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KEY AREAS

OF INDUSTRIAL TRANSFORMATION IN THE CONTEXT OF DIGITALIZATION

ÁREAS CLAVE DE TRANSFORMACIÓN INDUSTRIAL EN EL CONTEXTO DE LA DIGITALIZACIÓN

Pavel Valerievich Mikhailushkin[1]
E-mail: mikhaylushkin@mail.ru
ORCID: https://orcid.org/0000-0003-1304-8102
Alexey Valeryevich Oblizov[2]
E-mail: doc@krags.ru
ORCID: https://orcid.org/0000-0003-4756-9117
Denis Vitalevich Osipov[3]
E-mail: info@rut-miit.ru
ORCID: https://orcid.org/0000-0002-1251-5867
Tatiana Viktorovna Aleksashina[3]
E-mail: info@rut-miit.ru
ORCID: https://orcid.org/0000-0003-3675-4157
Victoria Georgievna Vorobyeva[3]
Email: info@rut-miit.ru
ORCID: https://orcid.org/0000-0002-1564-1826
[1]Kuban State Agrarian University. Russian Federation.
[2]The Komi Republican Academy of State Service and administration. Russian Federation.
[3]Russian university of transport, Moscow, Russian Federation.

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ABSTRACT

In the 21st century, the development of digital technologies has had a decisive impact on the lives of citizens and the development of the economy, both nationally and internationally. Any modern state in its development experienced such a stage as they transition from a feudal society to an industrial one. This transition was carried out with the help of such a process as the "industrial revolution". Before the Fourth Industrial Revolution ("Industry 4.0"), three previous industrial revolutions led to a paradigm shift in manufacturing: mechanization with water and steam, mass production on assembly lines, and automation with information technology. Hence, the article attempts to discuss the key areas of industry transformation in the context of digitalization. The constant changes that are taking place in digital technologies represent one of its main characteristic features, and at the same time - a particular challenge and threat for the actors involved in it. This is mainly since the speed of development of digital technologies is increasing every year. More and more new products appear on the markets, the use of which was not previously possible by consumers and therefore is not subject to state control. The result of such processes is the "failures" of government regulation, whose correction can take many years.

Keywords: Digitalization, industrial transformation, digital technologies, economics, risks.

RESUMEN

En el siglo XXI, el desarrollo de las tecnologías digitales ha tenido un impacto decisivo en la vida de los ciudadanos y el desarrollo de la economía, tanto a nivel nacional como internacional. Cualquier estado moderno en su desarrollo experimentó tal etapa en la transición de una sociedad feudal a una industrial. Esta transición se llevó a cabo con la ayuda de un proceso como la "revolución industrial". Antes de la Cuarta Revolución Industrial ("Industria 4.0"), tres revoluciones industriales anteriores llevaron a un cambio de paradigma en la fabricación: mecanización con agua y vapor, producción en masa en líneas de montaje y automatización con tecnología de la información. Por lo tanto, el artículo intenta discutir las áreas clave de la transformación de la industria en el contexto de la digitalización. Los constantes cambios que se están produciendo en las tecnologías digitales representan una de sus principales características y, al mismo tiempo, un desafío y una amenaza particular para los actores involucrad os en ella. Esto se debe principalmente a que la velocidad de desarrollo de las tecnologías digitales aumenta cada año. Cada vez aparecen más productos nuevos en los mercados, cuyo uso no era posible anteriormente por parte de los consumidores y, por lo tanto, no está sujeto al control estatal. El resultado de tales procesos son los "fallos" de la regulación gubernamental, cuya corrección puede llevar muchos años.

Palabras clave: Digitalización, transformación industrial, tecnologías digitales, economía, riesgos.

INTRODUCTION

Today digital technologies enable people to communicate with each other, being in different parts of the planet; instantly distribute and receive the necessary information; to manage enterprises at a distance; carry out electronic exchange of goods and services. Digital technologies have created the basis for the emergence of a new type of economy - the so-called. "Electronic", or "digital", economy, which today is rapidly developing all over the world (Goryushkina, et al., 2020; Belousova, et al., 2021).

