

ORGANIC COMBINATION OF CONVERGING NBIC-TECHNOLOGIES AND SMART TEMP ADVANCED TECHNOLOGIES OF INDUSTRY 4.0

I. Matyushenko, Dr. Sc. of Economics, Professor, O. Azarenkova, PhD

Department of International Economic Relations, School of International Economic Relations and Travel Business, V.N. Karazin Kharkiv National University, Ukraine

azarenkova.olesia@gmail.com

Abstract: *The paper is devoted to research of convergent technologies as a key factor in solving global problems in the new industrial revolution. It is shown that the concepts of the new industrial revolution, which today are widely used by Western scientists, also envisage the convergence of sciences and technologies and the creation of advanced manufacturing technologies on their basis. It is only possible to launch Industry-based trends in Industry 4.0 through the introduction of advanced manufacturing technologies based on convergent technologies. The approach to the periodization of scientific and technical development, which links the economic, technological and socio-political factors of development, as well as characterizes the structure of the sixth technological structure, the vision of the content of the new industrial revolution based on the organic combination of convergent NBIC-technologies with key factors, as well as approaches to solving global mankind issues are proposed.*

Keywords: NBIC TECHNOLOGIES, SMART TEMP, INTERNET OF THINGS

1. Introduction

From the last decades of the XIX century the research on periodization of main waves of innovation development the term "Industrial Revolution" simultaneously with the use of the concept of "technological structure" have become widely used. Initially, the industrial revolution meant only the process of transition from agrarian economics to an industrial society with a predominance of machine production, but today this concept has a much broader understanding.

At the same time, practically all developed countries took into account the difficult lessons of the crisis of 2008-2009 and revised their understanding of the role of industry and the priority of technological development. Already in 2011, in conditions of increasing competition on the external and internal markets for industrial production in the leading countries of the world, the state policy of these countries is becoming more and more clearly formed, aimed at developing the key factors of the new industrial revolution.

E. W. Drexler, the world-famous scientist-apologist for nanotechnology, believes that nanotechnology will be the basis for building a future civilization in the 21st century, emphasizing that the future will be connected not only with the proliferation of nanotechnological components, but with the transformation of the technological essence - the transition to what he calls atomically accurate production [13].

It is nanotechnology that becomes a connecting link between other revolutionary technological trends that have arisen in the last 20-30 years and allow us to obtain qualitatively new possibilities for convergence of these areas - to radically increase energy efficiency, to reduce the material intensity of the modern technosphere and, on this basis, enable mankind to exit Malthusian trap of limited resources of our planet and solve the problem of "the limits of growth" that faced modern civilization in the form of global problems. E. Drexler believes that this transition will not only be another technological improvement, but the fourth technological revolution - after agrarian, industrial and informational [13, pp. 96-97].

The concept of the Fourth Industrial Revolution, better known as Industry 4.0, was named in 2011 by the initiative of German businessmen, politicians and scientists led by C. Griffstaff (Siemens PLC Software), that identified it as a way of increasing the competitiveness of the manufacturing industry in Germany through enhanced integration of "cyber-physics systems" (or CPS) into production processes [14]. CPS means the integration of machines and human work connected to the Internet, as well as the process of creating a network of machines that will not only produce products with fewer errors, but will also be able to autonomously change the production patterns as needed, while remaining highly effective. At the same time, the driving force is integrated intelligence processes and products that generate so-

called big data that completely change the production landscape and create new markets.

2. Results of Discussion

Industry 4.0 is a production that is equivalent to consumer-oriented "Internet of things", in which household items, from cars to toasters, will be connected to the Internet. This concept provides that further industrial development will be associated with the implementation of three related revolutionary trends until 2030, namely: (1) a revolution in the design and organization of production processes (technological and organizational reengineering industry, based on the total digitalization of production processes); (2) the transition to new materials (their integration into automated systems of design and production, the combination of the production of materials and the production of components); (3) reasonable environments (their mass implementation is expected in the 2050's and 30's) [5-12].

