveal the essence of such categories as “digitalization” and “digital transformation”; today mechanisms for assessing the effectiveness and feasibility of introducing financial digital technologies in the activities of enterprises and organizations have not yet been formed. Paying tribute to the significant contribution and research results

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of scientists and specialists in this field, questions of the methodology of digital transformation of enterprises still continue to be the subject of scientific research due to the importance of further research in order to achieve economic entities at various levels of sustainable development.

2 Literature review

Analyzing modern research on digital technologies, we can note the lack of unity of authors regarding the definition of the essence of such key concepts as “digitalization”, “digital transformation” and “digital organization”.

So, Plotnikov V.A. Under digitalization, it means “the modern stage in the development of informatization, characterized by the predominant use of digital technologies for the generation, processing, transmission, storage and visualization of information, which is due to the emergence and dissemination (including increased economic and physical availability) of new hardware and software solutions” [12]. Further, the author gives a number of advantages that, in his opinion, enterprises receive when using digital technologies:

- “the flexibility of production is increased due to its quick reconfiguration, dynamic changes in the characteristics of the production process, which creates a competitive advantage and leads to potential profit growth;
- provides informational integration of the stages of the life cycle of products from its development to disposal, which allows us to efficiently and comprehensively solve problems not only of optimizing production itself, but also of quality, environmental safety, creating new business opportunities, etc.” [12].

In turn, Ananyin V.I., Zimin K.V., Lugachev M.I., Gimranov R.D. and K.G. Skripkin under the organization’s digitalization is understood as “its transformation, in which the role of a locomotive of change is played by the complementary assets of computer capital, including information systems - data sources, data processing, transmission and storage systems, practices and processes of working with these systems, as well as data that generate information systems” [3].

Large-scale digitalization leads to the digital transformation of the enterprise. Kitova O.V. and Briskin S.N. in their research, they note that digital transformation affects the strategy, operations and technologies used by the enterprise according to the following logic:

- 1) “The digital enterprise strategy focuses on identifying best customer experiences, managing a unique business model and ecosystem, and managing change;
- 2) operational activities include continuous improvement, the integration of physical and digital entities and the creation of a culture that encourages iterative innovation;
- 3) technology involves the flexibility and use of the full modern technological potential, including analytics, cognition, mobility, etc.” [14].

Arenkov I.A. explores the impact of digital transformation on enterprise competitiveness. The author notes that “in the process of digital transformation, the enterprise goes through stages of qualitative change, which are reflected in the improvement of processes in the production, financial, material, information spheres of its activity, which allows us to adapt to modern conditions of the digital economy and consolidate competitive advantages. In the process of enterprise management, challenges arise related to the growing share of intangible components in the final cost of goods, combined with the increasing ease of access to digital technologies, platforms and advanced technologies and markets, which will affect the level of competitiveness associated with what place in digital hierarchy occupies the enterprise” [4].

The highest level of digital transformation of the enterprise leads to the emergence of a digital organization. Ananyin V.I., Zimin K.V., Lugachev M.I., Gimranov R.D. and Skripkin K.G. a digital organization is called such “an organization in which the assets of computer capital are the most volatile complementary asset of an organization” [3].

Further, the authors give signs of digital organization:

- “digital products. The entire content of the product is shifting from material to digital form. At the same time, the material form of the product does not disappear, simply the use of the product becomes impossible without its digital representation. This representation of a real object is called a “digital double.” For example, in engineering, the main value will begin to be represented not by the material product itself, not by the documentation for it (even electronic), but by the electronic (digital) model of the product, according to which this product can be produced, serviced and restored. The electronic layout of the product is overgrown with many services, which also become digital products;

- digital business models. The possibility of using the “digital double” of the supplied sophisticated equipment, combined with the continuous monitoring of all its elements and processes, has led to the emergence of fundamentally new business models. For example, companies that manufacture sophisticated equipment switch from a delivery business model to a service one, when it is not equipment and its technical support that is sold, but the guarantee of its trouble-free operation or readiness for use (for example, flight hours or volumes of pumped air). Digital business models require not only deep digitalization of all internal value chains of an enterprise (design, production, logistics, technical support and product support), but also building close partnerships between the business and all of its counterparties. The most important element of such a deep partnership is the creation of a common integrated information and communication space. The integration of the information space can be carried out, for example, on the basis of the same “digital double” of the product and plans for coordinating the movement of orders along the value chain. At the same time, many routine daily interactions of chain participants can be translated into the form of digital services provided by third-party organizations (analytics, references, applications, offers, contests, call centers);

