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Trend Attributes of the Implementation of a Technological Breakthrough

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Abstract—An analysis of the trend attributes of the domestic creation of a modern technological breakthrough is carried out. The volumes and shares of countries in the world market of high technology products, as well as the comparative structure of technological structures of the Russian Federation and the United States are considered. Examples of the attributes of modern technological development are given. The state of development of domestic science is assessed. The role of state management in ensuring a technological breakthrough is noted. The research is based on the general scientific method (problem statement, information and analytical generalizations, classification and analogies, analysis and synthesis, and an inductive–deductive approach).

Keywords: trend attributes, creation of a technological breakthrough, public administration, funding science

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INTRODUCTION

The development of science is one of the strategic priorities for achieving a new quality of industrial, technological, and economic development of the Russian Federation, thus ensuring its national security.

The strategic goal of the scientific and technological development of our country is to ensure that Russia will be among the five leading countries of the world that carry out research and development in the areas determined by the priorities of scientific and technological development by 2030–2035, as well as to achieve world-class research and development that create the conditions for the country's global competitiveness in these areas.[1] The following are especially important in the field of scientific and technological development: concentration of resources, focusing of intellectual, financial, organizational and infrastructural reserves on the support of research and development, on the creation of products and services that are necessary to respond to the great challenges facing the country[2] within the framework of the national goal Opportunities for Self-actualization and Development of Talents, ensuring the presence of the Russian Federation among the ten leading countries in the world in terms of scientific research and development by 2030,[3] as well as the parallel formulated problem of creating a technological breakthrough in our country [1].

Due to the relevance of the technological breakthrough problem (as a modern basis for the systemic modernization of the Russian economy), which is declared at different levels of government, as well as at various forums in the form of communications and events, an update of goals within the competence of a set of interrelated subordinate regulatory legal acts of government will definitely take place in the expected future.

In addition to natural resources, the welfare of the country is made up of the latest diverse knowledge, much of which is being transformed into technologies that play the most significant role in the development of the economy, increasing the competitiveness of economic entities and the entire country (with its regions and municipalities). Modern trends in technological progress lead not only to the development of breakthrough technologies and to technological breakthroughs, but also to global changes such as the solution of the humanitarian problem that has arisen due to the disappearance of a number of labor mar-

[1] Decree of the President of the Russian Federation as of December 1, 2016 No. 642 On the Strategy of Scientific and Technological Development of the Russian Federation. http://www.kremlin.ru/acts/bank/41449. Accessed December 7, 2020.

[2] Decree of the President of the Russian Federation of May 7, 2018 No. 204 On National Goals and Strategic Objectives of the Development of the Russian Federation for the Period up to 2024. http://www.kremlin.ru/acts/bank/43027/page/2. Accessed December 7, 2020.

[3] Decree of the President of the Russian Federation of July 21, 2020 No. 474 On the National Development Goals of Russia until 2030. http://www.kremlin.ru/acts/bank/45726. Accessed December 7, 2020.

Table 1. Technological breakthroughs of the 20th century at the level of the world scientific and technological revolution

Years	Inventions
1940s	Television, transistor, computer, radar, atomic bomb, penicillin, synthetic fiber
1950s	Hydrogen bomb, artificial Earth satellite, jet aircraft, CNC machine, nuclear power plant, disposable syringe
1960s	Laser, communications satellite, integrated circuit, high-speed train
1970s	Microprocessor, industrial robot, biotechnology
1980s	Ultra-strong ceramics, genetic engineering, thermonuclear fusion
1990s	Compact disc, player, mobile phone, surrogacy, nanotechnology

kets, through the transformation of these technologies and the formation of others, as well as the creation of new business models. Only a radical technological breakthrough can accelerate economic growth with the elimination of uneven spatial development.

A domestic technological breakthrough is understood as the task of a forced technological evolution, an accelerated innovative transition of the country to a new technological order (TO) under the auspices of state organization/management. In this regard, the attributes of creating a technological breakthrough can be understood as the apparently primary (necessary, essential, and inalienable) defining areas of ensuring scientific and production technological breakthroughs (by public administration, without which a technological breakthrough cannot occur), and the trend attributes of creating a technological breakthrough (main trends, areas, principles, factors, features, methods and approaches to the cardinal growth of indicators) can be determined by the urgency of their relevance (significance, adequacy, and applicability).

