www.revistageintec.net
ISSN: 2237-0722
revista GEINTEC Gestão, Inovação e Tecnologias

Digital Transformation of Enterprises under the Influence of Industry 4.0 in Russia and at the Global Level

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Abstract

The article describes the Industry 4.0 which characterizes the current trend in the development of automation and data exchange, which includes cyber-physical systems, the Internet of Things and cloud computing. It represents a new level of organization of production systems and management of the value chain throughout the entire life cycle of products. The article is devoted to the consideration of modern approaches to the definition of the concept of "Production systems digital transformation." The study used several methods: generalization, systematization, formalization, logical, formal methods, as well as comparative analysis methods to study modern approaches of the definition of the studied concept. The tasks considered in the article are theoretical. The economic content of the concept of "Digital production systems transformation" is disclosed. The article presents the current economic content of the concept of "Digital transformation of Production systems under the influence of Industry 4.0" based on a review of modern approaches to the definition of this concept, and also highlights key indicators for the digital transformation of production systems under the influence of industry 4.0 at the global level. The basic concepts, ideas, methods of digital transformation are formulated. A new technology for the implementation of management tasks based on system design, control theory, business process and intelligent modeling were proposed.

Key-words: Production System, Digital Transformation, Intelligent Modeling, Technological Potential, Performance Evaluation, Continuous Improvement, System Design, Digital Twins, Internet of Things, Industry 4.0., Robotics, Artificial Intelligence, Additive Manufacturing, Big Data and Analytics, Cybersecurity, Cloud Technologies.

1. Introduction

Nowadays, the development of the Internet, info communication technologies (ICT), sustainable communication channels, cloud technologies and digital platforms, as well as the information “explosion” of data bursting out of different channels, provided the emergence of open information systems and global industrial networks that go beyond the boundaries of an individual enterprise and interact with each other. Such systems and networks are having a transformative impact on all sectors of the modern economy and business outside of the ICT sector itself, and are moving industrial automation to a new fourth stage of industrialization known as industry 4.0. Main elements of that systems are: Elements of the Internet of Things, Artificial intelligence, machine learning and robotics, Cloud computing, Big Data, Additive manufacturing, Cybersecurity, Integration system, Modeling, Augmented reality.

Many of these elements have been successfully applied in practice for a long time, but their integration into one integral system will allow to develop the concept of "Industry 4.0" and provide a new level of production efficiency and additional income through the use of digital technologies, the formation of network interaction between suppliers and partners, and also implement innovative business models.[3]

The digital transformation of enterprises is becoming a key factor in increasing competitiveness and production efficiency. This requires the use of new information technologies for managing machine systems and supporting the network interaction of people-operators of the production system using artificial intelligence. [1, 2, 4] From the point of view of potential, it is most advantageous to join international chains, which over the years have accumulated traditional and modern experience in the development of the production system, a unique production culture. [5]

The concept of Industry 4.0 is based on the creation of “smart” factories, where it is possible to ensure the uninterrupted implementation of production processes (monitoring the cycle in real time, controlling the production in automatic mode, etc.).

The various mechanisms of Industry 4.0 are involved in almost all production processes, from product design to production safety. They can help improve performance results, make changes faster and more scalable, and get more consistent results [6].

If we talk about the qualitative transformation of the production process itself, the introduction of robots can play a significant role. Many operations carried out in production are primitive, highly repeatable and do not require human intervention. On the contrary, the use of labor

in such cases can only inhibit development. Nevertheless, the Russian industry is currently distinguished by a low level of production robotization.

According to the National Association of Robotics Market Participants, at the end of 2018, about five thousand robots were in operation in Russia, that is, about five robots for 10 thousand jobs. While in the world this figure is on average about 20 times higher. At the same time, according to the OECD, labor productivity in Russia is only $ 23.5 against $ 48.8 in the OECD countries.

Despite the readiness for widespread use of information technologies, the degree of penetration of digital solutions in the industry is quite low. It's all about investment. Not every business is willing to incur high costs and tough savings to get on a new track. This is especially noticeable against the background of other sectors of the economy. The digital transformation of a plant requires significant investment.

