

SCIENTIFIC AND TECHNOLOGICAL PROGRESS AND ITS IMPACT ON ECONOMIC SECTORS, ECONOMIC GROWTH, AND INNOVATIVE DEVELOPMENT

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Science, Innovation and Investment: Prospective Aspects of Russian Industrialisation

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Abstract. The present article examines the development of science and innovation in systemic relationship with the producibility of economy and investment. The study aims to structurally analyse the effects of *innovator-conservative* models on industrial development and formation of economic policy strategy. The methodology of the study involves a neo-Schumpeterian approach to economic development in combination with structural analysis, theory of industrial development and empirical assessments. The research base consists of the data from Rosstat, Eurostat, National Bureau of Statistics of China, World Bank, as well as the author's own scientific findings of previous years. The specified methods have demonstrated that innovators and conservatives, as two types of agents embodying scientific and technological progress, differ in their behavioural patterns depending on the mode of innovation and technological development according to the principle of creative destruction and combinatorial growth. Types of industrialisation as a policy can only be implemented through the dominance of one or the other principle. The investment policy for promoting new technologies differs for each of the considered modes. The performed study demonstrates the low sensitivity of total producibility to investment in new technologies at a reduced risk of development due to the state component of investment and necessary increase in financial, labour and capital resources for solving the problem of new industrialisation and possible insurance schemes. This approach can be useful for stimulating R&D and implementing domestic patents in production.

Keywords: basic research, research and development, innovation, conservative innovators, technology, industrialisation, economic growth

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НАУЧНО-ТЕХНИЧЕСКИЙ ПРОГРЕСС И ЕГО ВЛИЯНИЕ НА ОТРАСЛИ ЭКОНОМИКИ, ЭКОНОМИЧЕСКИЙ РОСТ И ИННОВАЦИОННОЕ РАЗВИТИЕ

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Наука, инновации и инвестиции: перспективы российской индустриализации

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Аннотация. В статье рассматривается системная связь развития науки, инноваций, обеспечения технологичности экономики и инвестиций. *Целью исследования* выступает структурный анализ влияния моделей новаторов и консерваторов на индустриальное развитие и формирование стратегии экономической политики. *Методологию* составляет неохушпетерианский подход к развитию хозяйства, структурный анализ и теория индустриального развития, эмпирические оценки. Информационную базу исследования составили данные Росстата, Евростата, Национального бюро статистики Китая, Всемирного банка, а также полученные автором научные результаты предыдущих лет. На основе указанных методов показано, что новаторы и консерваторы как два типа агентов, воплощающих научно-технический прогресс, отличаются по модели своего поведения в зависимости от содержания режима инновационного и технологического развития по принципу «созидательного разрушения» и «комбинаторного наращивания». Типы индустриализации как политики также можно обеспечить только посредством доминирования одного или другого принципа. Инвестиционная политика стимулирования новых технологий имеет отличия для каждого из рассмотренных режимов. *Результатом* является демонстрация низкой чувствительности общей технологичности к инвестициям в новые технологии с необходимым наращиванием ресурсов, причём не только финансовых, но и трудовых, капитальных, снижением риска развития за счёт государственной компоненты инвестиций при решении задачи новой индустриализации и возможных страховых схем. Этот подход будет полезен для стимулирования НИОКР и внедрения отечественных патентов в производство.

Ключевые слова: фундаментальная наука, НИОКР, инновации, новаторы-консерваторы, технологичность, индустриализация, экономический рост.

Информация о финансировании: Данное исследование выполнено без внешнего финансирования.

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Introduction

The widely known position of science ensuring the economic growth and development of society (Anchishkin, 1986) is often used as a fundamental basis for research into the effects of scientific and technological progress on economic development (Glazyev, 1993, 2018). However, the state of science as a field of activity, as well as the level of accumulated knowledge, which varies from country to country, have a different effect on the emergence of technologies and development of education and society (Sukharev, 2016). The transfer of knowledge is strengthening; however, the transfer can be intensified by a more developed initial base for the growth of the level of science, technology and engineering. If the initial conditions are absent for historical (evolutionary) reasons, then the exchange between countries will be maintained non-equivalent in full accordance with the rule of R. Prebisch, a founder of the dependent development theory: “Resources in exchange for technologies of not the most advanced class”¹ (Prebisch, 1992). However, import-substituting

industrialisation of underdeveloped countries under protected domestic market, unlike its export option, also failed to solve the problems, making numerous industrialisation programs ineffective. The reason was the established economic structure of these countries, as well as the lag in science, technology, engineering and education.