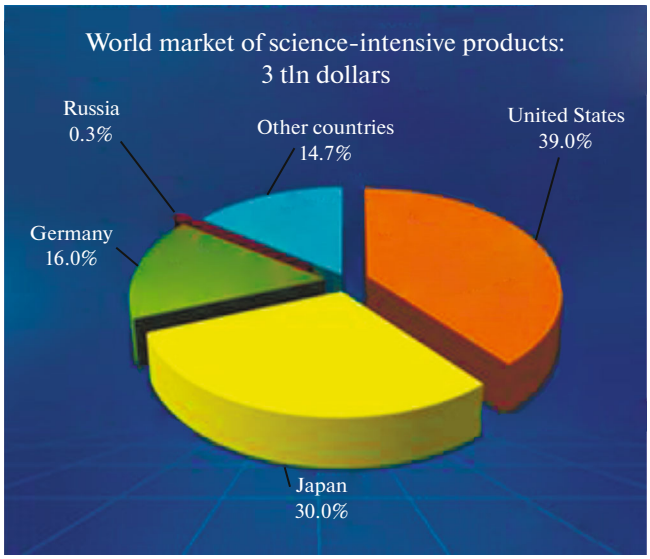

Fig. 1. The volume of the world market for science-intensive products and the share of countries [2].

The goal of this article was to analyze the trend attributes of the creation of modern domestic development aimed at ensuring technological breakthroughs under the auspices of public administration.

THE VOLUMES AND SHARES OF COUNTRIES IN THE GLOBAL MARKET OF SCIENCE-INTENSIVE PRODUCTS. THE COMPARATIVE STRUCTURE OF THE TECHNOLOGICAL ORDERS OF THE RUSSIAN FEDERATION AND THE UNITED STATES

A technological breakthrough focuses on science-intensive/high-tech industries related to the science-intensive sector that is a part of the economic system that includes industries, which produce products and perform work/provide services using the achievements of science and technology. The scale of the science-intensive sector and its impact on the development of other sectors of the economy characterize the economic and scientific technical potential of the state and determine its development, competitiveness, and national security (especially in the face of the threat of high-tech war). Thus, the well-known technological breakthroughs of the 20th century occurred at the level of the world scientific and technological revolution (at that time, with the participation of the Soviet Union) (Table 1).

After the 1990s Russia is far from a high level in terms of the level of modern technological development and we own only no more than 3% of the volume of the world market for high technology products (Fig. 1); the leading countries are representatives of the American, European and Asian models who have found ways to support high technology industries and also are owners of the market for high-tech products.

The following is of the highest priority for the macroeconomic progress of the Russian Federation on the path to increasing its global competitiveness: the directed approach, the achievement of significant results in the creation of import substitution, cooperation with leading countries, and entering areas of the world market [2]. However, at the present stage of technological development, in terms of the structure of the technological order, the Russian Federation is still noticeably inferior to a number of countries, first of all, the United States (Table 2): the creation of a domestic technological breakthrough requires a complex of modern trend attributes of a scientific, technological, and production nature.

Table 2. The structure of the technological order of the Russian Federation and the United States [3, 4]

TO	TO structure, %	
	USA	RF
I–III	15	35
IV	20	55
V	60	10
VI	5	–

Table 3. An illustration of the dynamics of American progress in civilian use of electronic technology

Years	Electronic products
1993	First smartphone
2000	Multifunctional smartphone
2003	Launch of Skype
2004	Launch of Facebook
2005	First video on YouTube
2006	Launch of Twitter and SMS
2007	Series of iPhone smartphones
2008	Opening of an online store
2010	Emergence of iPad
2012	Practice of iPad school application
2015	Apple entering the watch market
2020	Presentation of new models of the iPhone smartphone with supporting technologies of wireless networks 5G (line of iPhone 12, iPhone 12 mini, iPhone 12 Pro and iPhone 12 Pro Max devices)

EXAMPLES OF TREND ATTRIBUTES OF MODERN TECHNOLOGICAL DEVELOPMENT

In the presence of successful modern domestic projects (such as the "Russian collider," synchrotron and "Super charm-tau factory"), a clear example of our missed innovative opportunities is the sphere/industry of electronic technology, where steady progress of the United States occurs in the sphere of civilian use (Table 3), which is observed in parallel with the rapid development of American information technologies and the process of creating a quantum computer.

