

# *A model for managing the sustainable development of industries under the new industrial revolution*

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**Abstract** — Due to the development and widespread adoption of technologies of the fourth industrial revolution, there was a need to revise approaches to the sustainable development of industries. A critical analysis of the existing approaches describing the industrial revolution, the sustainable development of economic systems, the innovative development of the economy and economic cycles has been carried out. The elements of the internal and environmental factors of the existing production functioning in the conditions of the fourth industrial revolution are clarified. The model of sustainable development of production in the conditions of the fourth industrial revolution is formulated

**Keywords** — fourth industrial revolution, sustainable development, balanced development

## I. INTRODUCTION

Industrial revolutions begin their history in the second half of the 18th century - the first half of the 19th century, when Great Britain gained the status of the largest industrial and trading power in the world due to the high rates of economic growth, based, according to researchers, on the use of new technologies and machines (Fazy J.J., 1830).

Over the following years and to the present, scientists have constantly made attempts to develop a holistic theory of industrial revolutions, despite the fact that ideas about the causes, frequency, technological foundations, and the role of industrial revolutions in world history have changed at different stages of the development of science and society.

Since the 1980s engineers, entrepreneurs, politicians and scientists discuss the onset of the next industrial revolution and the technologies that should become its basis. In 2011, the President of the World Economic Forum in Davos, Klaus Schwab, formulated the concept of "Industry 4.0", the essence of which is the accelerated integration of cyberphysical systems into production processes, as a result of which a significant part of production will take place without human intervention (Schwab K., 2016).

In Russia, the development of Industry 4.0 technologies is determined by the federal program Digital Economy of the

Russian Federation, according to which the end-to-end digital technologies are: big data, neurotechnologies and artificial intelligence, distributed registry systems, quantum technologies, new manufacturing technologies, the industrial Internet, robotics and sensor components, wireless technologies, virtual and augmented reality technologies.

According to existing concepts, those countries that will "lead" the industrial revolution will become leaders in terms of economic growth due to higher labor productivity in both existing and new production processes. In addition to opportunities for economic growth, the new industrial revolution poses threats associated with a radical restructuring of the existing system of the world division of labor due to the reduction of the obsolete elements of the technological chain of previous ways, the reduction in the need for unskilled labor and the exacerbation of the global unemployment problem (Anpilov S., 2012).

The process of transition from technologies of the previous period to technologies of the future period, which are the basis of the industrial revolution, is a threat to the balanced and sustainable development of existing industries. Most managers understand what changes they should expect in the transition to Industry 4.0, but do not have a clear understanding of what to do specifically to take advantage of these circumstances (Deloitte, 2018).

The purpose of this study is to develop a model for the sustainable development of existing production in the conditions of the fourth industrial revolution, to clarify the elements of the external and internal environment of existing production, which are the object of management in the implementation of projects implementing technologies of Industry 4.0.

In order to develop a model for the sustainable development of existing production in the conditions of the fourth industrial revolution, existing approaches describing industrial revolutions, sustainable development of economic systems, innovative development of the economy and economic cycles will be analyzed.

## II. RESEARCH METHODOLOGY

Since the time of the first industrial revolution, a considerable number of concepts and theories have accumulated that explain the laws of socio-economic development in general and the conditions, causes and consequences of industrial revolutions in particular.

Some researchers consider the industrial revolution, as one of the stages of the gradual development of human society, through which it is completely transformed, changing the socio-economic structure. The main role in this process is played by technological innovations, and the living conditions of workers as a result of the industrial revolution are deteriorating (Engels F., 1845).

In the writings of researchers of the late XIX - early XX centuries, the industrial revolution is considered as the most important historical stage, while the industrial revolution itself is understood as a relatively short period of "great" inventions, which were the result of a long evolution of social, economic and political premises (Toynbee A., Rostow U., Maddison A.). So A. Toynbee, as a key prerequisite for the industrial revolution in Great Britain, notes the formation of a new, capitalist, scheme of economic, commercial and social relations.