Many underdeveloped countries excluded from the achievements of scientific and technological progress are unable to fully replicate its results. They do not possess a full range of contemporary technologies, which creates and perpetuates deep global discrimination and inequalities in development. Emerging technological revolutions cause no effect on these countries (Perez, 2011; Perez, 1983), consolidating their structural lag behind the leaders in technological progress.

The potential of science in developing technologies and innovations is limited (Chichkanov & Sukharev, 2023). Moreover, the aspect of efficiency remains particularly unclear, both in terms of effects (for example, on GDP growth) and use of the results of scientific and technological progress considered as a development factor (Heinman, 2008). Indeed, fundamental science has no function of creating technologies and ensuring their generation at the moment when research is being conducted and

¹ Scientific and technological progress in developed countries always reduced costs and increased wages due to a sharp increase in productivity. Developing, backward countries had no significant growth in wages, which hampered their technological progress with the lion's share of technologies and their updating occurred through imports from abroad.

fundamental results are being created. Only further interpretation of these applications can show some prospects in the field of improving existing and developing new technologies and emerging innovations. A direct correlation between fundamental scientific research, emerging technologies and innovations is absent in many countries (Sukharev, 2016).

Scientific research certainly forms a common basis for the emergence of innovators as active agents introducing new results, i.e., concepts, ideas, projects, products, processes, etc. into the economy (Schumpeter, 2007; Sukharev, 2020). Such effects occur over time, so the annual representation of the relationship between the costs of scientific activity and technological development is likely to be weakly indicative². Fundamental science has autonomy characterised by tasks indirectly related to applications: the latter arise or become visible at later stages of search work. The function of fundamental science is problematic to incorporate the feasibility of developing new technologies used in economic sectors, since the applied nature of many fundamental discoveries is scarcely evident at the stage of invention. Moreover, the applicability of technology and emerging innovations themselves form a field of activity on searching new applied solutions long defined by fundamental science.

Therefore, the vast majority of contemporary growth models (Futia, 1980; Jati, 2001), including the costs of science and R&D as a factor of science-intensive growth, still show a limited correlation between these activities and dynamics of the total product. This applies even to a set of non-Schumpeterian models incorporating innovative growth (Jati, 2001; Hanusch & Pyka, 2007) or institutional (North, 2008) factors, except those that immediately determine the applied nature of used innovations and describe the economic growth by switching between innovator and conservative models (Sukharev, 2020), applying the logic of both *creative destruction* and *combinatorial growth* (Jati, 2001; Sukharev, 2020).

² In this regard, assessing the effectiveness of scientific organisations or scientists for only one year also becomes weakly meaningful.

An array of best available technologies is recognised (Skobels, 2020) as actually affecting the economic dynamics, yet only if they are widely used. Although considering their effect on costs makes the assessment largely conditional, the models of economic growth (in their overwhelming majority) fail to take into account the qualitative side of technologies and innovations.

This results in the innovation dynamics presented by changing the number of innovators and conservatives (agent-oriented approach³) as groups of agents embodying the results of scientific and technological progress and affecting the economic growth. The very switching of agents from one model to another has been well researched by the Russian school of Economics of Technology (Sukharev, 2016, 2020)⁴. This model is advisable to build a policy of technological industrialisation becoming increasingly urgent in connection with changes in the world economy in 2022–2024. The industrialisation policy was discussed in numerous scientific papers (Sukharev, 2016; Glazyev, 2018).

Summarizing the above, the present study aims to determine the effects of *innovator-conservative* agent groups in the structure of innovative activities and investment in new and old technologies on the economic growth and producibility in the prospect of Russian industrialisation. For this, the methodology of the present study is based on the theory of innovative development by J. Schumpeter, industrialisation and technological changes (Glazyev, 1993; Sukharev, 2016), as well as on approaches to assessing the effects of science and technology on economic development. Two essential problems can be distinguished. First is to outline the methodology for including the *innovator-conservative* structure in the study of growth and process of industrial change (the next two sections of the article). The second is to analyse the dynamics of producibility depending on investment in technological innovations in order to identify

³ Although these groups of agents are accounted for in the Russian Federation (Sukharev, 2020), appropriate statistical methods are required for their regulatory measurement at the level of the federal static organisation (Rosstat).

⁴ The model proposed by the author in 2003 was further developed and tested on the material of the Russian economy.

the prospects of technological industrialisation in contemporary Russia.

The present study focuses on technological innovations, i.e., the term “innovation” in the article title refers to technological innovations that form the basis of innovative development, being implemented in different types of activities.

