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BREAKTHROUGH TECHNOLOGICAL DEVELOPMENT OF INDUSTRIAL ENTERPRISES AMID DIGITAL TRANSFORMATION

Yu.P. Anisimov (a), Yu.V. Zhuravlev (b), E.V. Shkarupeta (c)*, G.A. Khmeleva (d)
*Corresponding author

(a) Voronezh State Technical University (VSTU), 14, Moscow Avenue, Voronezh, 394026, Russia, svsh1977@mail.ru
(b) Voronezh State University of Engineering Technology (VSUET), 19, Revolution Avenue, Voronezh, 394036, Russia, yura.zhuravlev.49@mail.ru
(c) Voronezh State Technical University (VSTU), 14, Moscow Avenue, Voronezh, 394026, Russia, 9056591561@mail.ru
(d) Samara State University of Economics (SSEU), 141, Sovetskoi Armii Street, Samara, 443090, Russia, galina.a.khmeleva@yandex.ru

Abstract

The relevance of the research topic can be attributed to modern realities where production processes and finished products are becoming more complicated and all engineering, technical and technological competencies are rapidly becoming obsolete. To guarantee global competitiveness, industrial complexes have to undergo breakthrough development, carry out technological jump, ensure extremely short development cycles, low prices and high quality of the product. In order to meet these requirements, a global digital transformation of economy into digital economy and of high-tech industry into digital industry is going on in the world. These phenomena of the forth industrial revolution affect Russia and its high-tech and science-based industry in full and form frontiers within which industrial complexes will work in the foreseeable future. Economy digitalization presents new possibilities for the industry, in particular, in processing sectors and a service sector related to them, as well as possibilities for transformation of production processes and business models and for improved economic growth in the medium and long term. Significant progress has been achieved in many developing technologies such as the Internet of things, big data, cloud computing technologies, artificial intelligence, robotic technologies, industrial production based on additive technologies, new materials, augmented reality, nanotechnologies and biotechnologies. Technological developments like that allow for smart manufacturing, customization, co-production and introduction of other new production methods and business models. However, this new environment also causes problems for enterprises, workers, consumers, governments and other parties concerned.

Keywords: Breakthrough development, technologies, cross-cutting technologies, scaleups, nation champions.

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1. Introduction

Russia has currently reached the point when evolutionary scientific and technological, social and economic development prevents achieving targeted indicators of country's development.

Only through breakthrough, inclusive and innovative development can Russia ensure global competitiveness, rise in labor productivity, improvement of the quality of people's lives (Tolstykh, Shkarupeta, Kostuhin, & Zhaglovskaya, 2018; Maloletko et al., 2016).

2. Problem Statement

Let's illustrate the need to undergo breakthrough development and to carry out technological jump with statistic data.

When describing the state of the Russian economy by 2018, it is necessary to notice that following the results of 2017 there has been the lowest ever level of inflation (2.4%) and unemployment (5%); low budget deficit (1.5% GDP) and low state debt (15.1 % GDP) (according to data of Russian statistics Agency). However, according to IMF estimates, the prospects are rather modest: GDP growth at the level of 1.5-1.7% per year for the period from 2018 to 2024. Low potential growth rates are conditioned upon the absence of free labor forces and production capacities as well as upon unfavorable demographic situation and low capital inflow.

According to Russian statistics Agency, shares of sectors in GDP in 2017 were as follows (in the order of decreasing): other sectors – 17%; trade – 14%; processing – 13%; extraction – 10%; real estate – 10%; public administration – 8%; transport – 7%; construction – 6%; science – 5%; agriculture - 4%; finances – 4%. Thus, there is a significant capacity for growth in all sectors; development of industrial complexes is the main driving force for economic growth. But the growth may be restrained by obligations under OPEC+, restrictions on transfer of technologies, archaic regulatory environment.

For the achievement of the first goal (table 1), the example of Turkey – the country with similar GDP per capita ($ 24.8 thousand in the Russian Federation, $ 25.2 in Turkey) is representative for Russia. Turkish economy in 2017 demonstrated a rapid growth – 7.4%. Among other things, it was possible to reach such an impressive indicator due to huge amount of state guarantees – 7.0% GDP in 2017. State guarantees in this case were the best protective tool against non-economic risks.