Other researchers define the industrial revolution as one of the cycles of recovery of the world economy. The cyclical development of the economy, researchers (Kondratyev N.D., Mensh G., Schumpeter J., Kuznets S.S.) associated with profound changes in the technology of production and exchange, made on the basis of previous significant technical inventions and discoveries. The hypothesis of the predominant role of scientific and technological inventions in social progress led to the formation in the first half of the twentieth century. theories of innovation. S.Yu. Glazyev, considering the issues of innovative development, introduced the concept of "technological structure", the transition to a new technological structure is largely due to "profound changes in technology (production technology)".

In the scientific literature and in the mass consciousness, innovations are almost exclusively associated with the improvements that they bring to the daily life and economic activity of economic entities. Much less attention is paid to the negative effects of innovation, which, for example, cause job cuts and, consequently, structural unemployment; an even smaller number of publications are devoted to a completely unexpected consequence of the introduction of innovations, namely, to a reduction in the share of the middle class in the social structure of modern developed states (Sniderman B., Mahto M. and Cotteleer M., 2016). For individual organizations, the emergence of new technologies can also be a threat when it comes to so-called "disruptive innovations" (Christensen, KS, 2006).

The formation in developed countries of post-industrial society in the second half of the XX century led to a rethinking of the industry role in the socio-economic development of countries, the emergence of the concepts of the information society, knowledge economy. Key research in the field of the information society can be considered the work of D. Bell "The Coming Post-Industrial Society" (Bell D., 1967), F.

Webster "Theory of the Information Society" (Webster F., 1995), M. Castells "The Information Age: economics, society, and culture" (Castells, M., 1997).

Modern concepts of industrial revolutions (Frank A.G., Korotaev A.V., Grinin L.E.) are based on the use of a systematic approach and assume that the industrial revolution is the most important stage in the development of the global world system, and industrial revolutions would be impossible without reaching the world-system of a certain level of population.

At the same time, the opinion of J.Rifkin is officially accepted by the European Community and China. He considers the upcoming industrial revolution to be the third and predicts that the merger of Internet technologies and renewable energy sources will lead to the creation of new jobs and companies of the XXI century. (Rifkin J., 2011).

Shchedrovitsky V.G. identifies technology platforms that underlie the corresponding industrial revolutions and are characterized by "their own" system of division of labor. According to Shchedrovitsky P.G. the base of forming platform is forms of cooperation of corporations (Shchedrovitsky P.G., 2005).

If we consider industrial revolutions as a stage in the transition of an economic system from one state to another, then we should turn to the postulates of theories of the natural sciences, such as synergy, bifurcation theory, chaos theory and system theory. According to the theory of self-organization, an economic system develops cyclically along a certain trajectory along many attractors. At the moments of bifurcations, the system moves to another trajectory, which is attracted by an alternative set of attractors. Bifurcation points in economic systems arise as a result of significant discoveries in science and technology, political and economic crises, and global disasters. An important consequence of the theory of systems self-organization is the conclusion that development processes are predictable. The upcoming industrial revolution (the third or fourth in various concepts) is associated with the development of the knowledge economy, the emergence of "artificial intelligence" systems, which over the next few decades can become thousands of times "smarter" than humans, which should result in a technological singularity. At the same time, environmental problems, problems of social inequality are compounded in the world, and the gap between developed and developing countries is widening. The answer to the social and environmental challenges of our time is the emergence and development of sustainable development concepts.

The basic principles of the concept of sustainable development were introduced by Brundtland G. Kh. in 1987 (report of the International Commission on Environment and Development: "Our Common Future"), the concept itself was adopted in 1992 at the UN Conference on Development and the Environment in Rio de Janeiro. From the point of view of this approach, sustainable development involves synchronous development in three vectors: economic (efficiency and sustainability of growth), social (investment in human capital, the preservation of cultural traditions and the achievement of social equality) and environmental (the equality of different generations in meeting needs due to the whole variety of environmental objects).

Research in the field of sustainable development of a country, region or independent business entity has been carried out by many researchers (Barbier E., 1987; Costanza R., Daly H.E., 1992; Ursul A.D., 2005; Welford R. J., 1995 and others). Despite the fact that a common understanding of the concept of “sustainable development” has not developed to date, the main sign of the sustainability of a company’s development can be considered its ability to maintain competitive advantages over a long period of time.

