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BELARUS ON THE BACKGROUND OF GLOBAL INDUSTRIAL DEVELOPMENT TRENDS

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The article is devoted to the analysis of techniques and technologies evolution in the process of civilization development. It is provided technique-technological and political-economic characteristics of the main stages of this evolution; special attention is paid to the study of the modern stage, referred to as the "fourth industrial revolution". Its main feature istheproduction intellectualization based on the prevalence of "industrial internet" and flexible automated production systems. Trends and problems of intellectual economy formation in Belarus and other countries of the Eurasian Economic Union are analyzed, determined the ways of their solution.

Key words: technique-technological progress; technological practice (structure); industrial (production) revolution; production intellectualization; intellectual economy.

БЕЛАРУСЬ НА ФОНЕ ГЛОБАЛЬНЫХ ТРЕНДОВ ИНДУСТРИАЛЬНОГО РАЗВИТИЯ

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Анализируется эволюция техники и технологий в процессе развития цивилизации. Дана технико-технологическая и политико-экономическая характеристика основным этапам этой эволюции. Особое внимание уделено исследованию современного этапа (именуемого четвертой индустриальной революцией), основной признак которого – интеллектуализация производства на основе распространения «промышленного интернета» и гибких автоматизированных производственных систем. Рассматриваются тенденции формирования интеллектуальной экономики в Беларуси и других странах Евразийского экономического союза, предлагаются пути их решения.

Ключевые слова: технико-технологический прогресс; технологический уклад; индустриальная (промышленная) революция; интеллектуализация производства; интеллектуальная экономика.

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Introduction

The global financial and economic crisis, which has beencaused by massive resources reallocation from the production sphere in speculative intermediary sector of the world economy, hasforced specialiststo pay attentionagain to thereal economy needs, especially industry. In this regard, such terms as "new industrialization", "neoindustrialization", "reindustrialization", "the Renaissance of industrial policy", "industrial internet", "the Indusry 4.0 strategy" and even "fourth industrial (industrial) revolution" are firmly established in modern scientific vocabulary [1–4]. After hope years for post-industrial society and service economy advantages, which have pushed the real economy sector, including industry, to the services sector shadow, this reversal requires the most careful study. Such study is really important for the Eurasian Economic Union countries and especially for Belarus with its developed industrial production sector, which has been created since the days of the USSR. Whether our country will be able to choose and implement suitable development strategy depends its placein the world among technologically advanced countries.

The "Fourth industrial revolution" as the modern technological progress stage

Europe and especially Germany has been, as usual, the original source and the epicenter of studied revolutionary mood in the article. Thanks to its'submission "Industry 4.0" initiative has become the all-Union (this refers to the EU), and then – and the global project. It is assumed that, more than 900 billion dollars will be spend on industrial production sector development for this project (the "Industry 4.0" initiative) implementationin the world until 2020 year [5]. The United States are also concerned with creation of conditions for "industrial Renaissance". This means the deployment of new industrial enterprises and returning back "home" high-tech industries, "escaped" from the country closer to cheap resources [6, p. 69].

China has also responsed for this strategic challenge and confidently been challenged technological and intellectual superiority of the West [7]. According to the strategy "Chinese manufacturing – 2025" (well known as the program "Made in China 2025") the China Development Bankhas planned to spend (provide) else 300 billion yuan (44 billion dollars) for industrialization, which has been actively implemented for a quarter of a century [8]. Even in Russia after rises and falls of its raw materials it has been remembered about saving industrial break through on the eve of world war II and attended to the neoindustrialization [3]. In other words, today in already post-industrial world we are able to see the industrial revolution.

First of all, analyzing the phenomenon of the "fourth industrial revolution", it should be noted, that in the Eurasian Economic Union (EAEU) countries, including Belarus, the concept of technological structures is used for the description of the engineering and technology evolution, proposed by the Russian academician Sergei Glazyev. In particular, the Directive No. 3 of the President of the Republic of Belarus "About the priority directions of strengthening of economic security of the state" (in edition of Decree No. 26 of 26.01.2016) it is required to "create conditions for increasing the output of innovative and high-tech production, released by using technologies of the fifth and sixth technological structures".