- digital value chain management. The digital organization business specializes and integrates into a deep cooperation network with all of its counterparties and customers. In this network, an organization is embedded in value chains in the market. In this case, business management is necessary not only at the level of the organization itself, but also at the level of the entire value chain in the market. Let us give an example of the value chain in mechanical engineering: a management company - a general contractor - an experimental design bureau - component manufacturers - head serial production - customers - after-sales service centers. Each organization is independent, but at the same time enters into many chains and therefore must coordinate not only its operational activities, but also its interactions with all participants in each chain. Recently, many global companies have begun to create business platforms. A business platform is a business model of a company on which counterparties of this company can quickly create their value chains, attracting more and more new participants, while the company itself receives a mechanism for managing these chains;

- digital business processes. The processes of operating a digital product themselves become digital. This is especially evident in the case of documents that have become digital. In this case, users can work with a digital document only using special applications, while the logic of coordinating the actions of these users also requires special applications and data” [3].

Thus, summarizing the approaches considered, we formulate the author's definitions of the studied economic categories:

- digitalization - the process of introducing modern digital technologies into the production process and the process of managing the enterprise;

- digital transformation - a qualitative change in the strategy and business processes of the enterprise under the influence of large-scale digitalization of the production process and the process of managing the activities of the enterprise;

- a digital organization is a digital double of a physical enterprise formed as a result of its digital transformation.

The mutual mediation of the studied categories is schematically presented in Figure 1.

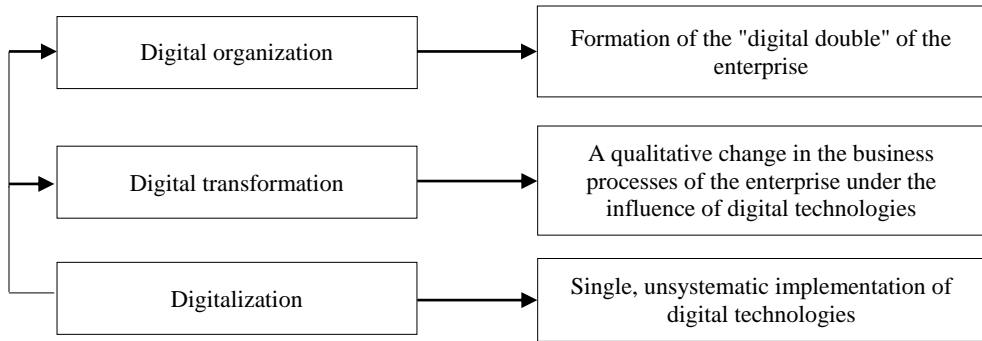


Fig. 1. Stages of the introduction of digital technology in the enterprise.

The main goal of the digital transformation of the enterprise, in our opinion, is to increase its competitiveness and provide conditions for increasing the economic efficiency of production activities. In accordance with the goal of the task of digital transformation, enterprises can be defined as follows:

- organization of production of competitive products;
- achieving a high level of efficiency, adaptability of production and organizational processes;
- increasing the investment attractiveness of the enterprise;
- increasing the flexibility and transparency of the management system, which guarantee the economic efficiency of the enterprise, etc.

In the process of digital transformation, the enterprise goes through stages of qualitative change, which are reflected in the improvement of processes in the production, financial, material, information spheres of its activity, which allows you to adapt to modern conditions of the digital economy and consolidate competitive advantages [13].

In the process of enterprise management, challenges arise related to the growing share of intangible components in the final cost of goods, combined with the increasing ease of access to digital technologies, platforms and advanced technologies and markets, which will affect the level of competitiveness associated with what place in The digital ecosystem is occupied by the enterprise. The introduction of digital technologies in the production process and the process of managing the enterprise becomes an objective requirement that ensures its survival and is not so much a competitive advantage as a vital necessity, a mandatory requirement for competition.

As a theoretical concept, the digital transformation of an enterprise is based on the following theoretical and methodological principles:

- cyclic development of N.D. Kondratiev, G. Mensh;
- innovations of J. Schumpeter;
- technological dynamics and economic growth (K. Fremen, S.Yu. Glazyev, S. Kuznets, Yu.V. Yakovets), which are based on the idea of the concept of modernization as a process of changing technological structures;
- the evolutionary approach in economic science (V.L. Makarov, I. Prigogine and I. Stengers, V.I. Mayevsky); institutional theory [11].

