Digitalization and robotization as instruments for managing the production of innovative goods and services

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Abstract. The absence in modern economic science of a clear idea of the place of robotics in the reproduction process led to the purpose of the study: to determine the place of robotics in managing the reproduction of innovative goods and services in digitalization. The authors conducted a study of the problems of modernization and the creation of a model of industrial-technotronic economic development in the context of digitalization. During the study, the authors identified the main aspects of modernization, the order and stages of transformation. According to the author’s concept, modernization is considered as a form of three levels: the level of the working machine (micro level); level of industrial stage of production, level of national economy. Particular attention is paid to the problem of digitization and robotization of processes as tools for managing the production of goods and services. The authors proposed a new model for the reproduction of goods and services, including, in addition to traditionally production, processes associated with applied research. In the course of the study, a mechanism was developed for the transition from a four-link control system to a five-link (“unmanned technology”). The paper found that the problem of evaluating the effectiveness of digitalization and robotization is of a twofold nature: increasing labor productivity while increasing the number of workers released. The problems associated with the implementation of the digital economy implementation program in Russia are identified. The contradictions that arise during the creation and implementation of "smart robots" in the process of managing the production of goods and services are identified.

1. Introduction

When researching the development strategy of the national economy and determining the target orientation of structural transformations, it is necessary to reveal the essential principles of modernization and industrialization.

In modern conditions, many scientists analyze this problem in detail. Their work examines the various aspects of the formation, functioning and impact of innovation and modernization processes on the economic development of the country, as well as the role of the state in this process: Bodrunov S.D. (2016) The future. New Industrial Society: Reboot; Glaz’ev S.Yu. (2012) Transition to a new humanitarian technological structure; Grinberg R.S. (2014) Deindustrialization and Industrial Policy; Gubanov S.S. (2012) Sovereign impulse. Neo-industrialization of Russia and vertical integration; Dyatlov S.A., Kamyshova A.B. (2011) State policy of stimulating economic growth in conditions of innovative economic development; Ivanter V.V. (2006) Innovative and technological development of...
the Russian economy; Inozemcev V.L (2001) Post-industrial society; Kamysheva A.B. (2011) Theoretical foundations of state regulation of the volume and structure of production in the context of globalization; Popov A.I. (2012) Creating a new development model: modernization and the condition for the transition to an innovative economy; Ryazanov V.T (2014) New industrialization of Russia as a real goal and post-industrial ideal.

The problems of using the digital economy are investigated in detail in the work Rikhter K.K., Pakhomova N.V. (2018) The Digital Economy as an Innovation of the 21st Century: Challenges and Opportunities for Sustainable Development.

The prospects for the impact of digitalization on the management of the production of innovative goods and services at the micro level are considered in the works: Krasyuk I., Kirillova T., Bakharev V. and Lyamin B. (2019) Life cycle management in network retail enterprise based on introduction of innovations; Krasyuk I., Medvedeva Y., Baharev V. and Chargaziya G. (2019) Evolution of strategies of retail and technological systems under broad digitalization conditions; Krymov S., Kolgan M., Suvorova S. and Martynenko O. (2019) Digital technologies and transformation of modern retail.

An analysis of foreign and domestic literature has led to the conclusion that in modern economic science there is no clear idea of the place of robotics in the reproduction process. The purpose of this study is to determine the place of robot building in the process of reproduction of innovative goods and services. In accordance with this goal, the following tasks:

- Determine the level of knowledge-intensive goods and services in the transition to a digital economy;
- To develop a new mechanism for managing the production of innovative goods and services in a digitalized economy;
- To evaluate the economic effect of introducing a “smart robot” with elements of artificial intelligence in the process of managing the production of goods and services.

The object of research is the production of innovative goods and services. The subject of the study is robotics as a tool for managing the production of innovative goods and services.

2. Methods

When considering the problems associated with digitalization and robotization, we proposed a research technique in the form of three levels:

- Level of the working machine (submicro level);
- Regional and sectoral level;
- Level of social production (macro level).

For a deeper study of modernization processes, we have adopted a period of more than 100 years (1890-2019). The complex of automated control systems is studied by groups and includes:

- The first group includes automated enterprise management systems;
- The second group includes industry management systems;
- The third group includes specialized management systems of functional units.

2.1. The economy of our country, since the end of the 19th century to the present, has been distinguished, on the one hand, by its large-scale modernization development strategy, which is aimed at using the latest industrial methods for creating new products. On the other hand, the rapid development of industrial production was interrupted three times by unprecedented major disasters, which each time ended with the economy being thrown back 10-20 years in its development.