According to forecasts by 2030, the world's leading institutions (UNIDO, OECD, World Bank) and international industrial associations and research companies (in particular MIT, KPMG) can launch these trends in industrial production only through the introduction of advanced production technologies (APT) on the basis of convergent technologies, which are called "breakthroughs", emphasizing their revolutionizing influence on the structure of production. The general understanding of the APT is as follows: (1) technological substitution, leading to a qualitative improvement of existing or the creation of fundamentally new products; (2) automation of the production process, which introduces new requirements for the qualification of specialists; (3) customization of production as a flexible adaptation to the needs of the customer; (4) localization - reducing costs by saving on logistics and geographical proximity to the customer (customer); (5) economic efficiency, related either to a reduction in cost relative to mass production, or to resource savings, increased productivity, investment attractiveness and competitiveness [5-12].

Thus, APTs are associated with non-traditional methods of processing, new tools for control and management of production processes, as well as the use of new materials, automated and intelligent control and management systems for equipment, production processes and systems.

Specialists define the following priority areas of the APT [5-12]:

- 1) production process control systems, including state equipment sensors, raw material flow conditions and state (size, composition, etc.) of objects created (cultivated or grown);
- 2) multidimensional modeling of complex products, which allows to optimize their various parameters (strength, life

and, possibly, production process) and customize the object, modifying it for individual or small-scale production;

3) intelligent production management systems (optimization of external and internal logistics, modes of technological processes), including in robotics and in the "Internet of Things" area;

4) systems for the creation and transformation (cultivation) of material objects, including 3D printing; infusion technologies; promising methods of surface treatment and work with thermoplastics (growth technologies are key);

5) materials that are effective in creating promising actuators for growth technologies: composite and those that exhibit their properties in small-scale structures.

Summarizing analytical materials, it should be noted that today PVTs are, first of all, 3D-printing, "cloud" technologies, "Internet things", new materials, and robotics [15-17].

The concept of the convergence of NBIC-technologies as the basis for the new industrial revolution and on its basis - the convergence of knowledge, science and society has been developing since 2001, when the first presentation of the report by M. Rocco (USA) on the concept of NBIC-convergence, and since 2003, when the report of the National Science Foundation (NSF) of the United States "Convergent Technologies for Improving the Quality of Human Rights" was published [1]. In 2005, during a regular meeting of leading scientists dealing with NBIC convergence issues, a Delphi survey was first conducted to predict the main goals of NBIC-convergence and the expected results of their implementation, as well as how positive their impact on the scale would be. from 0 to 10 [17, 18]. In addition to the 20 ideas that were proposed in 2001, up to five further studies on this issue were conducted in the period up to 2012 and 80 other ideas were collected and, as a result, systematized and published in the final report of the National Science Foundation in 2013 year edited by M. Rocco and B. Bainbridge, [17]. We selected 40 possible ways to use the convergence of NBIC-technologies and predicted a probable period of time when they could be implemented. Average estimates (median) on a five-year scale, from 2015 and up to 2070, fairly describe the implications of using the main ideas of NBIC-convergence. At the same time, M. Rocco and V. Bainbridge acknowledge that the experience of holding meetings and conferences on the topic "Technology Convergence" for the period 2001-2013 has proved the need for regular foresight research among scientists and engineers involved in this issue.

The report outlined the main provisions for the convergence of knowledge, technology and society, including the main principles of convergence of human activity, including for the creation of knowledge and technological innovation, and also proposed a transformational approach to achieving social benefits, mechanisms and possible systems solutions for challenges to society in the next decade, among which: (1) challenges creating new knowledge, industries, professions; (2) the struggle against population growth, massive urbanization and globalization; (3) the functionality of national security; (4) improvement of life prosperity and human potential; (5) the development of individual and integrated health and education programs; (6) the fight against environmental problems; (7) maintaining a stable quality of life forever [17, 18].

