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Center for strategic research of modern industrial revolution

Centro de investigación estratégica de la revolución industrial moderna

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Content

ABSTRACT:

Russia is now facing two existential challenges to its sustainable economic development - the Fourth Industrial Revolution, marked by the rise of cyber-physical systems, the Internet of things and cloud computing in manufacturing industries, and the inability of Russia's current economic model to ensure long-term sustainable growth. These factors condition Russia's transition to a new model of socio-economic development, focused on emerging and innovation markets, on the one hand, and on an in-depth modernization of traditional industries, on the other. The paper looks at the prospects for the "Russian Industrial Revolution" project. In this regard, the paper examines priority areas of Russia's technology development and analyzes the prospects for comprehensive modernization and optimization of traditional sectors and industries being a key factor to ensure the emergence of new domestic high-tech sectors. Authors come up with a number of solutions set to facilitate Russia's transition to a new industrial revolution, among them - a targeted technology policy within the federal state programs framework, a transformation of the personnel training system, and an overhaul of the strategic planning system for science and technology development.

Keywords: fourth industrial revolution; technological breakthrough; Russian economy; economic risks;

RESUMEN:

Rusia se enfrenta ahora a dos desafíos existenciales para su desarrollo económico sostenible: la Cuarta Revolución Industrial, marcada por el auge de los sistemas cibernéticos, la Internet de las cosas y la computación en la nube en las industrias manufactureras, la incapacidad del actual modelo económico de Rusia para garantizarlo por mucho tiempo y Crecimiento sostenible a largo plazo. Estos factores condicionan la transición de Rusia a un nuevo modelo de desarrollo socioeconómico, centrado en los mercados emergentes y de innovación, por un lado, y en una modernización profunda de las industrias tradicionales, por el otro. El documento analiza las perspectivas del proyecto "Revolución industrial rusa". En este sentido, el documento examina las áreas prioritarias del desarrollo tecnológico de Rusia y analiza las perspectivas de modernización y optimización integrales de los sectores e industrias tradicionales, siendo un factor clave para garantizar el surgimiento de nuevos sectores nacionales de alta tecnología. Los autores proponen una serie de soluciones para facilitar la transición de Rusia a una nueva revolución industrial, entre ellas, una política tecnológica específica dentro del marco de los programas estatales federales, una transformación del sistema de capacitación de personal y una revisión del sistema de planificación estratégica para Desarrollo de

investment in technology.

la ciencia y la tecnología.
Palabras clave: cuarta revolución industrial; avance tecnológico; Economía rusa; riesgos economicos Inversión en tecnología.

1. Introduction

In the late 2000s – early 2010s, the potential for productivity growth under the existing economic and technological order turned out to be nearing exhaustion in most developed countries (World Economic Forum, 2017).

The experience of scientific, technological, industrial, and economic policies in industrially developed countries over the last decades, primarily in the USA, Japan, and Germany (Hakansson, 2015; Kroes and Bakker, 2013), shows that it is impossible to regain high productivity rates in the economy and the profitability thereof by means of macro-economic measures (allocation of "cheap" money under state programs of industrial development, tax stimulation, etc.) or by cutting wages in the industrial sector and prices of raw materials. The technological optimization of production does not change its profitability radically, at least not in the industrial sector. The latter came under the effect of the law of decline of return on investment during the crisis of 2008 and the following years and faced the problem of excess fixed assets. Conventional technologies nearly reached "peak" productivity, after which return on investment in their development drops radically. One can see by the example of the USA that a five-time increase in investments in fixed assets from 1980 to 2015 did not produce a similar increase in productivity (OECD, 2015).