However, despite the difference of terminology in the Eurasian Economic Union (EAEU) countries and beyond, between our technological advancements, the Western industrial revolutions and Chinese industrializations it is detected unambiguous logical connection (table 1).

Technique-technological features of the main stages of the development of civilization

Analysis of presented information in table 1, allows to identify the features of the main phases of the evolution of engineering technique, technology and civilization in general.

First, the criterion of periodization of technological progress is the same key factor – the level of development of the industry. This is quite understandable, because if you look around, it is easy to see that the technosphere, which surrounds the modern man, very often consists of industrial products. The building materials for our homes and offices, transport and communications, household appliances and office equipment, clothing and footwear, furniture and food, research equipment and weapons are all the of industrial enterprises production. In the industrial production complex the main part of knowledge-intensive and high-tech industries are precisely concentrated. Exactly industry is the manufacturer and the supplier of progressive means of labour and articles of consumption to all other sectors and spheres of modern man life. In other words, the level of industrial development of the country today entirely determines its place in the hierarchy of technologically and economically developed Nations, its global competitiveness, therefore, the chances of maintaining economic and political sovereignty in the Technotronic era of the XXI century.

Secondly, an important condition for the technological structures change and, consequently, make the industrial revolution happened, constitutes the appropriate development of the humanity energy base, but rather, the growth of installed power production. So, in the pre-industrial era people had only their own musclesand muscles of two-three horses as a source of energy for many centuries. Given the fact, that 1 horsepower corresponds to a power of 736 W, and an average worker during a working day is able to maintain physical activity capacity corresponding to 141 W, it is easy to calculate that the usage of working cattle increased power production compared to the manual variant of execution of the works only in 5–10 times. The British have quickly realized this advantage and, according to scientists evaluationat the end of the XI century 70 % of the power, consumed by English society, was provided by animals [10, p. 70].

The invention and wide spread of steam engines with a capacity of tens, hundreds horsepower has increased labour productive power in many times. Now, taking into consideration the mentioned above values, depending on the size of the used steam engine in company (enterprise), from 50 to 1000 "machine workers" together with people had already gone to work. It is clear that while using several such machines in the enterprise, the number of "native workers" have increased by the corresponding number of times. As a result, even a small enterprise with number of employees up to 100 people, due to the mechanization of production based on steam engines, de facto, could produce as much product as an enough large company released in the same time. According to some researchers, the steam engine had become the hallmark of Britain of XVIII century, where the specified century almost 2.5 million units were built. Due to such substantial growth of the productive forces of society the country was rapidly promoted leaders in technological and economic progress [10, p. 142].

Consequently, the first industrial revolution that occurred thanks to the steam engine invention, which was widely used as transportation in the composition of steamships and locomotives and manufacture of propulsion technology equipment, has launched theproduction mechanization, providing a multiple increase productivity and stimulating the development of large enterprises.

However, despite the fact that steam engines made it possible to substantially enlarge the company, the size of the latter was objectively limited in space because of the physical need for the equipment to be concentrated near the steam cars. The fact that in the case of use in the enterprise, the steam engine had long rotated throughout the shop gear actuator, to which by means of the clutch was connected to several machines, limiting the degrees of freedom of such production systems.

The invention and widespread electric motors together with their electric power supply and extensive electric grid successfully has solved this problem, serving as another impetus to a substantial increase in productivity. Large-scale production electrification has made it possible to use at the enterprises of dozens, hundreds of electric motors of different capacities, each of which de facto ousted from the production processes from 1 to 50 people.