Thus, let us consistently solve the problems set in the study.

Innovator-conservative assessment of innovative activities

Even J. Schumpeter was presented with rather justified claims (in particular, from G. Haberer) that his theory of economic development provides no convincing recommendations in the field of macroeconomic policy and public administration (Schumpeter, 2007; Hanusch & Pyka, 2007; Sukharev, 2016, 2020). However, the problem is even broader and boils down to the fact that each economy has its own structure of innovative activity, which supposes a certain dynamics with a corresponding level of system producibility and investment structure. Moreover, the structure of innovations often changes independently to the current development of fundamental science. Nevertheless, contemporary Russian and foreign scientific publications are lack of deep research taking into account such a change and assessing its effect on both the innovative and socioeconomic dynamics, even for the Schumpeter type assignment of new combinations.

Structural aspects of economic development remain largely outside the scope of researchers and performed economic analysis. Different types of innovations (product, technological, process, marketing, management, etc.) form their structure, interrelationship and effects on each other and economic development. Innovation types also differ by activity and industry, as each innovation has a specific nature in its subject area. For example, technologies, like products, processes and markets, of textile and metal industries drastically differ from those of food industry. Applied research designed to solve problems of a certain activity type also has its own characteristics. The structure of innovation

changes, affecting the development of the system where innovation is deployed. This structure can be represented as a dichotomy of two agent types – innovators and conservatives. The innovator is assumed to generate an innovation (of the above types), while the conservative retains existing products, technologies, processes, etc. without bringing significant novelty into them, despite the ability to somehow improve the efficiency of its activities and listed aspects of production.

Approaches to simulating innovation dynamics based on the agent groups of innovators and conservatives⁵ were developed as part of the Russian contemporary school of Economics of Technology (Sukharev, 2016, 2020) in the early 2000s based on Schumpeter’s idea that the innovator is striving for economic success⁶ “by saddling the debts”. This means that the economic growth in the innovative growth model requires both lending and advance capital. Moreover, if inflation suppression is a prerequisite for economic growth, as long as it has been in Russia, then a Fischer growth model is present. Its application in the long term can reduce the potential for innovative growth, which inherently generates the upward price dynamics (Glazyev, 1993; Sukharev, 2016). Therefore, macroeconomic policy can significantly affect the innovation dynamics and structure, which, in turn, will set the potential for future growth.

The statements of some Russian economists that the increase in the key interest rate causes no effect on the economic growth in the long term of 5–10 years and affects the volume of output in the short term of 2–3 years seems contradictory and logically incorrect. If increasing interest rates rise the costs of servicing credit and using advance capital, they increase the cost of final benefits and resulting science-intensive means of production. This limits production and supply by acting as an inflation-promoting function rather than a fight against it. An increase in investment and consumption first slows down

⁵ Alternatively, a third, intermediate group of imitators is also possible. Despite the ability to spread innovation, imitators in their pure form are neither innovators nor conservatives, since they imitate a new result.

⁶ Economic success means an economic result that provides the agent with profit and further development.

and then absolutely decreases. If this occurs within 2–3 years, it is impossible to left the recovery of dynamics and GDP values unaffected in the interval of 5–6 and next three years. Any long-term economic development is made up of short-term ones. Their changes can be very strong in terms of the effect on the economic growth. Applied monetarist models are typically designed in such a way as to show the neutrality of money in the long term, which ultimately assumes the absence of the effect from changes in interest rates. Such an absurd result, inconsistent with empirical data and partly with the logic of analysis, is nevertheless considered as the basis for building economic policy, regardless of how it affects the development of science and innovation, as well as the total producibility of economy. The argument that the model is incorrect and contradictory to the facts is typically left aside.

For example, a similar factual picture destroying the “malicious logic” of mainstream monetarist models (Glazyev, 2018; Sukharev, 2016) has been observed in relation to the growth rate of the economy since 2013 until 2021, when factors (sources) of this argument were exhausted and the interest rate was relatively low, increased in 2014–2015 and then declined from 2016 to 2020 without tangible acceleration, as other factors were compressed. Their compression can be assumed affected by the exact increase in interest rates within the framework of the general structural degradation scheme of the Russian economy⁷: increasing inflation causes the rise of interest rates, which lowers investment and aggregate demand, resulting in the low efficiency and competitiveness of the economy and encouraging the development of financial speculators, who provoke a crisis and accelerate inflation by disrupting the stock and currency markets, while maintaining the vicious structure of dependent economic development (capital withdrawal). This again leads to an increase in the interest rate. Explicit stagnation and structural degradation ensure high churn of researchers and reduction in their number at low science

and R&D costs (no growth in scope), which suppresses the emergence of breakthrough results, with separate local exceptions. As a result, the number of innovators decreases; the number of conservatives grows. At the same time, the level of producibility first increases and then decreases to almost the same values, which becomes a symbol of the structural degradation of the economy, i.e., its deintellectualisation and reduced scientific intensity of production. Such development makes the achievement of technological sovereignty problematic (Glazunova, 2024), especially in the absence of qualitative assessment of technological development.