The real sector of the economy is least associated with the development and application of digital technologies. However, the acceleration with which the emergence of more and more new technologies is forcing the business to make modernizations, to form new business models (Bakharev, et al., 2020). Today, many enterprises in the "heavy" industrial and infrastructure sectors of the economy face a choice - to join the race for those companies that are rebuilding production using digital technologies or to use traditional business models that have been tested by time.

The first industrial revolution began in the second half of the 17th century with the use of steam and water energy, which helped in mechanical production and greatly improved the agricultural sector. The second industrial revolution, which took place in the late 19th and early 20th centuries, is defined as the period when mass production was introduced as the main means of production in general.

Mass production helped to introduce railways into the industrial system, which subsequently contributed to the massive development of manufacturing in general. Since the end of the 70s of the 20th century, the Third Industrial Revolution began, as a result of which the mass use of electronic and information systems in the production began, which provided intensive automation and robotization of production processes. Despite the active use of various types of infocommunication technologies (ICT), electronics and industrial robotics, industrial automation was rather local in nature, since each enterprise or division within the same company used its own control system, incompatible with other systems.

DEVELOPMENT

The development of the Internet, ICT, digital platforms, the availability of information, the exchange of experience through the Internet have led to the emergence of open information systems that go beyond the boundaries of one company and interact with each other. Such systems and networks have a tremendous impact on all sectors of the modern economy and business outside of the IT sector itself and are transferring industrial automation to a completely new degree of industrialization, expressed in the Fourth Industrial Revolution (Industry 4.0). This term was introduced in 2011 as part of the state Hi-Tech strategy of Germany. Based on this program, the following directions of industrial transformation can be distinguished (Figure 1.) (Transformation of the industrial complex):

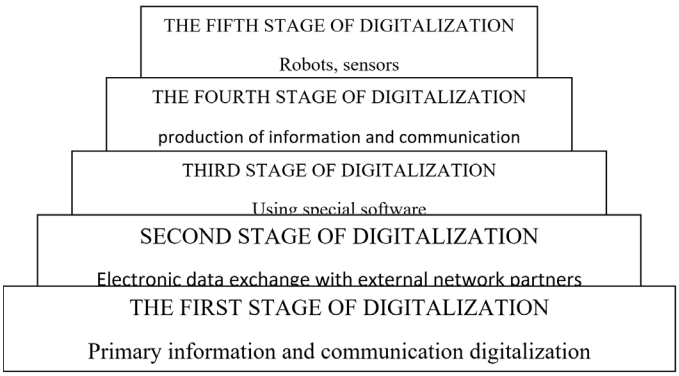

Figure 1. The pyramid of the process of digitalization of the industrial complex (Source: Author)

At this stage, it is planned to computerize the enterprise, to introduce large-scale computers into the production sphere (Nguyen, et al., 2020). Computerization is central and imperative for further digital transformation of industry. This stage is usually considered as a process of implementation and technical modernization of computers, which make it possible for further automation of information processes of the enterprise. So, computers are necessary for the control of technological processes, production, transmission of electricity, the design of complex objects, planning, accounting, collection and analysis of statistical data, ensuring the execution of operational processes (Magsumov & Grakhova, 2020). The use of computers, as well as their constant updating and modern equipment, in various areas of industrial enterprise management increases the efficiency of collecting and processing information, is a key factor in increasing the efficiency of management interaction. The indicators that characterize the level of development of this stage at the enterprise include the equipment and quality of computers, the availability of local area networks, e-mail, the use of "cloud" servers, the provision of smartphones, tablet computers with high-speed Internet connections to employees.

The second stage of digitalization of an industrial enterprise is electronic data interchange with external network partners (EDI). EDI in conjunction with the Internet allows you to make electronic transactions and, thus, accelerate the processes of interaction between suppliers,

contractors, consumers. The exchange of information on paper provides for the subsequent entry of the latter into the computer system. The use of electronic document management allows you to avoid these processes and significantly speed up the collection and processing of data. The number of indicators that characterize the level of development of this stage at the enterprise include the share of enterprises using EDI by forms of exchange, the share of the cost of purchases and / or sales of goods and services transmitted (received) via the Internet, the share of enterprises using the Internet to communicate with suppliers / consumers.