Digitalization as a practical activity of the enterprise, taking into account modern technological requirements, is based on the terminology of the third industrial revolution

(based on the introduction of new energy sources in conjunction with information and communication technologies), which has not yet been fully formed (due to the speed and scale of modern changes), and following (fourth) industrial revolution:

- Industry 4.0 – the concept of creating digital enterprises based on the digitalization of all enterprise systems (physical assets) and their integration into the digital ecosystem, together with partners involved in the value chain;
- the new industrial revolution of the “makers” C. Anderson - the concept of mass customized production with the possibility of an interactive exchange of ideas and developments based on the development of 3D-design and 3D-printing and the use of additive technologies;
- the fourth industrial revolution of K. Schwab - the concept of the transition from simple digitalization (third industrial revolution):
 - a) innovations based on combinations of technologies (fourth revolution);
 - b) information platforms that combine supply and demand and violate existing production structures;
 - c) new organizational forms and business models, for example, sharing economy (“sharing economy” as proposals to use free or extra things and resources) and on-demand economy (“economy on demand”, when access is not made to goods and services, but to gain access to them precisely at the moment when it is necessary, moreover, orders are received online, and their execution is offline);
- the new (fifth) industrial revolution of P. Marsh - a new industrialization of the economy in developed rich countries, which will affect industry around the world.

In addition, in the practice of digital transformation of enterprises, there are also the following concepts:

- Industrial Internet (Industrial Networks);
- Connected Enterprise (Integrated Enterprise);
- SMART Manufacturing (Smart Manufacturing);
- Smart Factory (Smart Factory);
- Manufacturing 4.0 (Production 4.0);
- Internet of Everything (Internet of everything);
- Internet of Things for Manufacturing (Internet of things for production) [6, p. 36].

Thus, the digitalization of the enterprise is one of the key areas for the formation of an effective, sustainable and competitive production. At the same time, the widespread introduction of digital technologies in the enterprise’s activities leads to its full-fledged digital transformation, which is proposed to mean a qualitative change in the strategy and business processes of the enterprise under the influence of large-scale digitalization of the production process and the process of enterprise management.

Thanks to digital transformation, the production system reaches a different, more high-tech level of production and a high level of controllability and functioning, while changing the old management system to a more flexible one. The essential component of the digital transformation of enterprises is manifested in the restructuring of production facilities, changing the goals and objectives of their activities, the formation of a new approach to the methods of production and management of enterprises.

3 Methodology

Modern digital technologies play an increasingly important role in production management, gradually expanding their influence on all sectors of the global economy.

The Eurasian Economic Commission identifies the following main technological trends in the use of digital technologies in production:

- mass introduction of smart sensors in production facilities, equipment and production lines;
- mass introduction of cyber physical systems replacing human labor;
- storage, processing and management of information on "cloud" resources;
- the use of end-to-end automation, horizontal and vertical integration of production and management processes into a single information system;
- the use of structured and unstructured information to form analytics for the purpose of making management decisions;
- the use of common digital standards for technical documentation and electronic document management;
- the introduction of digital design and modeling of technological processes, objects, products, total control over the entire life cycle of an industrial product from generating ideas to operation, further service, repair and disposal;
- application of additive technologies (layer-by-layer application of materials) instead of stamping and casting;
- the use of global digital platforms for the automatic order of raw materials, consumables and components for the production of products;
- the use of unmanned technologies in transport systems, including for the delivery of goods;
- the use of mobile technologies for monitoring, control and management of production processes, industrial flows;
- the transition to the sale of goods through digital platforms for the automatic delivery of finished products to the consumer, bypassing the chain of intermediaries [2].

From the formed technical and technological trends, experts single out basic digital technologies that are promising for implementation in the enterprise. Among them:

- industrial Internet of things;
- artificial Intelligence;
- big data;
- robotization;
- foggy computing;
- paperless technology;
- mathematical modeling;
- cyber physical systems;
- additive, unmanned, mobile, biometric, quantum, super-computer, end-to-end technologies;
- identification technologies;
- blockchain technology;
- technologies of open production [2].

The analysis of digital strategies and initiatives adopted by the world community over the past decade shows that technological trends in the field of digital transformation of industry, characterizing a change in production paradigms within the framework of the Fourth Industrial Revolution, can be grouped in the following order:

- 1) the creation of end-to-end automation and integration of production and management processes into a single information system;
- 2) mass introduction of smart sensors in physical elements and objects of production lines;
- 3) the use of cloud technologies for storing information and performing calculations;
- 4) the introduction of robotic technologies;
- 5) the formation of analytics using the technology of "big" data [7].