Both Russian and foreign researchers, considering the sustainable development of companies, take into account a set of economic, social and environmental variables. Researchers of industrial revolutions also consider these variables, but place a greater emphasis on the economic component, based on the introduction of new technologies, and the social component. As to the specific technologies that enterprises need to introduce in the context of the new industrial revolution, there is no unity of opinion; the majority of authors single out “smart systems”, the Internet of things, and artificial intelligence (Fran Yáñez, 2017; Alec Ross, 2016; Palmer D. , Kaplan S., 2007). Social transformations associated with changes in the content of labor and the formation of a new system of division of labor leading to mass unemployment are also reflected in the works of researchers (Shingles M., Briggs B. and O'Dwyer J., 2016; Schwab K., Samans R. , 2016; Salamon, L.M., 2010; Lane R.E., 1966; Burenina I.V., 2018).

Thus, each of the considered approaches considers various aspects of transformations in the economic and social spheres caused by industrial revolutions. Each company, in the context of the transition to technologies and technology platforms of the new industrial revolution, faces the challenge of achieving sustainable development of production in the context of a dynamically changing external environment and the need for a radical transformation of the internal environment, in particular production processes. This study is aimed at creating a conceptual model of sustainable development of companies in the conditions of the fourth industrial revolution.

### III. RESULTS OF THE RESEARCH

By the sustainable development of existing production in this study, it is proposed to understand the implementation of such internal changes in the existing production by the company, the result of which is an improvement in the adaptability of the company's activities to changes in external conditions and factors, an increase in quantitative indicators of activity, and a progressive increase in the complexity of equipment and technology. The root cause of sustainable development is competitive advantage. For existing industries in the conditions of the fourth industrial revolution, sustainable development will be expressed in the generation of new competitive advantages and their most effective use.

Competitive advantages for existing production give the company superiority over competitors in the economic, technical and organizational fields, based on the ability and ability to manage existing resources more efficiently.

In the general case, the creation of a system for managing the sustainable development of existing production includes the following main steps (Figure 1):

- a clear statement of the functional requirements of the product/service necessary to meet the needs of the market, and a breakdown of functional requirements for target problems related to the project business model;
- determination of ecosystem potential;
- creating an effective interaction model for deciding on the most appropriate and logical choice of new technologies within the ecosystem;
- the formation of a common architecture of solutions and the management of individual solutions in order to integrate them into a single whole in order to increase the competitive advantage of existing industries.



Fig. 1. Model of functioning of existing production for sustainable development

It is proposed to supplement the concept of sustainable development of the company in the conditions of the fourth industrial revolution with the following provisions of the theory of innovation and industrial revolutions:

- the decisive importance of environmental factors and the readiness of the economic system for revolutionary transformations,
- new technologies, which are the core of the industrial revolution, are forming a technology platform, the transition to a new technology platform is accompanied by a change in the division of labor;
- in the conditions of the fourth (third) industrial revolution, the social vector of sustainable development of the company takes on new content, the sustainability of the development of the company will depend on how the issues of releasing a significant number of people employed in the economy as a result of the introduction of Industry 4.0 technologies are resolved at the national level and in the world at large.

Moreover, in the conditions of the industrial revolution, consumer demand remains the driver of production growth: in other words, if society can provide its citizens or their maximum number with the opportunity to consume the maximum amount of products, work and services, then it acquires the maximum potential for sustainable growth.

Figure 2 presents a model for the transformation of existing production in the context of the fourth industrial revolution.

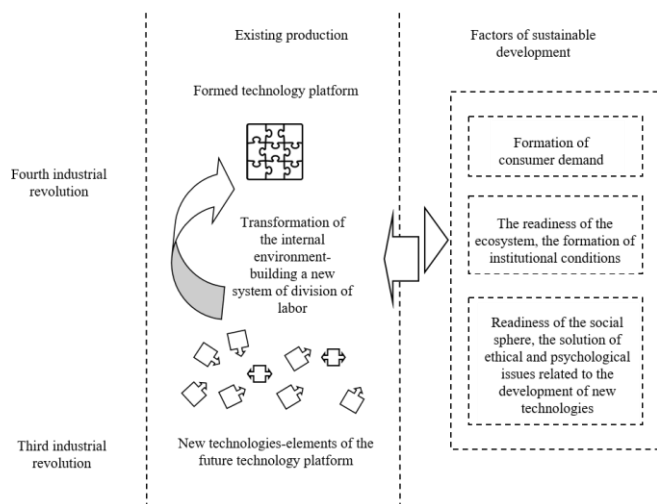


Fig. 2. The model of transformation of existing production in the conditions of the fourth industrial revolution

Figure 3 shows the elements of the external and internal environment of the model of sustainable development of existing production in the conditions of the fourth industrial revolution.