In the process of a domestic technological breakthrough, it is necessary to take the fact into account that new breakthrough technologies in the West (mainly in the United States) are occurring in parallel and continuously in various fields, not only in electronics. As an example, in 2020 these were personalized medicine, quantum Internet, digital money, anti-aging drugs, "compact" artificial intelligence systems [5]. The *Business Insider* publication (according to the report of the International Council, which took place in the framework of the World Economic Forum) has compiled a Planetary Checklist of Technological Changes by 2025–2027 (Table 4).

Another example of an already unacceptable lag in strategic development is at the level of the intersectoral complex: we are still at the initial stage of the development of a fundamentally new technosphere (NBIC-convergence) integrated into the natural resource turnover, which is a hypothetical core of the VI tech-

Table 4. A Planetary Checklist of Technological Changes by 2025–2027 [6]

Years	Technological changes
2018	90% of the population had free and unlimited access to data storage services
by 2021	The first robot pharmacist will appear in the United States; 1 trillion sensors connected to the Internet will work around the world (including the clothes of 10% of the world's population)
in 2022	The first 3D-printed car will be launched
by 2023	10% of reading glasses will be connected to the Internet, 80% of the world's population will be in the digital world, 90% of the world's population will carry a supercomputer in their pocket
in 2023	The State Population Census will be replaced for the first time with bigdat technologies and the government will collect taxes using blockchain for the first time
by 2024	The first 3D-printed liver will be transplanted and 5% of consumer goods will be 3D printed
by 2024	Internet access will become a basic human right and more than half of Internet traffic will come from household appliances and electronic appliances
by 2025	30% of the solutions for corporate audits will be replaced by artificial intelligence, and the number of trips by cars of car-sharing services (worldwide) will exceed the number of trips by private cars
in 2025	The first implantable mobile phone will enter the market
by 2026	Every 10th car in the United States will be unmanned, a device with artificial intelligence will become a member of the company's board of directors for the first time, the world's first city with a population of more than 50 000 people and the complete absence of traffic lights will occur
by 2027	10% of GDP will be stored using blockchain technologies

Table 5. Indicators of the current state and factors that affect the level and quality of development of the sphere/sector of Russian science [8]

№	Indicators and factors
1	The main source of funding for science in Russia is still the budget (on average, approximately 60–70% of total spending on research and development is provided at the expense of state funds)
2	The mechanism for financing science by attracting extra-budgetary sources does not lead to an increase in the volume of extra-budgetary funds spent on science, which contradicts not only global trends, but also the priorities of the Strategy for Innovative Development of the Russian Federation for the period up to 2020
3	The management system of Russian science is not focused on the formation of demand for domestic results of scientific activities, including from business and industrial consumers, as well as on the creation of new scientific knowledge recognized in the international academic community
4	Activities in the sector of Russian science have a low level of attractiveness for both young scientific personnel and leading scientists, including foreign ones, which is due to significant institutional barriers, as well as an undeveloped and outdated labor market in research and development
5	Negative dynamics in the number of researchers under the age of 29 and researchers hired after graduation from the university, which has not stopped decreasing since 2001

nological order (with NBIC projects of scientific and technological breakthrough of the 21st century), which is based on the unification and synergetic strengthening of the achievements of nano-, bio-, information, and cognitive technologies with their fusion into a single scientific and technological area of knowledge [7]; under these conditions, due to the expected radical transformation of the technical equipment of production, as well as productive forces (with a qualitative leap in the structure and dynamics of their development), this area is, first, a harbinger of a revolutionary leap in technological development and, second, an example of transformation of science into the leading factor of production with the evolutionary transformation of an industrial society into a post-industrial one.

In addition, cardinal modernization of our industry (at the technological breakthrough level) is impossible without the active use of financially capacious modern approaches of a technological nature such as the development of digital technologies (for example, digitalization in the concept of technological preparation of production), cloud computing, uberization, network-centric management, and the sharing economy and is also impossible without innovative communications. The technological breakthrough capabilities of a particular industrial enterprise/organization are determined by the technical level and quality of products, whose production depends on the "technological environment," including the research base, the volume and structure of R&D, and the financial possibilities of acquiring/purchasing licenses.