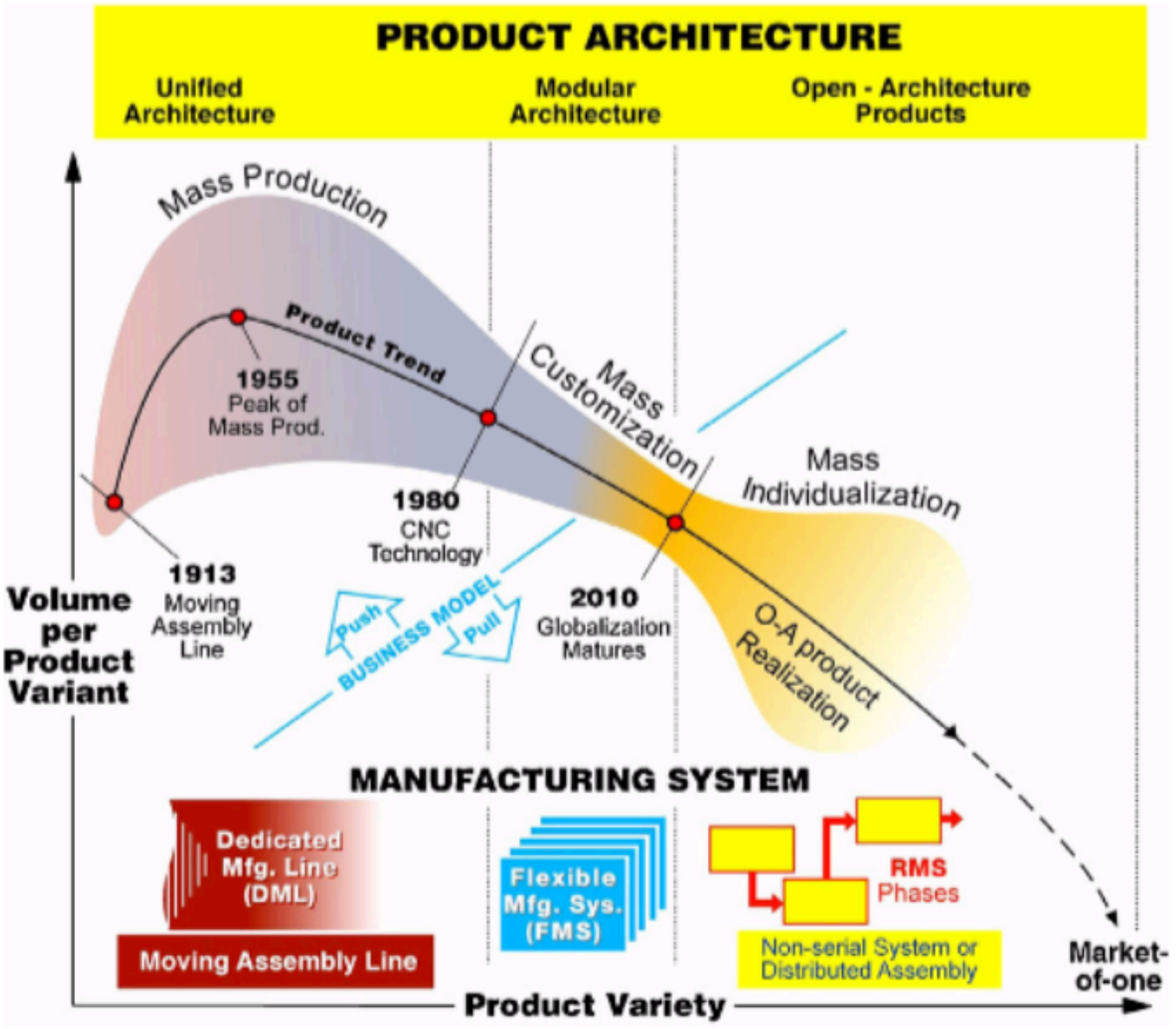
Conventional technologies have also started reaching the limits of their productivity and efficiency in the non-industrial sectors of the economy: agriculture, transport, power industry, healthcare, education, and the social sector in its broad definition (Magyar, 2016; Park, 2016). This dynamic coincided with the trend of reduced growth of mass produce market, changes in the main parameters of consumer demand, and the increasing need for extensively customized or even individualized products. In such conditions, an urgent need emerged for an acceleration of economic growth by means of new sources (factors that are traditionally taken into account in multifactorial production, primarily innovations and cutting-edge technologies).

The answer to the challenge of preservation of competitiveness and achievement of high productivity rates is currently sought by scientific, technological, and innovative policies that are being carried out in various countries. Their goal is to stimulate the development and implementation of cutting-edge technologies, the productivity whereof significantly exceeds the characteristics of conventional technologies.