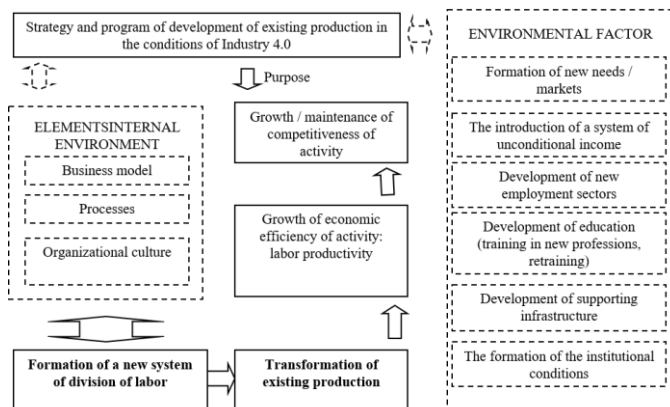


Fig. 3. Elements of internal and external environment factors of sustainable development of existing production in the conditions of the fourth industrial revolution

Sustainable development of existing industries is based on the management of elements of the internal environment of the enterprise: processes, business model, and organizational culture.

Existing production is actually a manufacturing complex that produces products (services), provided with unified management within the framework of a legal entity (branch), which has existing relationships (contracts) with suppliers and sells products on the market and uses common technologies of outgoing technological structures.

In traditional production, there are typical types of activities (processes), which can be represented as:

TABLE I. UNMANNED AERIAL VEHICLES (DRONES) (T2);

| Ci-pher | Type of activity (process)                             | Characteristic  | Activity Management Result  |
|---------|--|---|---|
| P1      | Marketing and advertising, sales promotion             | Processes of market research, segmentation, selection of technologies that best satisfy customers   | The enterprise has studied the features and needs of customers, known and justified methods of obtaining an order for a product of optimal quality. The formulated value propositions correspond to the market level and are ahead of competitors |
| P2      | Logistics of finished products and the act of sale     | Technologies for product delivery, interim storage, including the involvement of outsourcers and dealers or sales representatives. The process of buying, paying and processing financial flow from consumers                                     | An opportunity for a client to receive a product as soon as possible while maintaining its quality with a minimally complicated payment (credit) procedure  |
| P3      | Primary production                                     | Production lines and posts, internal logistics, storage of semi-finished products, labor techniques and methods   | Technologies correspond to the best available in the world, and their productivity (effectiveness) meets the requirements for volume and quality requested by the consumer  |
| P4      | Recycling  | Warehousing, processing, sale or disposal of waste  | Environmental damage - none   |
| P5      | Energy supply  | Energy supply, energy efficiency and independence   | No risk of shutdown, minimized losses   |
| P6      | Supply of raw materials and components                 | Suppliers and input logistics, storage of raw materials and components  | The quality, process of delivery and processing of raw materials is better organized (or similarly) to international practices.   |
| P7      | Support processes, repairs and maintenance             | maintaining equipment in working condition, including the use of external forces, ensuring working conditions   | There is no risk of failure of equipment and other systems; safety is ensured   |
| P8      | Human Resources and Social Security                    | The processes of selection, training, support and finalization of work with personnel. Satisfaction   | The company is provided with the necessary and promising qualifications. Employee satisfaction higher than competitors  |
| P9      | Tactical Management, Information Processes and Finance | Building and optimization of organizational structure, collection technology, processing and use of information, linking information flows and financial flows with flows of physical movement of products, semi-finished products, raw materials | Errors of information support (collection, processing) are absent. The time and parameters of planning and implementing current decisions do not affect production processes.   |
| P10     | Strategic Management and Development                   | Formation and adjustment of a business model, functional strategies, research and innovation  | The business model allows to generate income higher than that of competitors, ensuring the coordination of goals and interests with the environment and the state. Business is attractive for investment  |

Based on this, it is possible to form the ideal, desired result of the transition of the existing production to a new technology platform in a general way, in the matrix "Process-Technology" (Figure 4). We introduce the designation of the technology of the fourth industrial revolution (hereinafter - I4.0):

- 1) Internet of things (T1);
- 2) Unmanned aerial vehicles (drones) (T2);
- 3) Three-dimensional printing (T3);
- 4) Virtual Reality (VR);
- 5) Augmented Reality (AR);
- 6) Blockchain (T6);



- 7) Artificial Intelligence (T7);  
8) Robots (T8).