Important detail, thanks to extensive power grids, all these motors were not crowded in one place, as it was in the age of steam with machines, doomed to coalesce around the craft steam gear drives. Electricity supply network shave made possible the simultaneous use of multiple motors in several workshops, including remote from each other over long distances. This allowed not just to extensively enlarge the enterprise, but to unite in their framework not only homogeneous, but also heterogeneous production processes (e. g. iron ore extraction, smelting steel out of it, fabrication of steel parts and components, the Assembly of a final product). Thus was created the preconditions for the formation of large and extra large mega-industry and inter-industry, horizontally – and vertically-integrated monopolies.

Total number of workers displaced from the production process, who employed in the simple physical labour, had already numbered in the thousands in such integrated enterprises. Moreover, the possibility of using electric lighting and motors outside companies at first allowed to facilitate labour (to increase productivity) not only in manufacturing but also in everyday life. As a result, due to the widespread use of electricity, mechanization of production and household processes has become truly massive. Thus, the universal ***electrification*** that occurred in ***the second industrial revolution*** had caused another abrupt increase in productivity.

The third industrial revolution was accomplished thanks to the emergence (advent) of electronic computing machines (computers), possessing the fundamental ability to control the electric motors according to specific programs. A combination of electric motor and electronic computing machines, which manages it, got the name of a digital electric, which can set in motion the process equipment (or part thereof) according to their program.

The usage of two or more coordinated working digital electrics, that move the workpiece and their machining tools relative to each other at a predetermined (programmed) path, in one machine, had given the possibility for ***automatization*** of industrial processes. Thanks to this flexibility, the production was not just a serial, it became massive. This led to a further consolidation of companies, foreshadowing their gradual transformation into sectoral, national and transnational, vertically-integrated corporations.

Stages of technical and technological

Area			
			Classification
	I technological structure (until the middle of the XVIII century)	II technological structure (the second half of the XVIII – first half of the XIX centuries)	III technological structure (the end of XIX – the first quarter of XX centuries)
			Classification of the EU
	Pre-industrial period (until the middle of the XVIII century)	The first industrial revolution (the second half of the XVIII – first half of the XIX century)	The second industrial revolution (the end of XIX – the first quarter of XX centuries)
			Classification
	Agrarian period	The first industrialization (1–2 five-year plan, 1953–1966), the innovative pause of 1966–1976 and modernization (5–8 five-year plan, 1980–1995)	
	Characteristics		
Key energy types	The natural power (the muscular energy of people and animals, the energy of wind, water, open fire)	The energy of burning coal and firewood, converted into steam energy	Electric energy
			Energy of burning hydrocarbons (Energy combustion of hydrocarbons)
Key tools and technologies	Hand tools, cartage, sail, water and wind wheel, loom	Steam engine; locomotive; steamer; steam gear drive of production equipment	The electric drive; electrified equipment; vacuum electronics; Telegraph
			Internal combustion engine, car, diesel locomotive, electric locomotive
The main link of the economy	Entrepreneur, household	Firm	Branch monopoly (Industry monopoly)
The predominant type of ownership	Disperse (atomic) property	Disintegrated property	Horizontally integrated property
Planning scale	Within the household	Within the firm	Within the industry
The political-economic system	Competitive-market capitalism		State-monopoly capitalism
Type of economy	Pre-industrial	Industrial	

S o u r c e: development of authors using [9].