In this case, the basic instruments of the process are precisely the NBIC-convergence, whose distinctive features are: (1) the emergence of a new, holistic science based on the material unity of the surrounding world; (2) the subject of the study of this science includes practically all levels of organization of matter: from the molecular nature of matter (nano) to the nature of life (bio), the nature of the mind (cognition) and processes of information exchange; (3) elemental structural elements are atoms, genes, bits and synapse; (4) intensive interaction between specified NBIC-scientific and technological areas; (5) significant synergistic effect; (6) the prospect of qualitative growth of technological opportunities of individual and social development of man [2-4].

Thus, according to the analysis of modern concepts of the industrial revolution, there is no single concept in relation to the content of the new industrial revolution, but they all focus only on individual constituent convergent technologies, namely: the concept of the APT revolution on nanotechnology; the concept of a combination of renewable energy and Internet technologies - on the digitization of sustainable development and alternative energy; the concept "Industry 4.0" absolves the so-called "reasonable" environment, based on the introduction of a new generation of Internet technologies and artificial intelligence in production processes; The concept of convergence of NBIC-technologies considers the possibilities of interdisciplinary research and development, but does not provide an instrument for their introduction into production. As a result, there is a need for in-depth study of the convergence of knowledge, technology and society and its application to solve global problems.

In the author's works [5-7] in connection with the implementation of the new industrial revolution in modern conditions, the assumption is made that Industry 4.0 technologies, combining Smart TEMP (T (technology) factors - intelligent technologies, E (environment) - reasonable environment, M (manufacturing) - reasonable production, P (products) - smart products), create new markets and industries, promote productivity and competitiveness of individual sectors and national economies. Based on the above, it is advisable to combine the key elements of the convergence concepts of NBIC-technologies and Industry 4.0 as well as to determine the ratio of relevant industrial revolutions and technological processes, as indicated in Fig. 1 [5, 6].

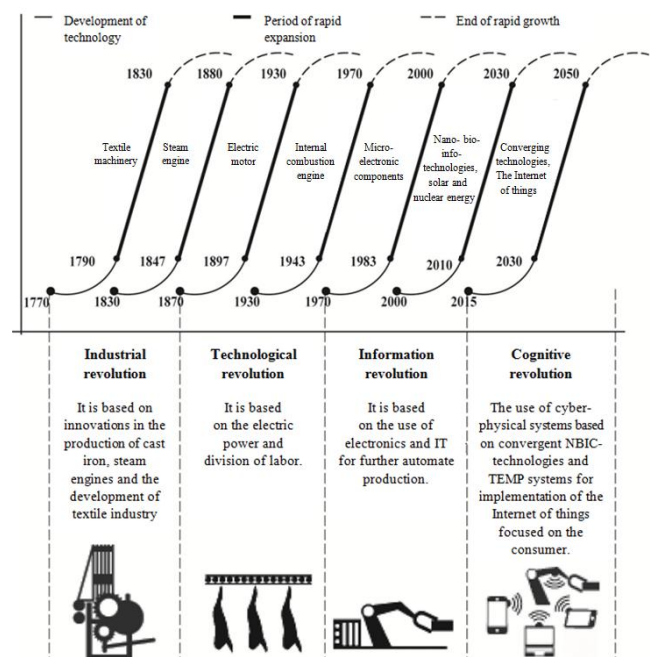


Fig.1 Relation of industrial revolutions and technological waves [5-6]

At the same time, the contours of the new technological system have already begun to be formed on the basis of the first convergent technologies and their explosive proliferation in 2010-2015. The fundamental abandonment of this technological wave from the previous ones is that human consciousness will become the same productive force as science has at one time become. The material basis and tool for implementing the convergent technologies of the new technological wave will be Industry 4.0 or Smart TEMP.

The study of global forecasts until 2030 showed that the main technological industries that will affect the development of the world economy will be: management of the course of the disease; regulation of population growth; genetically modified cereal crops; water resources management; bio- and solar energy; data processing solution; social networks; technology of "smart"

city; robotics; stand-alone vehicles; additive production / 3D printing.