At the same time, some lag in digital development gives Russian industrialists certain advantages over foreign competitors. Manufacturers have the opportunity to immediately replace all outdated systems and equipment with the latest, most advanced solutions and models. We are already witnessing the emergence of digital transformation of the industry, and with a competent approach, we have a chance to catch up and, perhaps, even overtake world leaders.[7]

2. Materials and Methods

The study uses several approaches: generalization, systematization, formalization, logical, formal methods, as well as comparative analysis methods to study modern approaches to the definition of the studied concept. The tasks considered in the article are theoretical.

Systematic literature review was conducted using the databases – Google scholar and Scopus. Emphasis was on the most recent publications, especially from 2011 – 2019, even though most of the literature was found before 2010. Only peer-reviewed articles such as journal articles, conference proceedings and book chapters were considered. Initial selection of articles included references about manufacturing enterprise information systems, the tasks that predictive analytics solves and its advantages. Analysis shows the stages of digitalization that an enterprise needs to go through. [8]

In the subsequent section, findings are discussed and finally, the conclusions are drawn (where research gap was also identified for further research in future). Case research allows the study of the phenomenon in its natural context allowing good use of existing experiences. It allowed the study to reconcile the evidence from observations and data, with research literature. Qualitative synthesis of the 15 eligible (eligibility based on their links to Virtual Enterprises and flexible

production systems) articles was done to write about application of flexible production systems as an instrument of the new paradigm of digital transformation. Given the requirement to generalize, thematic coding and analysis was done to draw the conclusions. Every section of this paper is written based on the qualitative methodology of literature review.

The main research method is remote analysis of open data cases published by companies that have included digital transformation and Industry 4.0 in their corporate strategies, and the method of expert assessments of the studied economic phenomena [9].

Research has confirmed that Industry 4.0 technologies have the greatest impact on productivity improvement and transformation of production systems and industrial production: robotics, Internet of things, additive manufacturing, big data and analytics, cybersecurity [10].

3. Results

The fourth industrial revolution is based on the convergence of real and virtual worlds. Through an increasingly widespread factory sensorisation, the real world provides a huge amount of data that are exploited by the virtual one (by integrating them with third parties' datasets) to produce more and more reliable analyses and forecasts, able to effectively support tactical and strategic management of the company. Digital transformation impacts on each phase of the company's life cycle, from product / process design to the optimization and day-to-day management, as well as its reconfiguration.

All production systems, when viewed at the most abstract level, might be said to be "transformation processes"—processes that transform resources into useful goods and services. The transformation process typically uses common resources such as labor, capital (for machinery and equipment, materials, etc.), and space (land, buildings, etc.) to effect a change. Economists call these resources the "factors of production" and usually refer to them as labor, capital, and land. Production managers have referred to them as the "five M's": men, machines, methods, materials, and money.

When viewed as a process, a production system may be further characterized by flows (channels of movement) in the process: both the physical flow of materials, work in the intermediate stages of manufacture (work in process), and finished goods; and the flow of information and the inevitable paperwork that carry and accompany the physical flow. The physical flows are subject to the constraints of the capacity of the production system, which also limits the system's ability to meet output expectations. Similarly, the capacity of the information-handling channel of the production system may also be an important measure of a system's output. The management of information

flows, or the planning and control of the system to achieve acceptable outputs, is an important task of the production manager. [11]

While the capacity of the system is the major factor in determining whether output expectations can be met, the additional consideration of quality must also be seen as a limiting factor. The quality of a product, measured against some objective standard, includes appearance, performance characteristics, durability, serviceability, and other physical characteristics; timeliness of delivery; cost; appropriateness of documentation and supporting materials; and so on. It is an important part of the definition of a system.