The first destruction in the last hundred years was associated with the civil war and military intervention of 1918-1920, when Russia's industrial production was almost completely destroyed. The second - World War II, as a result of which not only industrial production, but the entire living environment, including cities and villages of the European part of Russia, was completely wiped off the face of the earth. Thirdly, the transition to market methods took place in our country according to
the most destructive scheme, as a result of which, in the 1990s, the volume of production of engineering (the basis of innovation) decreased, according to the new Russian encyclopedia, to 37% in 1998 [1]. In 1996, the output of electronic industry products fell to 15.7% of the 1990 level [1].

2.1.1. In the foreign economy, the most common is the opinion that in developed countries there is a process of neo-industrialization in the form of a transition to the economy of a post-industrial society, which is developing on the basis of high technologies, vertical integration and the expansion of the scope of industrial services. This position is defined as basic. Moreover, it is used as a defining parameter of a new phase of the development of a knowledge-based society.

In the encyclopedia “Britanica”, the concept of “industrialization is revealed from the perspective of a change in the economic system as a whole as a process of transition to such a socio-economic system in which industry dominates” [2]. Such a definition in foreign literature is used, as a rule, when characterizing the structure of production (pre-industrial, industrial, post-industrial).

In this paper, we propose a three-level system for studying the processes of modernization and industrialization:

- Level of the working machine (submicro level);
- Regional and sectoral level;
- Level of social production (macro level).

2.1.2. First level. Level of the working machine (submicro level).

K. Marx singled out in it three links of machine production: “Every developed machine device consists of three essentially different parts: machine-engine; gear mechanism; finally, machines - tools or working machines” [3].

A machine engine acts as a driving force; transmission mechanism - regulates the movement, changes its shape (turns from perpendicular to circular); machine-gun - captures the subject of labor and expediently changes it. We can say that the machine tool acted as a starting point in the transformation of craft or manufactory production into machine production. With full automation of production, a fourth link is created in the machine - a control device that allows you to automatically control, monitor and regulate the production process. The difference between the automatic system of machines and previous tools is that here the three-link system is replaced by a four-link system of machines.

The use of an automatic machine system in Russia has been actively used since the end of the second five-year plan, when the transfer of machines to an individual electric drive was completed. Its use has led to an increase in the speed of the machines. An individual electric drive increased the flexibility of managing work operations, created the prerequisites for the automatic control of machines, opened the way to automation of production of goods [4].

In the 1950s, a new direction in the field of automation was created, which was widely used in the field of information processing and transmission - this is the so-called “Automated Control System” (ACS). It represents a complex of hardware and software tools used on a separate technological process scale. Management activity is reduced to the collection, analysis, processing and storage of information. The intended use of ACS is to monitor the progress of production, product quality control, preparation of production documentation. In addition, the ACS system is used to establish communication and interaction with exchange and banking structures.

At that time, as social production developed in leading countries, there was a parallel increase in the complexity of relationships and an increase in the number of management workers. In Russia, for example, only in industry between 1960-1968 year the proportion of managerial personnel in the number of employees increased from 12.9 to 15.7% [5]. As a result, the problem of partial replacement of managerial work through the introduction of automated control systems has become very urgent. Similar transformations began to be actively used in leading developed countries. The use of managerial processes and their replacement with machine systems acts as a complex of computer technology.
In our opinion, the automated control system (ACS) only partially performs management functions. At that time, it was mainly spread in the budget and financial sphere. Industrialization as the first phase of automation of production processes in Russia was carried out on the basis of electrification. In terms of its distribution, it was introduced into related industries in the form of engines, devices, devices based on the use of electricity. This process can be called the first phase of the distribution and use of electricity.

Further development is formed as an independent direction in the form of creating new, more advanced devices, which is accompanied by the expansion of electrified methods inland. At this stage, the processes of electrification gradually begin to penetrate the sphere of production.

The first phase as an automated management system, mainly spread in the budget and financial sphere, as well as in the sphere of national economy management, including various organizational levels of economic management.

The entire complex of automated control systems in their classification is divided into three groups:

- the first group included automated enterprise management systems;
- the second group included industry management systems;
- the third group consisted of specialized automated control systems of functional units, including statistical, planning, financial-banking and other types of organizational structures.

2.1.3. Second level. The mechanization of the industrial stage of the production of goods and services.

The second phase is the automation of production. The beginning of the growth of industrial production in Russia, based on machine technology, dates back to the last years of the 19th century. Vast territories with huge reserves of natural resources remained undeveloped due to the lack of transport interchanges. At that time, a prominent economist and statesman S.Yu. Witte and the famous scientist D.I. Mendeleev departed from the use of existing methods of modernization, such as: 1) copying the structure of modernization that has developed in the Western economy either; 2) by increasing existing capacities in sectors with a partial upgrade of the production apparatus.