The third stage of digitalization of an industrial enterprise is the use of special software (software). Special software is a set of programs that are used to solve a certain array of tasks. This stage of development of digitalization is closely related to the massive implementation of the automation process, which uses self-regulatory methods to free a person from participation in the production process, or to significantly reduce the labor intensity of the functions performed (Industry 4.0: Building the digital enterprise) (Dmitrieva & Romasheva, 2020). Such software is designed to support decision-making by an official, namely, the choice from an established database of the optimal (method) solution method, based on the developed and tested algorithm. In this case, an industrial enterprise, being at the same time a generator and consumer of technological innovations, is acutely susceptible to specialized software, since this ensures the process of acquiring competitive advantages. Also, an important part of this process of digitalization of an industrial enterprise is the renewal of the machine tool park and the presence of a high proportion of equipment with numerical control in it. The indicators characterizing the use of special software include the share of enterprises using software for scientific research, design and modeling, automated production management, CRM, ERP, SCM systems, solving managerial and economic problems, making financial settlements with counterparties in electronic form (Kashirskaya, et al., 2020).

4. The fourth stage of industrial transformation includes the production of information and communication technologies and equipment (Industry 4.0: Building the digital enterprise). This stage marks the transition to more and more digitalization of the enterprise and demonstrates the transition from the simple consumption of new technologies to their production, the development of the internal market for electronic equipment, and the start of the development of our own computer programs. The main indicators to which this stage belongs include the share of goods and services of its own production related to IT (Industry 4.0: Building the digital enterprise).

5. The fifth stage of digitalization of an industrial enterprise includes the production and use of robots and sensors, the so-called industrial Internet. At this stage, digital transformation is meant as a process of introducing digital data transmission systems at the level of primary systems, communication and control facilities that ensure the transmission and distribution of digital information flows at the level of secondary networks. The Industrial Internet is a multi-level system that includes various industrial objects with built-in sensors, controllers and software for collecting and exchanging information with the ability to remotely control and manage (Industry 4.0: Building the digital enterprise).

The main components of the industrial Internet are smart sensors that collect data directly during the production process, means of transmitting the collected data, cloud services, and analytical programs for the information received. The key idea of the final stage of digitalization of an industrial enterprise is that the production capacities of enterprises will interact with the manufactured goods and, in the course of industrial production, will adapt to new consumer demands (Dunets, 2019; Yemelyanov, et al., 2019).

The role of smart machines in the modern world is gaining so much weight that in the near future they will participate in the process of production, management and sales of products. Moreover, they will also be networked for independent data analysis and decision-making based on the information received (Chernyak, 2012). Production machines, assembly lines or even factories and factories will also be integrated into one network. With all this, they will interact without human intervention (Webster, 2004).

At the enterprises of the secondary sector of the economy, it should also be noted the impact of digital transformation on the supply chain at 4 levels: marketing, procurement, storage and transportation.

Big data will have a huge impact on the supply chain. At the marketing level, big data apps will better manage customer information, build better customer relationships, and generate leads. In this case, it uses a system of “big data” and artificial intelligence (“AI”) to predict the needs of customers for products that are sold directly. Based on demand forecasts and real-time data on remaining inventory, automatic purchase orders are generated for primary producers to replenish stocks

Digital marketing is defined by the use of numerous digital tactics and channels of communication with customers

where they spend most of their time: online. From the website itself to the online branding assets of a business - digital advertising, email marketing, online brochures, and more - there are a number of tactics that fall under "digital marketing." The best digital marketers have a solid understanding of how each digital marketing campaign supports their overall goals. And, depending on the goals of their marketing strategy, marketers can support a larger campaign through the free and paid channels at their disposal.

At the procurement level, internal and external system data must be integrated into a coherent whole during digitalization in order to reduce the cost of purchased products. The company's purchasing managers in this case manage a portal through which their suppliers provide information about their sales without the latter having to buy certain software (Frehe, et al., 2014; Khoruzhy, et al., 2020). The biggest impact of digitalization is the increase in speed. Thanks to automated purchasing processes, everything moves much faster. This includes both supply and demand - a very difficult scenario as they don't always move in the same direction. For purchasing teams, life is a constant push between internal and external forces (Frehe, et al., 2014; Kosenchuk, et al., 2019).