THE STATE OF DEVELOPMENT OF DOMESTIC SCIENCE

The main issues that hinder the scientific development of the country were determined to assess the sufficiency of state support measures aimed at the development of domestic science (first), expenditures in the field of science at the expense of the federal budget, budgets of the constituent entities of the Russian Federation and at the expense of extra-budgetary sources (second), and prospects for increasing the place of Russian science in the international ranking (third) [8]. At the same time, the state of the sphere of science was described and an assessment was made of the institutional environment of Russian science and state support measures aimed at its development, expenditures in the sphere of science at the expense of the federal budget, budgets of the constituent entities of the Russian Federation, and at the expense of extra-budgetary sources, as well as current world experience in applying measures for supporting the development of science. Table 5 shows the indicators of the current state of the sphere of Russian science, as well as factors that affect the level and quality of development of the sphere/sector of science.

Table 6 presents the main issues that hinder the scientific development of the country and the corresponding proposals/recommendations.

Thus, the accumulation of the evidence base in the form of versatile and large-scale factual material, as well as broad analytical generalizations, makes it obvious that the level of funding for domestic science is insufficient to ensure a technological breakthrough, which aggravates negative consequences; the problem of creating a real technological breakthrough will remain open until the issue of substantial funding for science and activities ("road maps") for long-term development with the specification of practical steps in a number of competitive areas is resolved.

Table 6. The main issues that hinder scientific development in the Russian Federation and the corresponding proposals/recommendations [8]

Issues hindering scientific development and proposals/recommendations	
The main issues that hinder scientific development in the Russian Federation	Despite significant investments in Russian science ... this area remains insufficiently productive, does not form its own scientific and technological basis for creating and implementing priorities, responding to the "big challenges" facing society and the state, and does not act as a driver for social and economic development. The institutional environment and regulatory framework for the development of the science sector have been largely formed. However, there are areas that require additional attention and improvement. A system of science management has developed that is not focused on the formation of demand for domestic results of scientific activity, including from business and industrial consumers, as well as on the creation of new scientific knowledge recognized in the international academic community. Activities in the Russian science sector have a low level of attractiveness for both young scientific personnel and leading scientists, including foreign ones, which is due to significant institutional barriers, as well as an undeveloped and outdated labor market in the field of research and development. A significant factor in reducing the attractiveness of the Russian science sector for scientists is the lack of a system for stimulating scientific and scientific technical activities. There is no liberalization of the attitude of state bodies involved in the process of financing intellectual property towards scientific developments that are in demand by business. The infrastructure of scientific activity is insufficient in terms of qualitative and quantitative characteristics to ensure the achievement of ambitious goals and indicators of a scientific breakthrough. The development of the Russian science sector uses the effects of the territorial concentration of scientific institutions and scientific activities insufficiently, which contribute to the development of innovative ecosystems.
Proposals (recommendations) of the Accounts Chamber of the Russian Federation	Sending an information letter to the Government of the Russian Federation with a proposal to instruct the Ministry of Education and Science of Russia together with interested federal executive bodies and federal state budgetary institutions to consider the following issues: • bringing normative legal acts in the field of science in line with the current legislation; • distribution of budgetary allocations for R&D taking the effectiveness of research activities into account, as well as monitoring data from scientific institutions; • creation of a system for monitoring the effectiveness of research activities, including accounting for the commercialization of the results of intellectual activity; • approval by the federal executive authorities of the procedure and terms for submission to the RAS of projects of research topics, draft plans of scientific works and reports on conducted scientific research and experimental developments of scientific organizations and higher education organizations carrying out scientific research at the expense of the federal budget, which are under the jurisdiction of federal executive authorities; • taking measures to increase budgetary allocations for the development of scientific infrastructure and human resources, including in terms of increasing the salary of researchers; • approval of the federal scientific and technical program for the development of synchrotron and neutron research and research infrastructure for 2019–2027; • approval of the characteristics of the created and modernized objects of the "megascience" class; • taking measures to improve the efficiency of centers for collective use of scientific equipment and unique scientific facilities; • determining the formats for ensuring mutual consistency of the activities of federal projects within the framework of national projects.