Ukraine has great potential and competitive technologies in the aerospace industry, the production of new materials with specified properties, industrial biotechnologies, mathematical modeling and regulation of chemical, biochemical and biophysical processes, and intelligent production systems. In addition, Ukraine holds one of the leading places in Central and Eastern Europe in terms of the IT market and human resources. For example, in 2016, domestic IT industry, despite the crisis in the Ukrainian economy, showed growth at the level of 10-15%, and the volume of the market has grown to 3 billion dollars. All this shows the huge potential for growth for the industry. The key advantages of the IT industry and software development are that large investments in fixed assets are not required to increase production, since the IT industry's main asset is the human factor - programmers [19].

Fig. 2 shows the author's proposed directions for solving global problems based on the introduction of convergent NBIC-technologies as the nucleus of the development of the advanced production system Smart TEMP, which provides a number of tools [5-7, 12]:

- overcoming the global problem of slowing down scientific and technological progress, based on the introduction of convergent NBIC-technologies as the nucleus for the development and dissemination of Smart TEMP advanced production system;

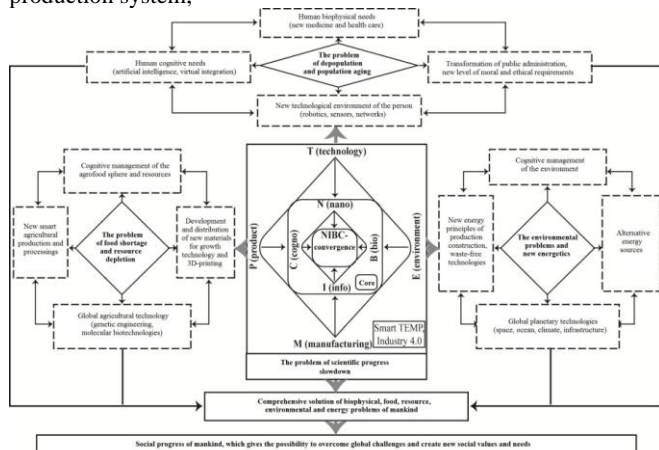


Fig. 2 Directions of solving of global problems on the basis of introduction of convergent NBIC-technologies as the nucleus of development of Smart TEMP advanced production system [5-7, 12]

- overcoming the problem of depopulation and aging of the population at the expense of: (1) satisfaction of the biophysical needs of man (new medicine); (2) the realization of the cognitive needs of man (artificial intelligence, virtual worlds); (3) new technological environment of the person (robotics, sensors-ethical needs);

- overcoming the global problem of food shortages and resource depletion by: (1) developing global agrarian technologies (genetic engineering, molecular biotechnology); (2) the creation of new intelligent agroprocessing and processing; (3) developing and distributing new materials for growth technologies and 3D printing; (4) cognitive resource management and the agro-food sector;

- overcoming environmental problems and creating new energy through: (1) global planetary technologies; (2) the transformation of public administration and the moral-energetic principles of construction of production, non-waste technologies; (3) alternative energy sources; (4) cognitive management of the environment;

- a comprehensive solution to biophysical, food, resource, environmental and energy issues as the foundation for social

progress of mankind, which opens up opportunities to overcome global challenges and create new social values and needs.

At the same time, the main trend in solving global problems of humanity on the basis of convergence of knowledge, technology and society through the use of NBIC-technologies as the nucleus and fundamental tools for the development and dissemination of the advanced production system Smart TEMP is the support of converged technologies and the development of the advanced production system Smart TEMP at the expense of: 1) implementation of state and private programs, the driving force of which is openness and visualization; (2) accelerating the development of fundamental NBIC technologies and creating new Smart TEMP industries based on interdisciplinary research and innovation. It is a combination of converged technologies with industry-leading Industries 4.0 to provide material ground for solving other global problems.

Thus, for countries that wish to modernize the economy on a new technological base (such as Ukraine), identifying the priorities of scientific and technological research in the field of convergent technologies and creating on their basis the innovations in the framework of a new industrial revolution becomes today of great importance.