The greatest contribution to technological and economic growth in these countries should come from new products and technologies. The latter should lead to an extensive transformation of the production, technological, and social spheres. The changes are so significant that they are called the "*fourth industrial revolution*" (Schwab, 2015; Maynard, 2015; Bloem et al., 2014), which is based on digitalization, automation, robotization, intellectualization of production, and formation of so-called cyber-physical systems, when digital models are created for virtually any object and the automated control over all production and technological processes is based on these models (Rifkin, 2011; Kemp, 2016; Kaplinsky and Cooper, 2005).

The characteristic features of the fourth industrial revolution are as follows (Magyar, 2016; Park, 2016): development of disruptive production technologies, customization of mass production, and transformation of the market architecture, including that of the labor market (Figure 1).

Figure 1
Market architecture transformation



The new industrial revolution comes into sight from the moment the “open” market architecture is launched and mass individualization commences. This is a time of multiagent systems, production ecosystems, and holonomic production. Essentially new products and technologies enter the market: modular open architectures that integrate not only materials, but also energy, hardware and software, and internet connection into the product.

Dominating global platforms already exist. Special national programs aimed at the formation and support of platformers are being carried out. There are companies that transfer their businesses onto the basis of product and program platforms.

The leading countries in this respect are the USA and Germany. The latter, courtesy of its Industrie 4.0 project, defines the conceptual framework of the new industrial revolution, while such companies as Siemens dominate in the supply of technological solutions for the new industrial revolution (OECD, 2017).

The purpose of this study is to investigate the risks and opportunities for Russia within the framework of the Fourth Industrial Revolution project. To that end, the objectives set in the study were as follows:

To examine the technological development policy of leading counties in this field

To examine the economic structure of Russia and its capacities

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2. Methods

The theoretical and methodological framework of this study includes the theory of regulation of sustainable economic development during technological development integrative

processes.

In order to achieve the set goal, the study uses a set of complementary research methods: abstract-logical, analytical, economical-statistical, and comparative analysis. The study included a monitoring of governmental programs of the Russian federation and a generalization of Russian and foreign experience in the problem at hand.

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3. Data, Analysis, and Results

The new industrial revolution (scaling of "disruptive" technologies and change of the market architecture) is expected to peak in the 2020s-2030s (Gokhberg, 2014; Dezhina et al., 2015; Federal Research Centre for Projects Evaluation and Consulting Services, 2014). Numerous forecasts show that cutting-edge technologies will unfold quickly and have a comprehensive all-round effect.

In order to compensate for the lost competitiveness, industrially developed countries (USA, Germany, Great Britain, Japan, China, South Korea, etc.) have decided to launch a new industrial revolution in the form of a state policy. Their research and development, economic, and social policies prioritize the acceleration of this industrial revolution, expecting to outrun their competitors (new centers of power) once and for all. These countries carry out an active industrial policy that aims to scale cutting-edge production technologies and structure new markets, primarily by concentrating key universal platforms that aggregate so-called "strategic data" and algorithms of their processing. In turn, "strategic" data and their processing systems serve as the foundation for the formation of huge self-learning human-machine systems (deep machine learning, artificial intelligence systems, etc.). The autonomous functioning of standalone production and technology complexes and objects (outside such systems) is becoming inefficient.

The USA and EU are currently implementing a series of large-scale state programs in cutting-edge technologies in both industrial and non-industrial sectors of the economy, which aim to launch the new industrial revolution and be too far ahead for their competitors to catch up (Coccia, 2015). In 2012, for instance, Germany initiated the Industrie 4.0 industrial strategy as one of the ten "projects of the future" under the Innovations for Germany plan, which aims to implement the updated federal strategy for advanced technology. The USA adopted the Strategy for American Innovation 2013, the National Strategic Plan for Advanced Manufacturing 2012, and implemented a series of specialized interinstitutional initiatives, such as the Materials Genome Initiative, the National Robotics Initiative, etc. Great Britain has its own plan for developing advanced manufacturing (Growth Review Framework for Advanced Manufacturing) and the Eight Great Technologies development program.