Software can help with this, but only if the company has clear goals. To fully realize the potential of the digital revolution, purchasing departments must re-engineer their entire philosophy and align it with these new technologies. The following goals are integral to the journey to digital transformation:

Category management

First, it makes sense to work with vendors that are investing heavily in digitalization. In fact, preference should be given to those who use digital products and services. It is a good idea to have a team that will keep an eye on competitors in the digital environment and keep up with new inventions.

Supplier relationship management

Supplier relationship management is an important part of the procurement process. However, digitalization requires precise supplier management to be successful. Using analytics and business intelligence tools can be very helpful in identifying potential vendors. The information gathered through these methods can also help stakeholders make informed decisions about future initiatives.

Risk management

The term "VUCA" is used to describe markets that are volatile, uncertain, complex and ambiguous. Depending on which industry the activity is in, this can very well describe the commercial landscape at certain times of the year. Maintaining competitiveness requires careful monitoring of the value chain at all levels.

Warehouse management (especially inventory management) has changed dramatically with the introduction of modern RFID identification systems. The current warehouse and logistics systems are not transparent, since the warehousing process is built and controlled by a limited number of people. Blockchain can play a key role in achieving transparency at all levels. This technology allows information to be disseminated quickly and securely, making real-time data exchange for warehouses efficient and transparent. Blockchain is incomplete without a key technology: the Internet of Things (IoT). The IoT is an ecosystem of sensor devices (for example, for determining location, humidity, temperature) that are linked through digital networks. They can collect and transmit data in real time without human intervention. Together, these technologies provide real-time transparency and seamless communication between processes and chain partners, resulting in highly developed, efficient and effective operating models (Giannikas, et al., 2013).

Moving from stationary desktop workstations to smartphones and mobile devices is an important step forward in improving storage efficiency. Today, devices and applications are dramatically reducing the time it takes to walk through the warehouse and allow warehouse employees to work and access data both inside and outside the warehouse.

Smartphones not only free clerks from the warehouse, but also add new capabilities to standard workstations. Modern mobile warehouse solutions can provide the superior operational efficiency and computing power that warehouse operators need. Benefits of features such as image processing (images and video), tracking, cloud integration, video conferencing, voice / face recognition, and even personal assistants open up new frontiers for the transformations these technologies can bring to warehouse operations. The more the direction of the future goes, the more mobility becomes essential. Warehouse mobility is one of the safest areas for investment if well planned and strategically aligned with operational needs.

Transportation and logistics (T&L) efficiency and risk forecasting ability have improved significantly through Big Data analytics. Companies can not only choose the optimal path in real time, but also effectively avoid natural disasters and car accidents. UPS uses telepathic trucks that have sensors that log more than 200 data points for more than 80,000 vehicles every day. The UPS used patented

packet flow technology to determine which packets are loaded on each vehicle, and then collects data on several aspects of fleet operations using a telematics technology system (Singh Jain, et al., 2017).

New technologies affect the entire organization, in every area - there are many technological breakthroughs affecting all areas of the company, from marketing and sales, warehousing and transportation, finance, purchasing, HR and IT. For example, the use of robotics in storage, as well as in customer service and in the back office, the use of data analysis in customer service, supply chain or procurement, migration to the cloud, blockchain use, use of drones, 3D printing, etc. All of these innovations are redefining the way that T&L companies operate.

New entrants can get (profitable) parts of the T&L value chain - technology allows non-T&L companies to enter the market, for example, new platforms for connecting supply and demand ("uberizing" the sector) and exploiting the sharing economy for delivery and collection (especially the last mile). More and more startups are entering this space, but so are the big shippers. The philosophy is becoming more "light and resource intensive", based on new technologies that provide control over the client and data.

Technology is a new way of collaborating in this sector - no longer needing all assets to be in one place: Today, companies are ditching trucks and warehouses, and are working through an ecosystem of partnerships to be more flexible and efficient. In this sense, the technology also enables companies to reduce their environmental impact by avoiding driving, swimming or empty flying. This allows T&L companies to be more scalable and flexible while meeting the dynamic needs of their customers.