Table 7. The level of financing of domestic science [13]

No.	Comparative data
1	In 2017, while ranking 10th in the world in terms of spending on science and leading in the absolute scale of employment in this area, Russia is an order of magnitude behind the leading countries regarding the effectiveness of scientific activities in terms of the number of patents: by almost 16 times compared to the United States and 38 times compared to China
2	In relation to GDP, expenditures on civil science have not increased in recent years. Russia, with 1.1% of GDP, lags significantly behind the leading countries of the world and is in 34th place. Even in the context of the target parameters of the Science National Project, spending will increase by 2024 to 1.2% of GDP. This is true despite the fact that the leading scientific and technological countries spend more than 3% of GDP for these purposes
3	The main source of funding for science is traditionally the federal budget—approximately 60–70% of research expenditures are provided at the expense of state funds; the share of business in financing Russian science is declining. In the leading countries, the share of R&D funding by businesses exceeds the share of budget funding. This proportion is 70% to 30%. The situation in Russia is reversed. According to the data of the Federal State Statistics Service, in 2000 the share of business in financing R&D was almost 33%, and in 2016 it was already 28%. The mechanisms and instruments for attracting extra-budgetary funds to the science sector have not been defined
4	In terms of the total number of people employed in the field of science, Russia is in the top five countries: in 2016, 428 900 researchers worked in this area. However, in terms of the number of researchers per 10 000 people employed in the economy, Russia is only in 34th place. The position is even lower in terms of the indicator of internal expenditures on research and development per researcher, it is only in 47th place
5	In general, activities in the Russian science sector are unattractive for scientists, including due to insufficient development of the relevant infrastructure and low wages. As an example, in Germany the level of salaries of the teaching staff employed in the field of R&D is 3.3 times higher than the same Russian indicator; in the Czech Republic it is 1.4 times higher
6	Another factor in the low level of attractiveness of Russian science for scientists is the lack of an effective system for stimulating scientific and scientific technical activities. The current system of economic and other benefits does not achieve its goal; there is no growth in the commercialization of the results of intellectual activity

STATE MANAGEMENT IN PROVIDING A TECHNOLOGICAL BREAKTHROUGH

The following information was used to assess the state of domestic scientific development, the issues that constrain it and comparative ratio of factors that provide structural changes at the technological breakthrough level [8]:

• on comparisons of indicators of the Scientific and Technological Development of the Russian Federation State Program, the Science National Project and the place of Russia in the field of science in international rankings [9];

• on normative legal acts governing state support in the field of science development [10];

• on the execution of budgetary allocations for the main administrators of federal budget funds, objects of an expert and analytical event [11];

• on foreign organizations that support science [12].

The assessment has shown that although the sphere of science and high technologies is intended to become one of the drivers of socio-economic growth in Russia, it still cannot cope with this role, since the level of funding for science is still insufficient to ensure the technological breakthrough of the Russian Federation (Table 7 shows the data that are to be compared with foreign ones).

The UNESCO ranking also indicates the underfunding of our science: for example, in terms of R&D funding in 2018, the Russian Federation ranked 10th, lagging behind even Brazil [14], once again confirming that the organization of the planned technological breakthrough is primarily associated with an unequivocal need for a significant increase in funding for science, that is, the problem of making a real technological breakthrough will also remain open in the first place until the issue of substantial funding for science and activities ("road maps") for long-term development with a specified form of practical steps is unambiguously resolved in a number of innovative competitive areas. The current focus and activation of government bodies on solving an urgent problem are the fact and objective inevitability of recognizing the priority of the producing economy over the raw materials economy, which gives significant confidence in the feasibility and consistency of the planned creation of the technological breakthrough. Meanwhile, although any innovative activity is characterized by an appropriate purposeful system of measures, frontality, a high level of uncertainty and risk, the complexity of pre-

dicting results also cannot be reduced to only one of its components; the technological breakthrough strategy and its tools as the core of management must definitely include, first, the formulation and creation of the main "goals–tasks–initiatives" undertaken by public administration on the basis of accounting for resources and assessing the internal and external environment and, second, organizational actions and methods (including risks of low costs) that are used for this creation.

There is no single approach for the creation of technological breakthrough, but its ambitious and illustrative examples in the mainstream of technological challenges of the times of the Soviet Union (except the technological breakthrough of the 20th century at the level of the world scientific and technological revolution, see Table 1) are the creation and testing of the RDS-1 atomic bomb in 1949 as well as the development and launch of the Vostok-1 spacecraft in 1961 against the background of the continued growth of industrial production and hydroelectric power plant capacities, oil production in Siberia and the construction of new plants, and the appearance of refrigerators, vacuum cleaners, washing machines and electric lighting in cities in Russia in the early 1960s. At that time the state acted as a single customer as now, simultaneously performing the function of management, that is, an interconnected set of long-term goals, measures, and approaches.