3. Research Questions

When defining the essence of the concept "development'', we should draw on the basic ideas of dialectic and materialistic development concepts. For instance, Akimova & Moseykin (2009) substantiate that the prevailing economy model at the modern stage is the infinite economic growth and the conception of progress.

When characterizing the main problems of modern development philosophy, the famous methodologist stated that Shchedrovitsky (2010):

- development is uneven;
- development is not guaranteed;
- development is dangerous.

Interrelation and interdependence of different types of the enterprise development includes:

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- economic development;
- technological and technical development;
- organizational development;
- social development;
- innovative development;
- other types of development, for example, scientific development etc.

Many scientists define development of industrial complexes as the change of state. They particularly highlight social and psychological effects of this process, which, being at a certain stage the result of the activity, are necessary for further progress.

By aggregating existing definitions of development of economic systems of different levels it is possible to give definition that most closely reflects the process of industrial complexes development: the development of industrial complexes is, in the opinion of the authors, the aggregate of progressive changes in accordance with organizational, technical, economic and social -cultural processes, that facilitate expansion of activity and mainstreaming of personal computers both in economic and social environment of the society.

Contradiction between people as linear thinkers, linear actors and the exponentially growing world is the key trend that will define the rest of development.

Most authors define sustainable development as the process with certain characteristics that includes adjustability to changing environment.

When it comes to economic systems, sustainable development can be considered as the process of implementing development strategy based on the conception. Sustainable development, in the author's opinion, represents dynamic model of the development of the society which ensures implementation of the main goal on the basis of justice, creation of multifold opportunities for everybody, reduction of inequalities, increase of basic living standards, fair social development and preservation of ecosystems. It is possible to say here that sustainable development of personal computers means the process of their functioning by means of efficient use of resources for the achievement of the main strategic goal – to ensure viability of the said systems and, in general, of World-System based on safe and harmonious living of current and future generations.

Goals in the field of sustainable development adopted by General Assembly of the UN in 2015 are the important benchmark today for the development of states and business worldwide. The goals are set in and described in the document "Transforming our world: Agenda in the field of sustainable development for the period up to 2030" (2015) and determined to end poverty, save resources and to ensure prosperity for all. Seventeen goals in the field of sustainable development are relevant to all sectors of economy, including the industrial sector.

Algorithm for ensuring breakthrough development for the purposes of achievement of global competitiveness is represented in Figure 01.

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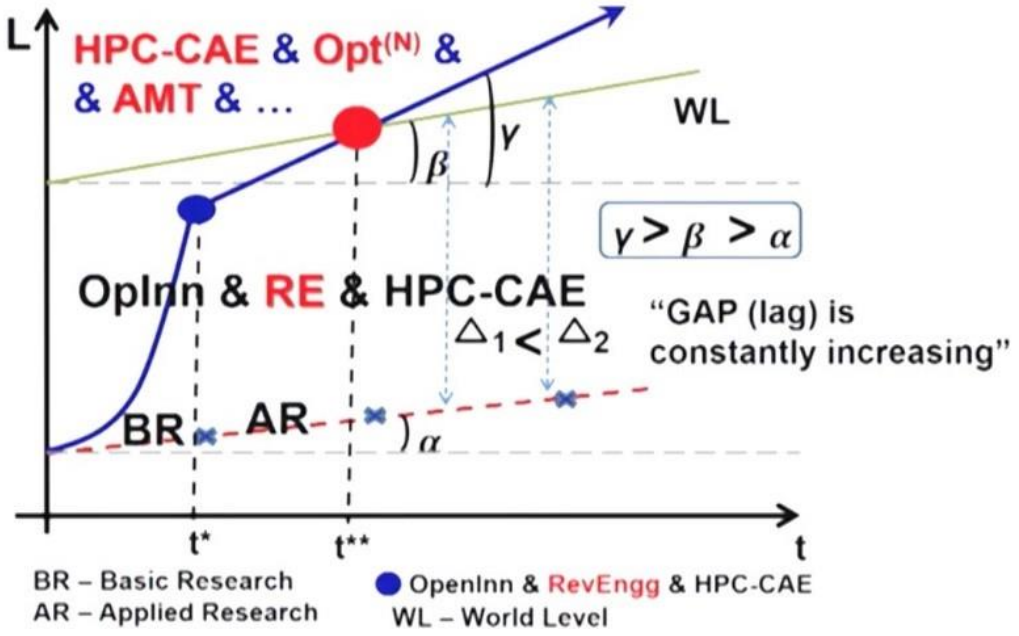