Table 1

progress and their characteristics

of the EAEU		
IV technological structure (1930–1980)	V technological structure (1980–2000)	VI technological structure (beginning of XXI century)
and the USA		
The third industrial revolution (1930–2000)		The fourth industrial revolution (beginning of XXI century)
of China		
Second industrialization (9–11 five-year plan, 1996–2010)	Building th Classification of China e knowledge economy (starting from the 12^{th} five-year plan, 2011–2025)	
Characteristics		
Electric, nuclear energy		Reasonable electricity, “green” energy, nuclear energy
Energy of burning hydrocarbons (Energy combustion of hydrocarbons)		
Electronic computer; semiconductor electronics; production of plastics; space technology	Microelectronics, microprocessor	Nanotechnology, biotechnology, microcontroller, flexible (intelligent) production systems, electric vehicle, design of the future
	Computer network, information technology, machine tool with numerical program control (CNC); energy saving, resource saving	
Internal combustion engine, car, diesel locomotive, electric locomotive		
Cross-industry Corporation	Transnational corporation (TNC)	International (global) Corporation (INCs)
Horizontally and vertically integrated property		Vertical- and system-integrated property
Within adjacent industries	Within the national economy	In the global economy
State-monopoly capitalism	State-corporate capitalism	
Industrial		Intellectual

It is important to understand that automation implies the substitution in the production processes are not only physical (muscular) energy, but also its administrative functions. Due to this, automation has become another important prerequisite for further sudden growth of labour productivity, both physical and managerial, leaving the person, mainly, creative, inventive, intellectual work. However, accomplishing right before our eyes ***the fourth industrial revolution*** gradually robs a man and his prerogative. Thanks to local, regional and global computer networks there is a fundamental opportunity for coordinated work of many equipped with CNC enterprises, including those located in different regions of the country, in other States and even other continents. This fact allows us to design and create a global ***flexible automated production system***, which integrates a variety of businesses related not only to the same and related industries, and even different sectors (fig. 1).

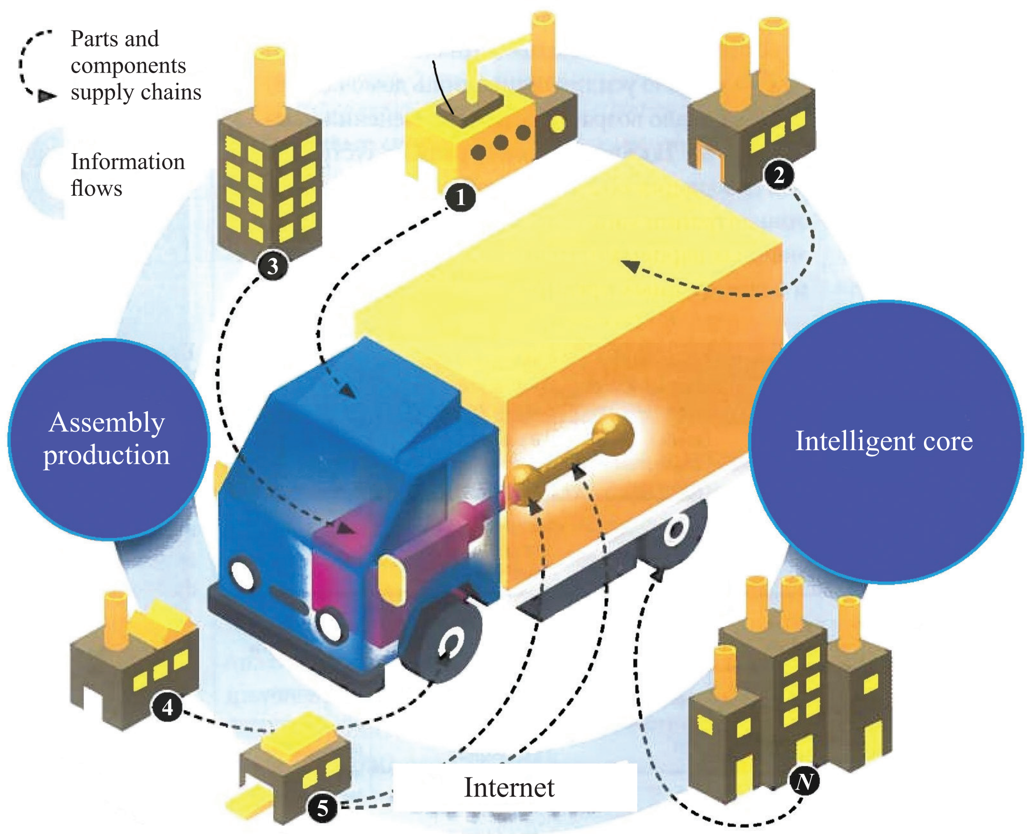

Fig. 1. The operation principle of flexible automated production systems.
S o u r c e: authors' own development