In the first case, the economic lag behind foreign countries remains, in the second case, the growth by sectors is reduced to extensive development methods. Under these conditions, in 1891, with the active participation of S.Yu. Witte and D.I. Mendeleev developed and adopted a new customs tariff for Russia, which, on the one hand, played an important role as a protective barrier for the developing industry. On the other hand, the new tariff allowed a sharp increase in customs revenue. As a result, income increased from 130.5 million rubles in 1890 to 212.17 million rubles in 1901 [6]. At present, a parallel arises connected with “the gradual entry of Russia into the WTO under conditions that have sharply narrowed the possibilities of protecting the domestic market” [7].

It should be noted that the solution to the transport problem at the end of the 19th century was carried out by constructing the Trans-Siberian Railway in the 1890-1913s. The creation of the railway brought into the mainstream of modernization, on the one hand, a huge mass of workers of various professions (the number of jobs in about 6 years, starting in 1891, increased from 9,600 to 90,000 in 1895-1896) [8].

On the other hand, dozens of factories of related industries were involved in the construction of the railway. For example, steam locomotives built 10 plants, cars - 20, rails prepared 16 Russian plants. In addition, the enterprises created metal structures for bridges, station buildings, etc. It is especially necessary to emphasize that orders were placed mainly at enterprises of the Russian Empire. This was done through the development and implementation of customs policy.

2.1.4. Third level. Electrification and transition conditions in the technotronic phase of modernization.

At this level, electrification is seen as a condition for the transition to the technotronic phase of modernization. The transition to continuous electrification of Russia originates from the development and implementation of the GOELRO plan (State Electrification Plan of Russia). An important role here is played by the methodology of modernization processes. K. Marx, studying the capitalist system, found that to identify the essential foundations of capitalism, it is important to determine the core, the “source cell” of the system. As such a cell, he used the concept of “product”.


The construction of the Great Siberian Rail Track during the period of industrialization of Russia in the late XIX beginning of XX centuries characterized as “rail modernization”. In the first years of Soviet power, industrial modernization was carried out - the GOELRO plan or the “State Plan for the Electrification of Russia”. If we apply the terminology of the theory of technological structures (the core of the structure and its key factors as parameters of the formation of the structure) used to create the economic system of an innovative type, it can be noted that in the first case, the “railway track construction” acts as the core, and the key factor is a “steam internal combustion engine”; in the second case, the “electrification of the country” became the basic basis, and the “electric motor” became the key factor. [9].

It should be emphasized that in both the first and second cases, the regulatory influence of state bodies dominated in the organizational and managerial sense, which is also relevant at the present stage of transition to innovative development of the economy [10, 11].

2.1.5. Modern economic phenomena associated with the transition to a post-industrial society have generated new, more complex processes. Currently, there are active discussions about the definition of the essential foundations of the concept of “Post-industrial society”. Many authors note that the essential conditions are reduced to two main provisions: firstly, this is a society based on knowledge, and secondly, the main parameter that determines the level of such a society is the “service sector”, the assessment of the development prospects of which is actively explored in the works domestic scientists [12-14]. Most clearly stated this position K. Clark. He introduced the concept of “service economy”. In his work, “Conditions for Economic Progress”, the author conditionally divided the economy into three sectors:

- Primary (mainly agriculture);
- Secondary (manufacturing industry or industry);
- Tertiary (services sector) [15].

C. Clark especially emphasized that with the growth of industrialization, the structure of the economy is changing: in terms of share, the services sector becomes dominant. Thus, a new direction is being formed, which is called the “service economy”.

Quite in detail, D. Bell investigated the problem of the post-industrial stage. In his work: “The Coming Post-Industrial Society”, the author used a wider range of parameters characterizing the new society:

- Firstly, he identifies three stages of the development of society: pre-industrial, industrial, post-industrial;
- Secondly, he gives his interpretation of these stages of society: a pre-industrial society is characterized by it from the standpoint of using simplified forms of production and labor, and on this basis this stage is defined as appropriating production [16];
- Thirdly, the industrial system, in his opinion, is distinguished by the fact that, within its framework, the extraction of natural resources is replaced by the production of predetermined products, and there is a transition from “appropriating production” to “producing production”. “The industrial sector, as D. Bell notes, is primarily of a manufacturing nature, it uses energy and machine technology to manufacture goods” [16].
- Fourthly, a post-industrial society is defined as follows: “If an industrial society is based on machine technology, then a post-industrial society is formed under the influence of intellectual technology” [16].