In 2013, France approved 34 top-priority projects and programs of future industries and technologies under the La Nouvelle France Industrielle (New French Industry) program. Japan has already launched a five-year plan for the development of science, technology, and innovation (2016-2020). In 2015, China launched the Made in China – 2025 and Internet+ programs.

The key condition for success in the unraveling technological race is early access to "disruptive" technologies at a stage when they have not yet been brought into a state of a prototype, but rate a scientific hypothesis and early technological idea. This forces everybody that is involved in the technological race to reevaluate the risks associated with the creation of products and rewrite the key components of the "time-to-market" formula. Investment in research and development, increase in experiment space, various ways of accelerating the R&D fast track program, creation of various risk unbundling mechanisms (research and development consortiums, simultaneous involvement of suppliers, consumers, and regulators, etc.) – these are risk hedging mechanisms that are commonly used nowadays. At that, in addition to the traditional intensification of the industrial and technological policy, virtually all developed countries have increased their investments in research – the source of "disruptive" technologies, since the 2000s. The peculiarity of this investment cycle is that the cutting of state budgetary funds allocated to research and development is accompanied by a growth of private investments therein.

Challenges for Russia. The challenge of participation in the new industrial revolution is one of the main socioeconomic and historical challenges facing Russia in the early twenty-first century. Nowadays, the technological inferiority of Russia in comparison to the countries that are leading in innovation has become a critical problem for the country's economy. Besides the universal "great challenges", such as exhaustion and declining efficiency of conventional resources, demographic contraction and aging of the population, lagging behind industrially developed countries in terms of life expectancy growth, climate change, and difficulties in the adaptation of the society and the government to the spread of the new "disruptive" technologies, Russia also faces a set of specific internal challenges that are caused by the end of the cycle of development of the traditional industrial society. Such specific "great challenges" for Russia that are related to the development of science and technologies are:

a) structural problems

Accumulation of systemic imbalances in the Russian economy (its increasing dependency on "unstable" petroleum revenue, decreasing percentage of investment in the structure of the gross domestic product, decline of qualitative and quantitative indices of budgetary expenditures) and exhaustion of the potential of Russia's raw material export model economic development; significant government presence in the economy combined with poor effectiveness of its participation therein; low rates of establishment of essentially new and globally competitive economic sectors. Russia retains a low share of high-tech products and knowledge-intensive sectors in the GDP. In spite of the intensifying modernization of the main assets and the general economic growth, this percentage amounted to 21.3% of the total production in the country, according to the date provided by the Russian Federal State Statistics Service in 2015.

In addition, the Russian economy has a disproportionate structural dependency on imported technologies. *According to the data provided by the Russian Venture Company, most Russian companies that create technological innovations (more than 58%) still prefer to purchase ready-made technologies and equipment, while only 15% of said companies independently order or develop the technological solutions they use.* The industrial and technological modernization of the Russian economy is mostly carried out through the import of ready-made technologies. The last several decades saw a formation of a structural dependency of the sustainability of the Russian economy and social sphere on imported technologies, which poses a risk to the former.

Insufficient development of domestic "parent" technologies that would ensure the country's leadership in key direction of the new industrial revolution makes it so the country risks losing its competitiveness and descending into a complete resource shortage. Russia's inferiority in research and development in the field of cutting-edge technologies, which are the foundation of the new industrial revolution, is becoming critical (*despite the fact that Russia is consistently on the list of top-twenty and, sometimes, top-ten countries that own patents in the field of "disruptive" technologies of the "fourth industrial revolution", its lagging behind the top-five leading countries is significant*). The risk of Russia lagging behind even certain developing economies, China, first and foremost, is also extremely high.

b) problems related to the quality of human capital assets and structural disproportion on the labor market

For Russia, problems related to the aging of its population and "brain drain", low labor effectiveness, conversion of the relatively high level of human capital assets, and results of technological innovation studies remain relevant.