In order to intensify the digital transformation of enterprises in Russia, a number of strategic documents have been developed. So, by Decree of the President of the Russian

Federation dated 09.05.2017 No. 203, the “Strategy for the Development of the Information Society in the Russian Federation for 2017-2030” was approved [1]. This Strategy defines the goals, objectives and measures for the implementation of the domestic and foreign policies of the Russian Federation in the application of information and communication technologies, aimed at the development of the information society, the formation of a national digital economy, ensuring national interests and the implementation of strategic national priorities.

For the purposes of designing a digital transformation of an enterprise, it is necessary to develop a classification of digital technologies according to the criterion of accessibility and expediency of their implementation in the enterprise. Thus, key digital technologies are combined into three groups:

1) basic technologies are technologies without which digital transformation of an enterprise is impossible (cloud technologies, wireless communication technologies, paperless technologies, etc.);

2) critical technologies - these are technologies that provide a complete digital transformation of the enterprise (big data, cloud computing, unmanned technologies, etc.);

3) breakthrough technologies - technologies that implement the transition from “analog” to a digital enterprise (artificial intelligence, neural networks, distributed data register, machine learning, etc.)

When summarizing the main approaches to digital transformation of industry, which are based on the above technological trends and classifications, the following types of models of digital transformation of an enterprise can be determined: process, industry, technology, matrix (Figure 2).

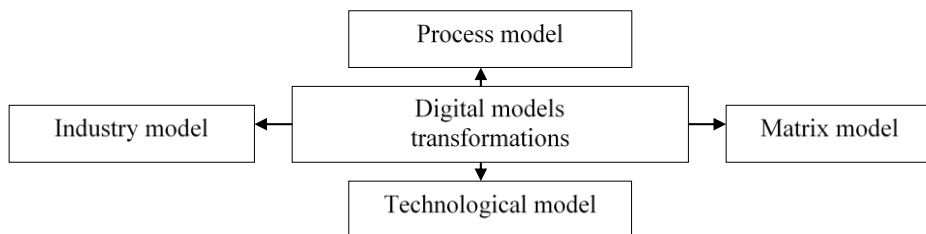


Fig. 2. Types of models of digital transformation of the enterprise.

The process model of digital transformation (process approach), builds a series of digitalized elements of the value chain. For example, first a digital center for research and development, then a digital factory, a digital warehouse and digital transport, electronic commerce, etc. Objects of the chain interact sequentially, while direct production takes the position of an equal object in the value chain.

A digital factory is understood as an integrated complex of digital models, methods and tools, interconnected on the basis of unified data management systems. The key objective of the digital factory is the integrated planning, evaluation and continuous improvement of all the basic structures, processes and resources of the enterprise. With decentralization and virtualization of resources, there is no need to build specialized lines for the production of certain categories of products. As noted in the EAEC Informational and Analytical Report when using this model to start the implementation of digital transformation of an industrial enterprise: “The first tools for digital transformation of industry can be the creation of a Eurasian technology transfer network and a Eurasian network of industrial cooperation and subcontracting” [2].

The industry model of digital transformation of an enterprise is based on the industry approach and the links of industrial enterprises with enterprises of other sectors of the national economy. Within the framework of this model, it is planned to create a digital infrastructure and organize functional interactions between its elements: a digital production system, food and water delivery, smart energy production systems, smart factories, distributed energy systems, unmanned automobile systems, unmanned aerial vehicles, digital railways, telemedicine, digital medicine, smart homes, smart roads, digital financial technologies, digital security systems, electronic commerce, e-ob azovanie digital culture interact with each other by functional relations and mutual requests. In this model, the TechNet direction is highlighted as the most important [9].

The construction of a technological model is based on the priority use of certain technical and technological tools of global trends in the digital transformation of an enterprise. The rapid growth of importance in the production of innovative technologies such as digital design and modeling of technological processes and objects, big data analysis, machine learning and artificial intelligence technologies leads to the formation of a digital transformation technological model in which production is managed by introducing a specific set of digital transformation technologies enterprises. Also, the growing importance of these technologies adapts the production system of the enterprise to changing conditions. And the transition to digital trade in products using digital platforms for placing orders, consumables, raw materials and equipment for the production of goods, as well as the delivery of finished products to the consumer at the right time, bypassing intermediary chains, leads to resource savings and increased income for the enterprise.

From an economic point of view, the technological model has the following advantages: the introduction of a specific set of technical and technological tools, such as the industrial Internet, the Internet of things, digital platforms for the sale and purchase of industrial goods, will expand the product market for the manufactured product, and optimize the cost of acquiring raw materials and components for production, as well as sales of products to customers.