As a result, the author gives a clear definition: a post-industrial society – “first of all, this is a society based on services”. As confirmation, let us cite the study of Professor S. S. Gubanov, who established: in countries, the share of the services sector in GDP and in the employment sector in the EU countries exceeds 60%, in the United States this indicator is more than 70% [2]. These data are of fundamental importance in determining the country's economic development strategy.

In modern conditions, the analysis of economic development according to the intersectoral balances (“Input-output”) does not confirm the figures given in the literature about the predominant development of the service sector. “The share of production of means of production in all countries of
the G7, without exception, exceeds 50%. Thus, in the USA, the share of the means of production in the total social product amounted to more than 55.8% in 2004, in Germany - over 58%, in Japan - about 60%. All the rest, naturally, was in the second division, in the production of final consumption” [2].

If we look at the ratio of total final consumption of US households, then in this case in 1984-2004, the proportion of the material factor ranges from 68.6 - 65.0% [2]. Consequently, the final consumption of US households by almost 2/3 is provided not by services, but by tangible goods.

It must be emphasized that at present, the use of the concept of “service” in the sphere of production and in the sphere of consumption does not have a clear distinction. So, V.A. Perepelkin, exploring the concept of “service”, established: “Even in the explanatory economic dictionaries, the concepts of the definition of “service” are quite distant from each other in content” [17]. It must also be emphasized that in the economic and mathematical dictionary L.I. Lopatnikov provides this list of definitions [18].

S.D. Bodrunov in his monograph “The Coming. New Industrial Society: Reloading” notes that “The processes of rendering services and creating material products can be closely intertwined in the same industries” [6]. Further, the author concludes: “Due to this, the traditional division into service industries and material production industries in some cases seems rather controversial” [6].

2.2. Digitalization and robotization.

It is known that the introduction of new technical and technological means of production or tools has an impact on the development of productive forces, the improvement of which, in turn, affects production relations. At the same time, the existing functional interdependence can lead to feedback, the influence of production relations on productive forces.

If we take the modern capitalist system, with its desire for superprofits, it is accompanied by an expansion of demand and improvement of methods of technical and technological development. As a result, a kind of prerequisite for the transition to a new stage of the “innovative technological ladder” is created. One of the problems of this development is digitalization and robotization, which are currently actively penetrating many sectors of the economy. In this regard, on the one hand, it is necessary to reveal the essential foundations of the problem and determine its positive aspects, on the other hand, it is necessary to disclose the limitations that occur during implementation and their distribution, as well as show and formulate the main points of overcoming the restrictions.

When considering digitalization and automation, it should be noted that these categories are components or a form of implementation of the technotronic phase of modernization. The target orientation of the industrial-technotronic phase is the creation of an automated control system for technical, technological and economic processes.

It is known that the theory of automatic control consists of a control object and a control device. The task of the automatic control system is to realize the specified mode of operation of the control object. For automatic control, two tasks are characteristic: analysis and synthesis of automatic control.

The analysis of the system consists in the study of typical elements of a control system; synthesis - the choice of parameters of an automated control system is a more complex process of building a system. The President of the World Economic Forum (WEF) in Davos, Klaus Martin Schwab, speaking about leadership in the competition in the field of efficiency, productivity and innovation, noted the need to use fundamentally new digital forms of communication between people, to use the opportunities provided by artificial intelligence in meeting individualized needs of people [19].

In 2017, the Government of the Russian Federation approved the Digital Economy of the Russian Federation Program (Order of the Government of the Russian Federation of July 27, 2017, No. 1632 p). The Digital Economy (CE) program includes three interconnected levels:

- The first level - markets and industries (field of activity), where the interaction of business entities is carried out;
- The second level - platforms and technologies, where competencies are formed for the development of markets and industries (fields of activity);
• The third level - the environment, which creates the conditions for the development of both platforms and technologies, and the effective interaction of market entities and economic sectors (fields of activity). The specified environment combines normative regulation, digital infrastructure, personnel, information security [20].

The development of processes associated with the digitalization of the economy is accompanied by the emergence of new principles in all areas of our lives, the transformation of business in the form of using digital technologies to optimize business processes, and dramatically increase the productivity of companies. At the same time, the digitalization of the economy and the emergence of new technologies can lead to a significant reduction in the need for living labor, not only in production, but also in the service sector. This, as a rule, is accompanied by an increase in contradictions between capital and wage labor, and the emergence of social conflicts in the country.

In past years in developed countries, the problems of employment caused by innovations were solved in the form of the movement of labor to other sectors and sectors of the economy. A new, deeper employment problem has now arisen. We are talking about increasing migration flows to more economically prosperous countries.