According to the data provided by the OECD, labor effectiveness in Russia in 2015 was more than 2.5 times lower than that in the USA: the American level of labor effectiveness (GDP per employed person, expressed in US dollars/worked hour (in current prices according to PPP), was 68.3 US dollars; in Russia, this figure was 25.1 US dollars, while the average index across OECD was 49.4 US dollars) (OECD, 2017).

c) problems related to the effective management of research and development in the Russian Federation

The country does not have a unified system for strategic management of research and development that is adequate to modern conditions, which is mentioned in the recently adopted Research and Development Strategy of the Russian Federation. Expenditures of technological development and innovation are still insufficient when compared to other industrial countries (in absolute and relative values). The current programs for innovative development of state corporations and companies with government participation are still ineffective. State-owned companies do not contribute to high-tech economic growth a share that would be proportionate to their share in the economy. *Russia's specialization in research and development resembles that of the developed countries in the 1980s. The Russian Federation currently has the scientific highest specialization index (SI, 2010-2014) in both WoS and Scopus in physics – 2.78 and 2.52. The closest SIs are mathematics (1.90 and 1.66) and chemistry (1.78 and 1.66).*

Another important fact is that Russia has a systemic gap between the industrial sector, the consumer sector, and research and development. Until the abovementioned challenges are dealt with and this gap is bridged, creating any long-term strategy for the development of the country is pointless.

Without a transition to cutting-edge technologies and innovative development, Russia will not be able to exceed a 4% GDP per annum growth rate and mobilize the resources required to promote investment. Slow growth will hinder the inflow of investments (investors consider attractive the technological sectors and industries with an annual growth potential of over 10%). A growth rate under 4% GDP per annum makes it so Russia risks descending into a complete deficit of resources for solving the most relevant economic and social problems, which could lead to an economic and social crisis.

If Russia is too slow with joining the new industrial revolution, it will face a higher risk of ending up among countries that are "forever inferior" on the technological aspect. For the country's economy, this threatens a loss of global competitiveness.

Technological development should become a tool for the effective inclusion of Russia in the new industrial revolution and the tackling of challenges facing the country, which should also increase the percentage of high-tech economic sectors and solve problems of social development.

The Russian Federation should switch to a new model of economic development, one based on high-tech industries that rely on scientific knowledge and innovative technologies. At that, traditional sectors of the economy and manufacturing should undergo extensive modernization.

The main objectives that have to be accomplished to achieve the set goal are as follows: develop new high-tech industries and economic sectors, transition to a "digital economy", ensure that the country enters new technological markets, including global ones, reach a new quality of human capital assets and a promising organization of the labor market that would be adequate to said assets.

Alternatives (forks and scenarios) of the realization of scientific and technological development of the Russian Federation in the long run.

When choosing top-priority courses for the accelerated technological development, the government of the Russian Federation can rely on the following models of realization of the scientific and technological development of the country:

1) *Evolutionary development opinion (extensive modernization and technological optimization of existing industries and companies)*

This option is based on the notion that the outlines of the future global markets have already been drawn. The development of these markets has already commenced in the world. In this regard, Russia can only develop according to the "catching-up development" model. This type of developed is characterized by a number of distinct aspects: mass spread of reverse engineering and a significant role of the government as the gatekeeper for the entrance to new markets, which ensures the formation of the entire production technology chain as a single complex, solution of issues related to the certification of products and standardization of establishing markets, and stimulation of active and purposeful incorporation of Russian

companies into the production chains of foreign manufacturers that aspire to become leaders on global markets. *With this option of industrial and technological development, the structure of the Russian economy will likely remain unchanged by 2035 – its basis will still comprise of currently dominating industries.* The main beneficiary of this scenario will be big companies that represent the industries of the current basic sector of the Russian economy.