Technology is changing the behavior and expectations of T&L stakeholders - customers (B2C and B2B), partners, suppliers and staff are changing the way they want to operate and receive service. Companies and end consumers expect greater efficiency, greater productivity, and significantly more personalized service. Retailers and high-tech companies expect the same level of experience for their customers from their T&L partners as they do themselves. At the same time, a digital culture is essential to attract and retain new talent that will drive productivity and innovation in the digital age.

Smart factories and smart machines are an important part of Industry 4.0 in the manufacturing sector. The term "smart factory" is used practically and scientifically in industry, although there is no single definition. There are several other terms used for this purpose: Factory (the ubiquitous factory), the thing factory, the real-time factory, or the smart factory of the future.

All of the above terms and concepts are very promising prospects for the upcoming technological development. However, while engineers and scientists are constantly working on these conditions, they remain just a vision. Despite everything, this success story is a long and winding path that must be solved with a multidimensional problem before you can become part of this vision of a smart factory in reality.

Based on the analysis of future manufacturing literature, the characteristics suitable for a smart factory are flexibility and reconfigurability, low cost and variability, and maneuverability. One way to achieve some of this functionality is to apply modularity to the application of the technology / product / process organization. Based on this, we propose a conceptual definition: "Smart Factory" is a manufacturing solution that provides flexible and adaptive manufacturing processes that solve the problems encountered in a manufacturing facility with dynamic and rapidly changing boundary conditions in the world (Kuznetsov & Petrov, 2017). This solution can, on the one hand, be related to automation, understood as a combination of software, hardware and / or mechanics, which should lead to optimization of production, which will lead to a reduction in unnecessary labor and waste of resources. On the other hand, it can be seen in the perspective of cooperation between various industrial and non-industrial partners, where the point is to form a dynamic organization.

With the rapid development of Internet technologies and network systems, it can be assumed that, the way is opening for the development of intelligent machines, which after a while will be able to think, learn, remember and at a certain point share that amount of knowledge, or react in certain situations. Regardless of what sounds fantastic right now, intelligent machines are expected to shape jobs, manufacturing processes, and manufacturing systems in the near future.

A smart product is a technology to reduce the chance of breakdowns and frequent production stoppages. These interruptions in production often result in wasted and reduced productivity. The configuration of the system in the field of information about products, their production parameters, requires an intelligent product that is available at the right time in the right place and which can be digitally processed. In this regard, the history of the production of intelligent products is directly shaped on the product itself, which makes the process faster and more efficient. Thus, an intelligent product becomes a means of transmitting information about production processes, stages of the process and characteristics of the product itself.

Advances in computer technology have directly influenced the development and improvement of sensor technology, especially when it comes to intelligent sensors. ISA (International Society for Automation) has defined a sensor as a device that provides an appropriate output signal in response to a specific measured value. Most sensors essentially behave like a passive device, such as a resistor, whose values change depending on external excitation. Sensors do not function independently, but are usually part of a larger system that contains various analog and digital signal processing circuits. The system can be a measurement system, a data acquisition system, or a process control system. A key feature of smart sensors is that they process the input signal at a logic level in order to increase the level of information processing. The sensor can make a logical decision about the level of information (for some initial information). It can take action based on this information, or it can send a message to a higher level. Other features include smart sensors in their self-test capability, variable calibration, improved false data (noise) rejection, and easier setup and use.

Microelectronics, being a part of microprocessor technology, thanks to the introduction of sensors themselves into production, has provided much more functionality, such as the ability to install intelligent and digital communications in the sensor. This allows the sensor to be digitized. Traditionally, sensor outputs are analog signals that are still in the metering system or displayed directly (on the display). This migration from analog sensors to the digital domain has brought significant benefits to users, as digital sensors are much more immune to electrical interference and can greatly simplify their interconnection. Networked sensors, a technology that was created by modifying electronics and PCs, is gradually reaching all areas in industrialized countries and is driving significant progress in the firm's manufacturing processes.

CONCLUSIONS

Thus, the main directions of digital transformation of an industrial enterprise were considered, highlighting the main features and the impact of each technology on the future development of the enterprise.

Industry organizations around the world are entering a period when new digital technologies are empowering people and processes to an unprecedented degree. New, commercialized cloud computing and artificial intelligence (AI) are changing the way people work. Approaches such as the Industrial Internet of Things (IoT) and Industry 4.0 are helping pave the way for digital transformation across a wide range of industries.

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