Figure 01. Technological breakthrough development of industrial complexes amid new industrial revolution
Source of figure: (Borovkov, Ryabov, Kukushkin, Maruseva, & Kulemin, 2018)

Level below – the Russian level where we are moving at the angle α. Top level – the world level – development at the angle β. Figure 1 shows that whatever we do, every day we fall behind. So, in order to ensure sustainable development, it is necessary to do the following:

- "jump" up to the world level, for example, by means of reverse-engineering;
- at the second stage it is necessary to ensure application of high-performance computing, simulation of all processes (including production processes), application of all types of optimization (multi-criteria, multivariable, multidisciplinary, topological, topographic etc.) and advanced production technologies.

As a result, it is possible to achieve a highly competitive product in short time (time-to-decision) with short period for market launch (time-to-market).

In the context of the fourth industrial revolution (in some sources, for example, according to Shchedrovitsky (2010), the third industrial revolution due to identification of the "0"-level), those company will become leaders who transfer their focus to the field of digital design and modeling, computer and supercomputer engineering alongside with multiple optimization techniques, bionic design, additive manufacturing, robotic automation etc. (Borovkov, Burdakov, Klyavin, Melnikova, & Mikhailov, 2012; Borovkov, Ryabov, Kukushkin, Maruseva, & Kulemin, 2018; Borovkov & Ryabov, 2018; Borovkov, Maruseva, Ryabov & Shcherbina, 2015).

Definition of advanced production technologies emerged in Russia in 2014 in Skoltech and then it was improved by Peter the Great Saint-Petersburg Polytechnic University: Advanced production technologies are the complex aggregate of multidisciplinary knowledge, science-based technologies and a system of intellectual know-hows obtained by means of long-term and expensive researches, efficient use of a concept of open innovations and transfer of advanced science-based technologies (Borovkov et al., 2018).

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According to the experts of the World Economic Forum 2017, the twelve advanced production technologies include (World Economic Forum Handbook on the Fourth Industrial Revolution and World Economic Forum Global Risks Report): artificial intelligence and robotic technologies; ubiquitous sensor networks; virtual and augmented reality; additive manufacturing; blockchain and distributed technologies; advanced materials and nanomaterials; storage and transfer of electric energy; new computer technologies; biotechnologies; genetic engineering; space technologies.

The concept "cross-cutting technologies" has begun gaining popularity among Russian specialists in the field of scientific and technological development since 2015. Cross-cutting technology is a promising technology that fundamentally changes the situation in existing markets or promotes formation of new markets (Agency for Strategic Initiative, 2017).

Accelerated scientific and technological development of Russia and your regions requires elaboration of platform (cross-cutting) technologies that have significant multiplicative potential (Khmeleva, Tyukavkin, Sviridova, & Chertopyatov, 2017).

Such cross-cutting technologies may include the following (Myazina, 2018; Vasin, Gamidullaeva, Shkarupeta, Finogeev, & Palatkin, 2018):

1) information and communication technologies:

- high-performance computational architectures and systems;
- technologies and communications infrastructures for high-speed data transmission;
- database mining technologies;
- human-computer interaction technologies, neurocognitive technologies;
- IT security technologies;

2) digital production and new materials:

- technologies for creation of intelligence control systems and "smart" infrastructures, technologies for M2M interaction and "Internet of things";
- new components and electronic devices technologies, quantum technologies;
- mechatronics and robotronics technologies;
- computer –based simulation of materials and processes;
- constructional, functional and metamaterials;
- additive and hybrid technologies;
- diagnostic of materials;

3) biotechnologies:

- genomic and post-genomic technologies;
- cellular technologies
- synthetic biology;
- neurotechnologies;
- industrial biotechnologies and biomaterials;
- biosafety technologies

4) space systems:

- technologies for construction and use of space vehicles and their systems;
- technologies for creation of promising launch vehicles;

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- technologies for creation of promising space vehicle propulsion systems for launch vehicles;
- orbital maintenance technologies;
- ground and space infrastructure technologies for ensuring of space activities;

Top-priority Eurasian technological platforms (members of the Eurasian Economic Commission are Armenia, Belarus, Kazakhstan, Kyrgyzstan, Russia) that can develop globally competitive products of future include extraction of natural resources, information and communication technologies, photonics, agriculture, industrial technologies and other directions.