As can be seen from fig. 1, the basis of any such system is its intelligent core programming, standardizing, and coordinating the functioning of its constituent parts – as individual units of process equipment with CNC, and entire enterprises. The main advantage of flexible automated production systems, provided by intellectual cores, is possibility for fast reprogramming, which allow effectively switch these dispersed in the space production system with the release of a modification, model, varieties produced products on the other.

In addition, the intellectual core has crucial ability in real time to monitor all stages of the life cycle of products, starting with the "prenatal" phase of innovative design in accordance with the specific requests of consumers to organized sales and operation until the return of recycling.

All this allows to integrate the assets, coordinate and plan production activities not only in space across the planet, but in time, what does humanity truly revolutionary changes associated with the designing the future [6].

The current industrial revolution opens up broad prospects for the organization of closed, non-waste, truly resource-saving innovative enterprises and, accordingly, to meet the immediate needs of civilization with the lowest cost.

In other words, in the process of the fourth industrial revolution and ***intellectualization of production*** the world has entered an era of ***intellectual economy***. Thanks tothis humanity has got first glimmer of real hope that the global problems of civilization (energy, raw materials, environmental, food, etc.) still have a humane solution.

Belarus in the conditions of formation of intellectual economy

As you know, the former Soviet Union until its destruction more or less successfully challenged the leadership of leading Western countries in the field of technical and technological progress. However, after 1990, in the remaining countries after USSR, including Belarus, the progressive increase in the average technological structure changed into a major decline and subsequent "stagnation" (table 2).This led to a threatening build-up of technical and technological gap between developed and successfully catching-up countries. One of the fundamental reasons for the incident should recognize the incorrect orientation of the countries of the former USSR on the medieval model of competitive-market capitalism, characteristic of the pre-industrial era and the first industrial revolution (see table 1).

As for Belarus, due to volitional effects on the economy from the top political leadership in our country was not allowed the destruction of its industrial complex, as in most former Soviet republics. In the result, the inertial growth of the Belarusian economy continued until very recently. There was a time when the world even talked about the "Belarusian economic miracle".

Table 2

Long-term trends of average technological practice in some countries and regions of the world

Country	Year				
	1950	1975	1990	2000	2010
USA	3.3	3.8	4.2	4.4	4.5
Japan	2.7	3.8	4.0	4.1	4.5
China	2.2	2.4	2.8	3.2	4.0
Western Europe	3.1	3.6	4.0	4.2	4.3
Countries in Africa	1.7	2.0	2.5	2.6	2.6
Russia	2.8	3.4	3.9	3.6	3.6
Belarus	2.8	3.4	3.9	3.4	3.5
Developing countries	2.1	2.6	2.8	2.9	3.1
Developed countries	3.1	3.7	4.1	4.2	4.4
The world as a whole	2.7	3.2	3.4	3.7	3.8

Source: compiled and refined by the authors based on data from [9, p. 63].

However, common to all post-Soviet countries mistakes in the sphere of monetary policy, which in recent years have repeatedly written to one of the authors of this article (see, e. g., [11]), led to the chronic underfunding of research and development, resulting in low research intensity GDP is 2–3 times lower than optimal. This led to the gradual accumulation of unrealized potential in the innovation sphere of the country. At the turn of the century, the techno-technological backlog created in the Soviet era was largely exhausted, and since 2005, the factor productivity of TFP (Total Factor Productivity), which characterizes the impact of scientific and technological progress on labour productivity, has begun to decline (fig. 2) [12, p. 28, 62]. As a result, this led to a corresponding drop in GDP and an increase in negative processes in the Belarusian economy, as economic and technological progress is largely interdependent [11].