3. Conclusion

1. It is shown that the concepts of the new industrial revolution, which are widely used today by Western scholars simultaneously with the notion of "technology" for the periodization of the waves of innovation development, also envisage the convergence of sciences and technologies and the creation of advanced production technologies on their basis. It is established that in today's developed countries the concept "Industry 4.0" is increasingly prevailing, which involves the enhanced integration of "cyber-physics systems" into production processes, and the driving force of which is integrated intelligence processes and products generating "big data" that completely change the landscape. production and create new markets.

2. According to the results of the analysis of the research of authoritative world institutions and international industrial associations and research companies, it is established that the launch of industry-specific trends in Industry 4.0 can only be achieved through the introduction of advanced manufacturing technologies. They are based on convergent technologies, which include "Internet of things", "cloud" technologies", 3D printing, new materials, robotics, associated with non-traditional processing methods, new tools for control and management of production and technological processes, and using new materials, automated and intelligent monitoring and control equipment, production process and systems.

3. The approach to periodization of scientific and technical development, which connects the economic, technological and socio-political factors of development, as well as characterizes the structure of the sixth technological structure, is proposed. This approach provides a new scientific understanding of the relationship between industrial revolutions and technological developments in the economy of the future, which, along with the traditional ones, includes the notion of a cognitive revolution, based on the use of cyber-physics systems based on convergent NBIC technologies, it enables the transformation of economic processes based on the introduction of internet of things. In this case, the key factor of the core of the technological structure will be the state of convergence of NBIC-technologies. The core of the new sixth technological wave will form industries such as: nanomaterials and materials for growth technologies, nanoelectronics and nanophotonics, scanning nanotechnology, nanosystem technology, nanotechnology and 3D printing, genetic engineering, molecular biotechnology, cloud computing and multidimensional simulation, Internet applications, artificial intelligence. The carrier industries will be: medicine and pharmacy; agro-food complex on the basis of nanobiotechnologies;

microelectronics, robotics; information and communication industry; systems of creation and transformation (cultivation) of material objects; intelligent production management systems; education and scientific-practical research; new nuclear and thermonuclear energy; renewable energy; aircraft building and rocket and space complex; automotive, shipbuilding and machine tools; chemical and metallurgical complex.

4. The vision of the content of the new industrial revolution based on the organic combination of convergent NBIC-technologies with the key factors of the advanced system of Smart TEMP, which enables to change the system of production qualitatively through the enhanced integration of "cyber-physics systems" (or CPS) into production processes, is proposed. These technologies of Industry 4.0 combine the factors of the advanced system Smart TEMP (T (technology) - smart technologies; E (environment) - reasonable environment; M (manufacturing) - reasonable production; P (products) - smart products); create new markets and industries, contribute to the growth of labor productivity, the competitiveness of individual sectors and national economies.

5. The approach to understanding the correlation of the industrial revolution and the technological structure in the future economy, which includes the concept of a cognitive revolution based on use, and defines the structure of the sixth technological wave (the key factor of the nucleus is the state of convergence of NBIC-technologies, and the core will form sectors of the advanced production system Smart TEMP), as well as identified directions for solving global humanity problems, based on the introduction of converged technologies as a factor for the development and spread of Smart TEMP advanced production system.

6. The directions of solving global problems of humanity, which include the following main directions and tools for: (1) overcoming the global problem of slowing down of scientific and technological progress, based on the introduction of converged NBIC-technologies, are proposed; (2) overcoming the problem of depopulation and aging of the population at the expense of satisfaction of the biophysical needs of the person (new medicine and health); realization of cognitive needs of a person (artificial intelligence, virtual integration, etc.); new technological environment of the person (robotics, sensors, networks); transformation of the system of public administration, satisfaction at a new level of moral and ethical needs; (3) overcoming the global problem of food shortages and resource depletion by: developing global agrarian technologies (genetic engineering, molecular biotechnology); creation of new intelligent agricultural production and processing; development and distribution of new materials for growth technologies and 3D printing; cognitive management of the agricultural sector and resources; (4) overcoming environmental problems and creating new energy through global planetary technologies (space, ocean, climate, infrastructure); new energy principles of construction of construction, non-waste technologies; alternative energy sources; cognitive management of the environment.

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