4. Purpose of the Study

The purpose of this study is to carry out analysis and to develop relevant theoretical and practical tools for breakthrough technological development of industrial complexes amid digital transformation.

5. Research Methods

Lots of countries have adopted medium- and long-term strategies in the field of breakthrough technological development, such as Industrie 4.0 (Germany), Industrie du Futur (France), Digitising European Industry strategy (the European Union), Manufacturing Innovation 3.0 (Republic of Korea), Make in India (India), Industria Conectada 4.0 (Spain), National technological initiative (Russia), New Robot Strategy (Japan), Manifattura Italia (Italy) and China Manufacturing 2025 (China) (figure 2).

Figure 02. Strategies in the field of breakthrough technological development in different countries
Source of figure: (Digitising European Industry: 2 years after the launch of the initiative)

During the research the authors concluded that breakthrough technological development of industrial complexes shall be carried out using the following principles (Initiative “Group of twenty” on development and cooperation in the field of digital economy):

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- Innovations. Technological innovations in information and communication technologies, as well as innovations in the economic activity related to information and communication technologies, are defined as the main factors of inclusive economic growth and development.
- Partnership. Closer partnership among all actors of digital, innovative and technological ecosystem may promote breakthrough technological development.
- Synergy. Since breakthrough technological development affects almost all social and economic sectors and is closely connected to innovation issues and issues of the new industrial revolution (reindustrialization), it is necessary to try to achieve synergy from the solution of such issues.
- Flexibility. Flexible approach that takes into account all parties concerned and their priorities in the achievement of breakthrough technological development (society, population, citizens, state, business) is especially important.
- Inclusivity. For the purposes of use and further development of information and communication technologies, it is necessary to cooperate with all parties concerned in order to overcome all forms of technological gap and in order to support entrepreneurship, innovations and economic activity, including in the field of further development of information and technological resources and services in different languages and in different formats that are accessible to all people who are in need of possibilities and means, including mass media, information and education in digital area.
- Open and favorable business environment. Private sector, as well as favorable and transparent regulatory and political environment and stimulation of open and competitive markets are extremely important for breakthrough technological development. It is very important to observe consumer protection and competitiveness acts since they promote improvement of access to markets, technological innovations in the field of information and communication technologies and growth of digital economy.
- Exchange of information with the view of ensuring economic growth, trust and safety. Freedom of expression and free exchange of information, ideas and knowledge are extremely important for breakthrough technological development and positively affect the development.

6. Findings

The following results have been achieved in the study:

- relevance of breakthrough technological development amid digital transformation has been justified;
- key goals for development of the country until 2024 were defined and within the scope of them key goals of technological development have been distinguished;
- theoretical and practical tools for breakthrough technological development of industrial complexes amid digital transformation have been elaborated through examining of the essence of the concept “development”, interconnection of types of development, characteristics of digital agenda of sustainable development of industrial complexes, technological future of Russian economy, algorithm for ensuring of breakthrough technological development for the purposes of achievement of global competitiveness, ranging and establishment of frontiers of

advanced production technologies, construction of a profile of a leading company in the sector, identification of principals of breakthrough technological development.

7. Conclusion

Integration of advanced technologies with addition of own intellectual know-hows, elaboration of "smart" models and digital twins, digital shadows and digital threads, implementation of digital platforms in key sectors of industry, creation of "smart" productions may become a real driving force, catalysts for breakthrough technological development of industrial complexes amid rapidly expanding the fourth industrial revolution (Digital production: methods, ecosystems, technologies).

Examination of new business models of breakthrough technological development and, therefore, new types of interaction between the main actors of this process may become an interesting field for future research.

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