Studying the experience of countries showing the "Asian miracle" (Singapore, India, Vietnam, South Korea, Malaysia, China, etc.) give us examples and thegeneral strategy for overcoming these negative processes.

So, in the countries of catching up development the stimulation of technical and technological progress is realized by the following measures:

a) strong regulatory and planning role of the state in economic development, including protection of domestic high-tech corporations from external competitors and their patronage in world markets;

b) stimulating monetary policy aimed at providing cheap financial resources necessary for accelerated technical and technological progress to such corporations;

c) large-scale state investment in the creation and development of priority, first of all, science-intensive and high-tech sectors of the economy;

d) targeted tax policy that encourages the development of high-tech and export-oriented productions and industries etc.

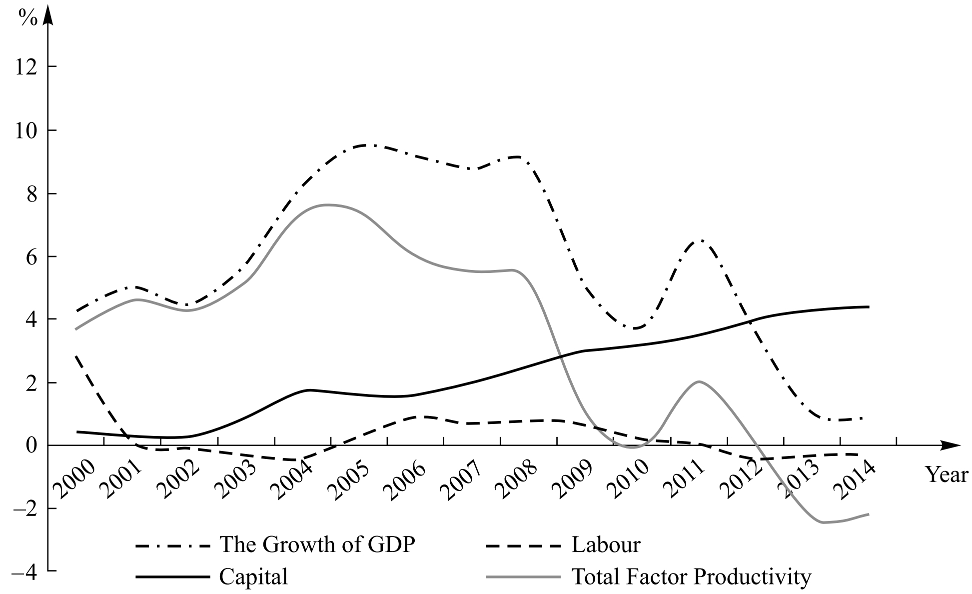

Fig. 2. The dynamics of GDP growth in Belarus and the contribution to this growth of labour, capital and technique and technological progress (in percent).
Source: [12, p. 62]

Thus, the formation of modern state-corporate capitalism, which is characteristic of the era of the third-fourth industrial revolution and, accordingly, the leaders of the world economy, takes place (see table 1).

Conclusion

The preservation of Belarus and other countries of the EAEU among the movers of technological progress is the issue of their presence in the list of civilized countries.

Examples of world economic leaders show that the current stage of this progress, called the "fourth industrial revolution", is inextricably linked to the formation of capitalism of a modern state-corporate type that has little in common with its competitive-market model which was inherent in the lower levels (phases) of technological development and, alas, taken into service in the former Soviet republics.

The modern model of capitalism implies a bet on the powerful innovation potential of large and extra-large TNCs and the deliberate creation of government macroeconomic conditions, stimulating technological creativity of the business.

The development of an appropriate scientific paradigm and the doctrine of development is a matter of technological and economic independence of Belarus and other EAEU countries in the technotronic era of the 21st century.

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