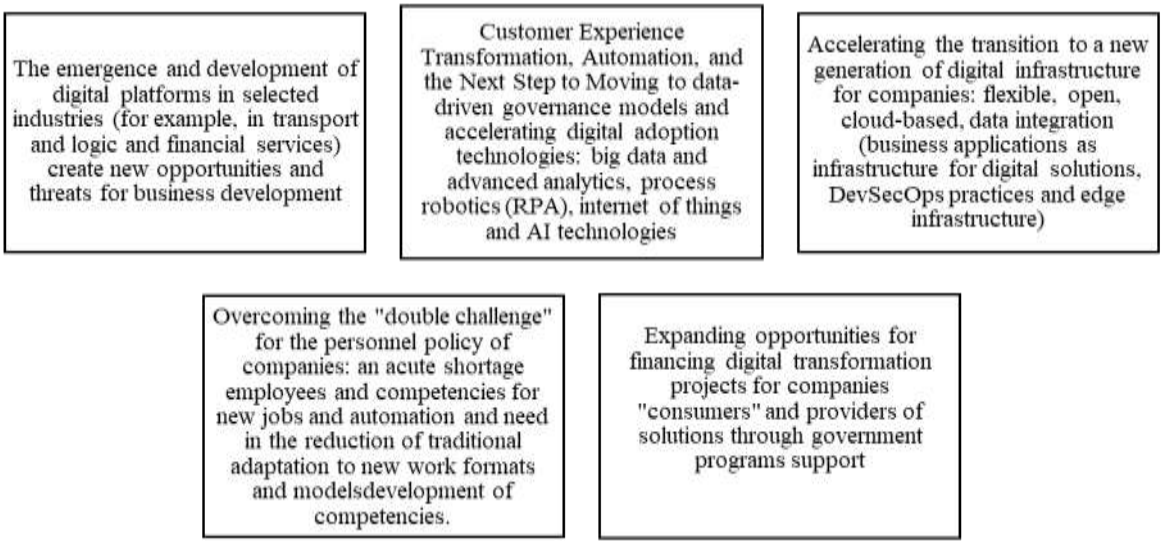
New goals of digital transformation of companies were proposed by authors in a range from implementing individual digital solutions to cultural transformation and ecosystem creation:

Fig. 1- Goals of Digital Transformation of Companies Range from Implementing Individual Digital Solutions to Cultural Transformation and Ecosystem Creation

Typical goals of Digital transformation	Short description
Operating efficiency increase/ Cost Reduction/ Generate revenue 	Reducing costs, increasing reliability, ensuring the level of health and safety and solving other operational tasks through the implementation of digital solutions
Competitive advantage/ Employee performance 	Launch of new products (services) using digital technologies ▪ Transition to new business models using digital technologies for maintaining the competitive position of the company and / or to improve the level of service (product quality) for consumers
Improving the quality of business decisions and transparency 	Collection of new data and digitization of existing data and implementation data analytics tools for the purposes: - Control over the activities of the company - Improving the quality of business decisions and excluding human mistakes
Implementation of innovative projects based on digital technologies in compliance with data security	Development and implementation of innovative solutions based on digital technologies and company data ▪ Implementation of solutions to external consumers (optional)
Agility 	Digital, cultural, organizational and often operational transformation for qualitative change of the company ("digital company"): The concept of an organization as an adaptable organism, as opposed to a rigid, autocratic body, is a compelling one in the digital world.
New business models	Monetizing a company's existing customer base or technology platform through the creation of a digital ecosystem ▪ Going beyond the traditional industry

Trends in digital transformation of companies in Russia in 2020-2021:

Fig. 2- Trends in Digital Transformation of Companies in Russia in 2020-2021



Companies that didn't have time to master digital tools before the pandemic still have a chance to close the gap with their competitors and catch up on downtime. However, the window of opportunity will not last forever. Digital transformation "wisely" is no longer a choice, but becomes a condition for survival not only in a competitive environment, but also in a situation of uncertainty [13, 14].

Digitalization is precisely the application of technology and information processing skills to simulate future scenarios. In a pandemic, the list of priority business tasks has changed, as well as customer requirements for the speed of implementation of certain solutions. Those who recognized the critical role of digital technology even before the pandemic clearly benefited from the announcement of the first restrictive measures.