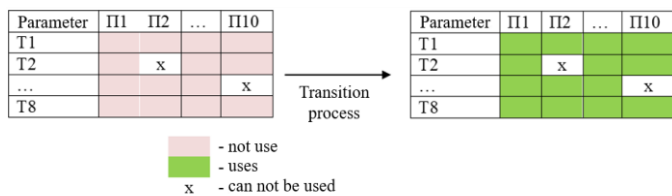


Fig. 4. The ideal result of the transition of existing production to a new technological way

#### IV. DISCUSSION OF RESULTS

When designing a conceptual model, one should proceed from the fact that there cannot be two identical enterprises (in terms of the composition of their external and internal environment). This is due to the significant variability of factors even in the structure of one industry. Among such factors can be distinguished objectively assessed, such as geographical location, climate, remoteness from sources of raw materials and energy, etc. And those that are difficult to measure, but which directly affect the efficiency and design activities of the enterprise.

Consequently, the conceptual model should be based on an approach that allows the company to design the process of transition to the technologies of the fourth industrial revolution with a restriction in projects determined by the need for sustainable development, taking into account the identified environmental factors of this particular enterprise.

The principles on which the conceptual model of sustainable development of existing production should be built in the conditions of the fourth industrial revolution should be considered as follows:

- 1) The feasibility of introducing one or another technology of the fourth industrial revolution should be determined through the study of its influence on all processes of existing production.
- 2) The formation and implementation of projects for the transition to a new technological structure is based on a logical sequence: preparation (leading projects necessary for the implementation of technologies in the internal environment), transition, support.
- 3) Production should justify the long-term goals of integration in Industry 4.0 technologies and coordinate them with the goals of process management (table 1).
- 4) Projects should be consistent with the commensurate development (transitions) to similar technologies among suppliers and partners, that is, take into account integration into the new system of division of labour.

Moreover, according to the established principles, we can consider the introduction of technologies of the fourth industrial revolution as a local phenomenon, as well as a comprehensive process of production transformation.

#### V. CONCLUSION

As a result of the study, a conceptual model of the transformation of existing production in the conditions of the fourth industrial revolution was developed, taking into account the influence of the following development sustainability factors: the formation of consumer demand, the readiness of the ecosystem and institutional conditions for revolutionary transformations, the readiness of the social sphere and the solution of ethical and psychological issues related to the introduction of new technologies.

The proposed model is based on the provisions of the concept of sustainable development of the company, the system concept of industrial revolutions, the theory of innovation, the theory of self-organization of systems. In addition to the existing models of sustainable development, the proposed model takes into account the decisive importance of environmental factors and the readiness of economic and social systems for revolutionary transformations, as well as the need to form a new division of labour that ensures the implementation of technologies of the fourth industrial revolution.

As a result of the study, the elements of the internal and environmental factors of the functioning of the existing production in the conditions of the fourth industrial revolution were clarified. For typical processes of existing industries, a transition scheme to the technologies of a new technological structure and the principles on which the conceptual model of the sustainable development of existing production in the conditions of the fourth industrial revolution have been developed.

The developed model will become the basis for the development of the organizational and economic mechanism for the transition of existing industries to the technologies of a new technological structure, as well as a model of socio-psychological adaptation of projects for introducing Industry 4.0 technologies in the context of existing production, which allows overcoming the resistance of society, the economic and social spheres to innovative transformations.

#### Acknowledgment

The study was carried out with the financial support of the Russian Federal Property Fund in the framework of the scientific project No. 18-010-00505 "Organizational and economic mechanism for adaptation of projects implementing technology "Industry 4.0" in the conditions of existing industries."

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