2) *Revolutionary (breakthrough and advanced) development option*

This option is based on the notion that not all the outlines of all new markets are already known. Therefore, Russia should not strive to assert itself on the markets that have already been launched and are developing in the world, despite the fact that they have not been completely scaled yet. It is necessary to prioritize "rapid" development and a breakthrough onto entirely new, currently nonexistent, markets to take the leading positions in the world (ensure a 10-15% share in a series of high-tech markets by 2035), and launch Russian products onto these global markets. It is necessary to restructure the architecture of the main markets and reorganize them into product platforms. Russia should have own its globally significant owners of the latter – "platformers". This means that *the structure of the country's economy should undergo profound transformation by 2035.* Hence, the realization of this notion implies a significant role of the government as an investor both, since the formation of the new global market requires a manufacturer, a consumer, and a regulator being launched onto it at the same time. This implies significant reliance on radical innovations and "disruptive" technologies in the state policy, but also creates significant risks associated with the poor predictability of the development of "breakthrough" markets and their high volatility. The best form of this option of industrial and technological development for the Russian Federation is a deliberate and large-scale experiment, the key subject whereof should be the organized networks and consortiums with participation of manufacturers, suppliers, and regulators. This scenario can benefit rapidly developing medium-sized high-tech companies that primarily represent the digital economy. This scenario is clearly enshrined in the National Technological Initiative 2014 and the program for the transition to a digital economy that is being developed by the government of the Russian Federation (The expert council has presented its vision of the concept of the Digital Economy program, 2017).

Forks between the above scenarios of industrial and technological development imply differences in the parameters of predicted changes in the structure of Russia's economy.

At the same time, the target scenarios for each model, if domestic expenditures on research and development are increased and the scientific and technological development is supported, feature similar notions in regards to the annual GDP growth rate being able reach 4.4% in certain years and being about 3.5% in 2035. At that, from the perspective of growth intensity, the most dynamic development is expected to happen in industrial branches, the indisputable leader whereof is mechanical engineering, which is expected to grow by more than two times (the "modernization" approach predicts that the share of mechanical engineering in the structure of manufacturing will increased from 12.7% in 2016 to 24.8% in 2035, while the "advanced" approach predicts a more than two-fold increase in the gross value added in mechanical engineering, the horizons whereof will expand significantly).

The most expedient course of action would be to combine these two options of executing the scientific and technological maneuver in the economy. Prioritizing new markets is difficult, considering the technological inferiority and considerable social obligations of Russia. Focusing exclusively on the modernization of existing industries and companies implies a risk of aggravating the disproportions in the economy to critical levels.

The first (modernization) model risks overlooking and not supporting substantial changes that systematically restructure the economic reality and serve as its integral foundation in the long run. This means that the country risks ending up without the development resources of the next period, without an adequate economic basis, the elements whereof are currently being formed in the world. This also means that Russia risks ending up without sectors that could replace the conventional basic sector of the economy when the latter finally becomes inefficient and globally uncompetitive. The advantage of this model is that in

the mid-term, current manufacturing, financial, corporate, and personnel related risks for the economy are generally lower, while the development and growth rates are more stable.

On the contrary, the second (revolutionary) model, which relies on the development of only promising segments of the future economy and new "disruptive" technologies, risks unjustifiably degrading the already established foundation of the economy – traditional sectors and technologies that ensure its current operation and generation of revenue to the budget. In the mid-term, the risks associated with this model are generally high, but, at that, there is a possibility to reach high growth rates and become part of the world elite – the leading countries and the "holders" of markets and platforms that define the relevant global economic, scientific, and technological agenda.

Thus, the main long-term scenario of the scientific and technological development of the Russian Federation is one that combines the creation of new rapidly growing markets and an extensive modernization of traditional industries and markets based on the scaling of "disruptive" technological and digitization.

Considering how difficult it is to combine two tasks (modernization of traditional markets and sectors of the Russian economy and creation of new "disruptive" markets in advanced development mode) that do not match, despite not contradicting each other, it is necessary to create two interconnected systems for the implementation of these policies: "regulatory" and "experimental". The first option will be tied to the plans and strategies for existing systems of scientific and technological development management, while the second one will be distinguished as an area for experimental strategic project initiatives that are implemented by a special project institution (project office), similar to the one that was founded under the government of the Russian Federation by Decree No. 1015 dated October 15, 2016 and Order No. 2165-p dated October 15, 2016, as well as the project office of the National Technological Initiative that was created by the Decree of the Prime Minister of the Russian Federation No. DM-P8-1523 dated March 12, 2015 and Decree of the Government of the Russian Federation No. 317 dated April 18, 2016 (Decree of the Government of the Russian Federation, 2016). This will allow unbundling the risks of development that emerge as part of each of the abovementioned models if they are implemented within the framework of the single state research and development policy.