A more serious contradiction in the field of employment is related to the creation and use of robots with elements of artificial intelligence. On the one hand, their use dramatically increases labor productivity. Embedding a “smart robot” in the manufacturing process of any product turns this process into a self-tuning system that works in an autonomous mode without the direct participation of people. In our case, this self-adjusting mechanism becomes the fifth link in the control automated device. In the 1930s, K. Marx’s three-link system was transformed with the introduction of automated devices, that is, there was a transition from a three-link system to a four-link. The fourth link was an automatic control system. The transition to “uninhabited technology” is carried out by including in the automatic system a robot with elements of artificial intelligence in the form of a “self-adjusting mechanism” that includes elements of intellectually labor.

To show the extent of the spread of robots in different countries, we present statistical data characterizing their use in the service sector, as well as in industry and other industries. In total in the world in 2017, there were 2.1 million units of robots, and in 2008 their number increased to 1 million units. According to forecasts, by 2020 the number of robots will increase to 3 million units. At the same time, China, South Korea, Japan, the USA and Germany account for 2/3 of all sales of industrial robots. In Russia in 2016, there were approximately 8 thousand industrial robots. A total of 69 robots per 10 thousand workers in the world. The leader at this time is South Korea. In this country, 531 robots, or 5.3 robots per 100 workers, fall to 10 thousand workers.

Sectorally, there are 9 workers per 1 robot in the United States. Practice shows that the introduction of one industrial robot leads to a reduction in 4 jobs. In recent years, robots are increasingly penetrating the service sector. Thus, the use of ATMs in the United States led to a reduction in operating staff in banks from 484 thousand people in 1985 to 361 thousand people in 2010 year [21].

3. Results and Discussion
When considering the essential foundations of industrialization, the authors presented this process with a fairly wide range of areas that characterize each economic category. This is largely due to the fact that industrialization as an integral part of the development and improvement of the productive forces of the economy affects all the basic elements of social reproduction.

Summing up the analysis of approaches to determining the category of post-industrial society, the authors propose a mechanism for the transition from a four-link management system to a five-link (“unmanned technology”). Such a transition is possible by incorporating a robot into the automatic system with elements of artificial intelligence in the form of a self-adjusting mechanism in the process of managing the production of goods and services.

In conclusion, it should be noted that in the sphere of economics major shifts are taking place both in the sphere of industrial-technological and organizational-structural orientation. This approach has already been reflected in several studies.
In this vein, a monograph was prepared and published by S.D. Bodrunova, in which he outlined his vision of the problem – “The new industrial society of the second generation”. In this work, the author revealed the main features of industrial-technotronic society.

Another approach was formulated by A.V. Buzgalin and A.I. Kolganov. They proposed their approach related to overcoming the crisis situations that arise in the capitalist system. Their position boils down to a combination of qualitative and quantitative characteristics of the socialization of capitalism.

In our opinion, the primary task in the current conditions is the transition to a new industrial and technotronic society based on the creation of a new model of “innovative person”, which should become adaptive to constant changes in economic development, in the development of science and technology, - an active initiator and producer of these changes.

4. Conclusions

1. A new model for the reproduction of goods and services is proposed, which includes, in addition to traditionally production, processes associated with basic and applied research, scientific and design developments, as well as experimental testing technologies for high-tech products.

2. A mechanism has been developed for the transition from a four-link control system to a five-link (“unmanned technology”), by incorporating a “smart robot” in the automatic system in the form of a self-adjusting mechanism that includes elements of artificial intelligence.

When studying digitalization and robotization, a control system consisting of five links was first proposed. Initially, K. Marx proposed a system consisting of three links: machine-engine; gear mechanism; machine-gun or working machines. During production automation, a fourth link is created - a control device that allows you to automatically control, monitor and regulate the production process.

During production automation, a fourth link is created - a control device that allows you to automatically control monitor and regulate the production process. As a result, this process turns into a self-tuning system that works in an autonomous mode without the direct participation of people. In this case, the self-adjusting mechanism becomes the fifth link in the control-automated device. As a result, the technological process of production of goods and services turns into a “deserted technology”.

3. It has been established that the problem of evaluating the effectiveness of digitalization and robotization is of a twofold nature: on the one hand, the digital economy dramatically increases labor productivity (in the banking system, the reduction in operating specialists reaches 25%, in general, 1 robot reduces 4 jobs) ; on the other hand, digitalization and robotization lead to an increase in unemployment. It is proposed to develop and implement a state program of structural restructuring aimed at the employment of dismissed workers.

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