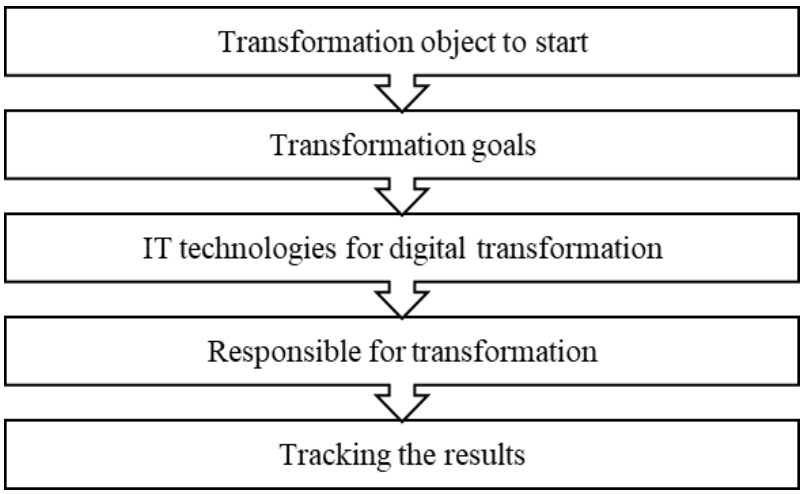
The key task of digitalization is not only to transfer processes from analog to digital, build a 3D model of a product or teach enterprises to predict, but to provide business with digital tools for modeling and production that will work at this particular enterprise, regardless of what tomorrow is weather in all areas of our life.

However, what will be more valuable is the creation of a "living" digital model of the entire production system, which allows you to play thousands of scenarios or production solutions, choose the only correct option and optimize processes taking into account the received data. We call this approach the “smart digital twin” of a product or enterprise as a whole. Of course, this will allow you to move to a completely different level of speed and quality of decision-making.

The main question is whether certain enterprises are aware of their key performance indicators (KPIs) and parameters that need to be improved or modeled through digitalization. We come across examples when the "tender for digitalization" is held not with the aim of achieving specific changes and improving KPIs, but in order to select the cheapest offer on the market and a contractor who is ready to implement anything at the lowest price. However, real digitalization projects are very complex and usually costly, so customers should first of all look for experts and technology partners.[12]

Stages of digital business transformation:

Fig. 3- Stages of Digital Business Transformation



Transformation Object to Start

The very first stage is to decide whether it is needed at the moment or not. Most often, such a transformation is not required by small companies with a small number of employees, especially if computers and the Internet are used poorly.

Also, the time of digital transformation has not come if the management does not have the time, resources and desire to do this at the moment.

Next, you need to figure out which area of business to start the transformation of the company as a whole. For example, sales, logistics, accounting, HR, etc.

For example, it was decided to automate the work of the HR department, that is, the business process of finding, hiring, registering new employees.

It is advisable to lay no more than 1-2 points at a time, since attempts to transform at once more and more often turn out to be unsuccessful. Undoubtedly, the transition to a true digital business

involves an integrated approach to transformation, but given the big picture, it is better to start small to get the first results in a short time.[15,16,17]

Sometimes, when starting automation, a business process is taken as the first “candidate” for it, the potential problems with which do not carry great risks for the company. For example, the process of generating a quarterly report. But here are another risk arises: since this process is not often in demand, the benefits of automating it are practically zero, and neither employees nor management may be impressed with the result achieved. Therefore, there will be no desire to go further along the path of automation and connect other processes.

To prevent this from happening, it is better to start with the most popular, but at the same time well-formalized processes. In this case, the company will get results by speeding up and streamlining, for example, paying bills. The real benefits of automating one process will be an incentive to move on.

Transformation Goals

You always need to start by choosing a goal. The first thing that comes to mind is cost reduction: time and financial. This is what is called "efficiency gain". However, in the era of digital transformation, priorities are increasingly shifting and you have to think about more than cutting costs. Often this goal fades into the background and the focus shifts to new opportunities that will help the business grow further.