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4. Discussion

The prioritization of the country's involvement in the new industrial revolution poses potential risks:

Risks to the social and economic development are as follows:

1) Risk of Russia transitioning to a labor-intensive economy as a direct result of the new industrial revolution (Gokhberg, 2014). Structural unemployment and loss of jobs in the traditional industry, service sector, social sphere, and management caused by mass dismissal of employees due to the implementation of new technological (automation and robotization), increase in labor effectiveness, and a series of "shut-down" technologies.

2) Risk of destabilization of the budget and loss of budget stability, especially if the external economic conditions deteriorate rapidly (Kemp, 2016). If the growth rates are low, the risk of a lack of a substantial economic results, growing technological inferiority, risk of insufficient social results and discredit of the technological breakthrough idea. Growing inequality both within the society and between certain social groups and regions. This risk can affect the program of scientific and technological development of Russia in that the policy in this area may encounter a deficit of budgetary resources that will be allocated to the solution of other relevant economic and social problems.

According to the estimations of the Bank for Development and Foreign Economic Affairs, in the basic scenario of structural shifts in the economy by 2035, expenditures on education may constitute not more than 5.4% of the GDP, while that on healthcare – not more than 6%. According to the Center for Macroeconomic Analysis and Short-Term Forecasting, the average annual growth rate of the consolidated budget deficit during the realization of the maximum stimulation (technological development) scenario will be 2.6% in 2016-2020 and

0.6% in 2031-2035, while the real disposable household income will increase by 1% in 2016-2020 and by 2.3% in 2031-2035. At that, according to the estimations of the Center for Macroeconomic Analysis and Short-Term Forecasting, the number of persons older than the working age may reach 551 per 1000 working-age persons by 2035 versus the 420 in 2015. This could lead to a considerable deficit of funds in the Pension Fund of Russia. This could also lead to other risks. For instance, 2015, Russia became the country with the most large-scale and rapidly spreading AIDS epidemic in the world.

3) Risk that the extensive technological modernization of existing sectors and industries will be poorly coordinated with the policy of formation of new advanced markets and aspirations to achieve global leadership therein. This poses a threat of resource dispersion between various programs and management systems, as well as a deficit of resources between the modernization and revolutionary models of innovative and technological development of Russia.

This could make it so the GDP growth rate does not exceed 2.6% and the total factor productivity drops to 0.95% by 2035, even if the expenditures on research and development are maintained at the 1.21% of the GDP level.

4) Preservation (growth) of the tax load on business and elimination of the possibility of growth not only "at the expense of state support", but also at the expense of the companies' own funds.

5) Risk of ineffective funding of research and development in Russia, poor effectiveness of the policy that is aimed to bridge the technological gap between Russia and the leading economies of the world:

growing structural technological dependency of the Russian economy on global suppliers, edging of Russia into the significantly more competitive and less marginal zone of module/application creation;

limited implementation of modern business models (for instance, product/service quality management, Asset Performance Management (APM), EaS, ETO) and other methods of mass customization (pre-configuring a set of product variants, bills of material (BOM)) by Russian companies;

Russian companies not having efficient parent technologies to manage the growing complexity of modern flexible manufacturing systems (including Russia's inferiority in engineering software and development of software platforms for managing production and technological processes);

technological barriers (unavailability of cutting-edge manufacturing technologies) that prevent Russian companies and other residents from switching to digital, intelligent, and robotized production and technological processes;

growing structural dependency of the economy on the import of traditional and accessible technologies, while advanced technologies are not imported and research and development thereof is not funded in the country.

A special risk that is associated with the country's transition to the new industrial revolution lies in the fact that the implementation of the technological growth policy is difficult to coordinate with the current priorities – prevention of decline in the standard of living and diversion of budgetary funds from social support. In addition, rapid technological development poses significant risks of job loss in the traditional industry, the service sector, the social sphere, and management and growing inequality both within the society and between certain social groups and regions.

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5. Conclusion

The involvement of the country in the new industrial revolution requires special social, cultural, and educational policies. The latter will resolve (relieve) growing public issues. However, it is not ready for this and is reactive, rather than proactive. The public administration, even if it decides to launch the new industrial revolution, should have an offer for the public, which would ensure consensus in regards to the choice of the

development course.

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