There are enough examples of diversified foreign achievements for the creation of the current technological breakthrough and there is a state need for domestic results that will surpass (and not only "reflect on the whole") the "overtaking" complex of modern features and specifics of "accelerated" technological evolution/development. Thus, in Russia there are signs of the emerging problem of a national economic technological breakthrough; it is relevant and is not only one of the national priorities; the national goals and development projects of the Russian Federation cannot be achieved without its solution [1]. Drawing an analogy by referring to the classical graphical dependence in the "expectations from technology–time" coordinates (Fig. 2), it is time for us to pass in our "technological expectations" from the "peak of inflated expectations" through the "failure of disappointments" and reach the temporal "productivity–efficiency plateau" of a technological breakthrough, that is, in order to promote the technological leadership of our economy (based on the development and accelerated industrial creation of science-intensive "intelligent" technologies), it is urgently necessary to activate the symbiosis of "public administration–science–technology–production" with representatives of the scientific and educational community, industry and business.

The well-known procedures for managing scientific and technological development [15] and national

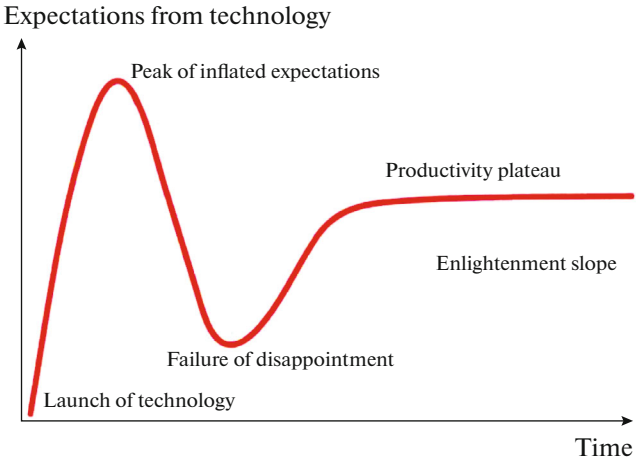

Fig. 2. The graphical dependence in the "expectations from technology–time" coordinates.

priorities for innovative development and the formation of scientific and production ties (due to the multifunctionality of the management mission) make it possible to create technological breakthroughs within the framework of subordinate regulatory legal acts that are within the competence of state and administrative decisions in the field of technological development; for example, these are national goals and strategic development objectives, country development strategies and national projects, national technology initiatives, state and federal target programs, programs of measures to support promising industries, technology platforms, technology valleys, clusters, and technological engineering [16, 17]. Thus, it can be assumed that if government decisions (in the form of a complex or separate subordinate regulatory legal acts) in the field of technological development are not yet aimed at the actual creation of a technological breakthrough, this will be done in a timely manner in the process of their transformation: clarification, adjustment, revision, and rotation. Certainly, the procedures for a technological breakthrough initiated by the state will be supported by the awaiting scientific community of the country's institutes and universities, industrial and production enterprises/organizations of various forms of ownership, and business structures.

CONCLUSIONS

(1) An updated analysis of the issues that restrain technological development and the ratio of factors that provide structural changes at the level of a technological breakthrough for achieving the world level shows that the current trend attributes of the creation of domestic development are associated with the need to organize scientific work on a national scale.

(2) Significant confidence in the feasibility and consistency of the planned creation of a technological

breakthrough is given by the fact that government bodies are focused and activated on solving a pressing problem as an objective inevitability of recognizing the priority of the producing economy over the raw materials economy.

(3) It can be assumed and hoped that if government decisions (in the form of a complex or separate subordinate regulatory legal acts) in the field of technological development are not yet aimed at a technological breakthrough, this will be done in a timely manner in the process of their transformation: clarification, adjustment, revision, and rotation.

(4) The accumulation of the evidence base in the form of versatile and large-scale factual material as well, as broad analytical generalizations show that the level of funding for domestic science is insufficient to ensure a technological breakthrough, which aggravates the negative consequences, that is, one should probably expect that the problem of a real breakthrough will remain open until the issue of substantial funding of science and activities ("road maps") for its long-term development with a specified form of practical steps in a number of competitive areas is resolved.

(5) It seems important that the state-initiated technological breakthrough procedures will be supported definitely and with interest by the awaiting scientific community of research institutes and universities of the country, as well as industrial enterprises/organizations of various forms of ownership and business structures.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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