In other words, digital transformation is not carried out when you need to lower some costs. It is needed if the business realizes that it absolutely needs new opportunities for development.

If there are many objects or goals, then you will need to select one or several business processes that will be transformed in the first place. When choosing processes, experts advise starting with the following:

- Established: those that have been around for a long time.
- Frequent: the process takes place at least 15 times a month.
- Short: 1-2 weeks from start to finish.
- Concrete, with a pronounced beginning and end.

With few stages and employees involved. Compliance with all these principles will allow you to select those processes that are really suitable for transformation, and it can be carried out quite quickly, and its effectiveness can be tracked in 1-2 months, and not in 10 years.

IT Technologies for Digital Transformation

There are a lot of strategies that the IT industry can offer. The main thing is to choose the most suitable:

- Big data analysis
- Omnichannel
- Blockchain
- Artificial Intelligence
- Cloud technologies
- 3D printing
- Remote workplaces

All these technologies can, if desired, be introduced into a specific business, but they are not always needed to solve urgent problems. In addition, experts emphasize that technology alone cannot make a business digital.

Digital transformation never starts with the choice of technology, because technology is just a tool. Before you take any tool, you first need to clearly define the task, since the tool is selected for it. In the case of digital business transformation, the situation is the same.

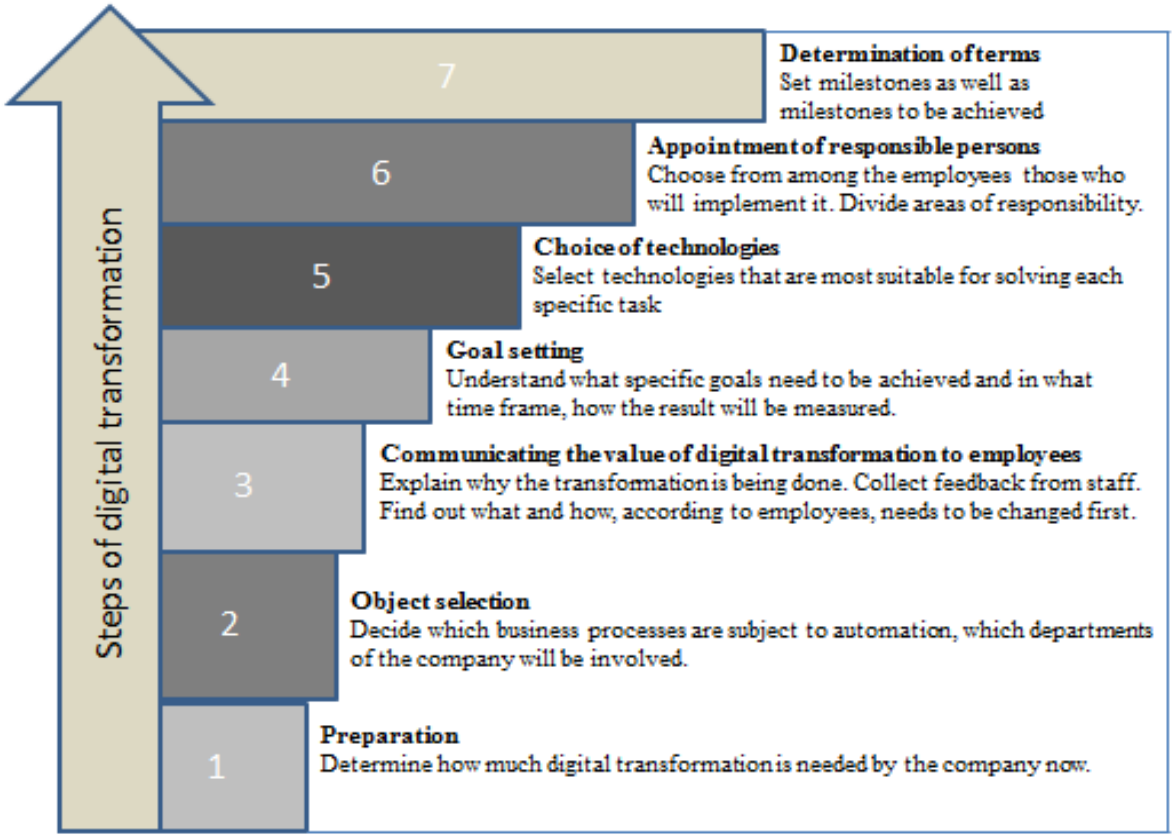
- First, you need to choose a specific business area and the goals of its transformation.
- Then - outline the range of problems that need to be solved.
- And only then come to choice of technology.