The matrix model of digital transformation of the enterprise is a system of matrices of "goal-means", which allows you to identify redundancy and duplication or, on the contrary, the insufficiency of technological developments and scientific research in the objects of the model, which combines objects by goals and objectives, for example, the matrix "Technology-research", The matrix "Tasks-products", the matrix "Products-technologies", etc.

Thus, the integration model of end-to-end digital transformation on the basis of the matrix and industry models will make it possible to build an integration interdisciplinary digital network in the digital economy, in which all resources are accessible globally and remotely, and enterprises are digital production centers for technological groups that are created and interact based on the principles of openness, provided by harmonious software support and access within the integration space.

4 Discussion and Results

According to the international network readiness index presented in the Global Information Technologies report, the Russian Federation ranked 41st in readiness for the digital economy by a significant margin from dozens of leading countries (Singapore, Finland, Sweden, Norway, the United States of America, the Netherlands, Switzerland, Great Britain, Luxembourg and Japan) [5], and in economic and innovative results of using digital technologies - 38th place. Next, we will assess the level of readiness of Russian enterprises for digital transformation, based on the targets of the Digital Economy program. The results of the analysis are presented in table 1.

Table 1. Assessment of the level of readiness of Russian enterprises for digital transformation.

Focal point	Evaluation results
Roadmap: Information infrastructure should provide access to the state, business and citizens to digital services and knowledge bases	
Infrastructure for digital technologies, the level of development of communication services, storage and transmission of information	<ol style="list-style-type: none"> 1. More than 70% of entrepreneurs in traditional companies and 90% of high-tech companies use broadband Internet access. This indicator is comparable to global trends. 2. The level of use of other data storage and processing services is at a significantly lower level for traditional companies. High-tech startups have a higher level. 3. 52% of traditional and 85% of high-tech companies use mobile Internet, 33% and 63% use servers and data centers, and 25% and 66% respectively use cloud services. These indicators do not correspond to global trends.
Business digitalization level	<ol style="list-style-type: none"> 1. About 63% of traditional business companies and 79% of high-tech startups are represented on the Internet. 2. Less than 50% of companies have full-fledged websites with detailed information about the company, its products and services (43% among traditional and 58% among high-tech companies). 3. Less than 50% of companies have their own pages on social networks or use digital communication channels in instant messengers (28% for traditional businesses and 47% for high-tech startups). These indicators do not correspond to global trends.
The level of automation of internal business processes	<ol style="list-style-type: none"> 1. Electronic document management is used by 64% among traditional and 68% among high-tech companies. 2. To automate business processes, companies use non-specialized solutions with a limited set of functions and an array of management solutions, the share of complex IT solutions does not exceed 20-30%.
Roadmap: human resources and education ensure the creation of key conditions for training specialists in the digital economy.	
Roadmap: the formation of research competencies and technological groundwork is aimed at creating a support system for search and applied research in the field of the digital economy, ensuring national security and technological independence at the global level.	
Human capital development	<ol style="list-style-type: none"> 1. Digital skills are below average. 2. Russian companies generally pay relatively low attention to the training of employees in the field of digital technologies. 3. High-tech startups show a higher level of activity: educational programs in the field of digital technologies are implemented in 33% of respondents.
Roadmap: information security ensures the achievement of a state of security of the individual, society and the state from internal and external information threats.	
Informational security	<ol style="list-style-type: none"> 1. Less than 20% of companies faced information attacks that caused financial losses. 2. More than 30% of respondents rate threats in the field of information security as probable. At the same time, companies do not have effective technologies to counter information attacks.
Roadmap: the formation of a new regulatory environment that provides a favorable legal regime for the emergence and development of modern technologies, as well as for the implementation of economic activities related to their use (digital economy).	
Digital state: services and regulation	About 53% of companies from traditional industries and 64% among high-tech start-ups use various types of public services in electronic form, while about 30% rate this experience as positive and only 6-7% as negative.

The results of the analysis show that the pace of digital transformation of Russian enterprises lags behind global trends.

5 Conclusion

At present, digitalization is a strategic development priority in many countries [15,16]. Digitalization of the economy is a priority objective of strategies and state development programs of the Russian Federation. At the same time, Russia still has low positions in the international network readiness index and shows a significant lag behind leading countries such as Singapore, Finland, Sweden, Norway, and the USA; indicators of the use of the Internet and computer networks in Russian organizations have positive dynamics, but their level is still insufficient to achieve the goals and objectives of the transition to a digital economy.

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