For example, while automating CAPEX at Hertz using solutions based on the Comindware Business Application Platform, the main goal was to provide a seamless experience for many employees from different locations around the world.

The exact correspondence of the chosen technology to the task at hand is a much more important guarantee of success than its innovation or successful experience of application in other companies.

The procedure for preparing for digital transformation is clearly presented in the figure 4:

Fig. 4- The Procedure for Preparing for Digital Transformation



Responsible for Transformation

Another fundamental task is to build a hierarchy of persons who will be engaged in digital transformation. Obviously, these should be employees from both the "business side" and the "IT side". Basically, the focus is on the heads of those departments where the transformation is planned in the first place. For example, the head of the logistics service or the chief accountant.

It is imperative that all of these individuals have the motivation to pursue digital transformation and understand why it is needed. Otherwise, the risk increases that everything will be done formally, and the company will not see the real effect.

Tracking the Results

Ideally, the company should have a lead digital transformation leader. This can be, for example, one of the deputy general directors, who will build interaction with each of the other responsible persons, and periodically arrange general discussions to understand whether the process is going in the right direction, what has already been achieved and what are the priority current tasks [23,24].

Summing up, we can say that the main thing before digital transformation is to determine its goals and objectives, deadlines and resources, as well as to come to an understanding between the responsible persons. At the same time, it will not be possible to make a breakthrough on technologies alone, but it will not work out without them in the process of reengineering business models. Only a combination of both will allow you to bypass all difficulties and get a positive result.

The benefits of Industry 4.0 include increased productivity, efficiency, flexibility, and increased profitability. Industry 4.0 also improves customer service.[18,19]

Industry 4.0 technologies providing more knowledge about the manufacturing process, supply chains, distribution chains, business performance and manufacturing. This creates opportunities for innovation, new product development, supply chain optimization, OEE improvement, and more. Industry 4.0 technologies enable to produce better quality, more marginal and / or more innovative products. For example, Industry 4.0 technologies allow to offer customers personalized products, but still use mass production methods to produce them.

4. Conclusion

The implementation of the principles of Industry 4.0 allows getting a number of advantages that were not available in the traditional models of the past. For example, businesses can now achieve personalization and personalize orders according to the personal preferences of customers. Old factories and factories are turning into "smart" and begin to produce literally piece products on individual orders. With all this, the unit costs for the production of a unit of output are reduced, and companies are able to produce a unique personalized product. The costs of producing customized products at an enterprise with deep automation are low: if earlier for each such pair of new tubes of toothpaste one would have to reconfigure the equipment by hand, today this is done by the computer system itself and in a matter of seconds[20,21,22].

Digitization has great potential for the further development of companies, but it also increases competition. Companies are forced to quickly improve, master new opportunities and technologies for efficient production and an even better product. Thanks to the high level of transparency, companies' actions are under close public scrutiny like never before. Companies that refuse to participate in these activities risk losing the public recognition on which their reputation is based[25].

The benefits of Industry 4.0 also include increased flexibility. For example, it is easier to scale production up or down in a smart factory. In addition, it is easier to introduce new products to the production line, as well as create opportunities for one-off production runs, high-mix production, and more.

The current industrial environment is distinguished by the adoption of novel production paradigms, often overlapped or competing with each other, along with the development of radical innovations resulting in several promising enabling technologies. Furthermore, this environment is distinguished by the massive digitalization of manufacturing and assembly processes which generate at high velocity a huge volume of data distinguished by a wide variety which could be leveraged to benefit of their hidden but remarkable value. All these aspects result in several challenges faced by current production systems.

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