Innovative and technological development is subject to more than one principle of *creative destruction*, identified by J. Schumpeter (Schumpeter, 2007), as well as his contemporary followers (Futia, 1980; Perez, 1983; Jati, 2001; Hanusch & Pyka, 2007). In addition to diverting resources from outdated innovations and technologies to the generation of new ones, a new resource can be created, or innovations and technologies can be combined for a breakthrough technological result. Previous research defined this effect as a *combinatorial growth*. According to this principle of describing innovative and technological development, a new resource can be discovered or created, or a new combination can be generated based on the well-known achievements of innovators.

Contemporary technological development, like the industrial basis of the economy, is subject to two principles at the same time. However, only one of them can be dominant at the considered interval; in the next period of time, this dominance can move to another principle (Sukharev, 2016, 2020). The created competitive model for technological innovation, presented in previous research, is within the rivalry of these two principles describing technological changes. Note that two fundamentally different innovators are recognised. One generates something new, diverting the resource from the conservative; the other synthesises a new resource or discovers it or creates a new opportunity for combined (within the framework of the supplement) application of technologies

⁷ This scheme has been present in the Russian economy for at least two decades.

(see Table 1). Both models are innovative, characterizing the innovator agent; however, they appear to result in different levels of technology requiring different investments. In particular, the implementation of the combinatorial effect can, all other things being equal, reduce the amount of investment compared to the innovation using old technologies and requiring their replacement. This, in turn, entails staff training and other costs of adaptation and replenishment of resources that are increasingly in demand. It is impossible to divert the full amount of the required resource due to the inherent unsuitability of the complete resource diversion.

Under the *creative destruction* mode, the scientific novelty of generated innovations is higher than that of the *combinatorial growth*; therefore, the former will be leading in innovative development with a strong base of science, applied research and R&D. Both modes are simultaneously present in the economy; it is only important which of them dominates, how the switching between these modes is carried out and for what reasons. This defines innovation, creating the foundation for science. Innovators typically invest in new combinations that they generate. The first mode depends on investment, being more sensitive to changes in macroeconomic policy, e.g. to higher interest rates. Since its distribution generates a demand for scientific results, applied science and R&D become

dependent on those policy tools that actually roll up the first mode. This proves the importance of maintaining the autonomy of fundamental science, as well as the independence of its funding (investment), without linking the results to current advances in engineering and technology in manufacturing industries. Conservatives also invest, yet for maintaining or securing their position in the market and production. The structure of these investments may be a characteristic of the structure of innovative development. It should be noted that if the incentive policy focuses solely on one agent group, ignoring the state of the other group and the fact that different modes of innovation and technological development assume different types of innovators, as well as conservatives, such policy fails to achieve results in the field of innovative and industrial development.

Next, let us consider investment in new and old technologies as costs for innovations, in particular, technological ones, and difference between capital investment and innovation (technological innovation) costs, respectively. Since this data are available according to the accounting and measurement procedures practiced by Rosstat, this approach is applied further in the study. It characterises the structure of innovative activities in the aspect of “innovation – non-innovation” as applied to technological activities. Moreover, it identifies various options for

Table 1. Modes of innovative and technological development: *innovator-conservative* characteristics

Таблица 1. Режимы инновационного и технологического развития: характеристика «новатора – консерватора»

Mode of innovative and technological development	Model characteristics	
	Innovator	Conservative
Creative destruction	Takes part of a resource by breaking down the conservative chains or emerges from a conservative model (switching from a conservative); generates something new that requires significant investment	Transforms into an innovator that generates something new and gains investment or less development resource at a less market share, protecting its competitive position
Combinatorial growth	Distracts no resources or a small resource fraction from the conservative without destruction of its chains; synthesises a new solution based on known approaches and methods, which requires a mode of creative destruction and less investment (costs)	Maintains position and can even strengthen them in the marketplace; becomes an innovator through a combination of effort without significant resource, distraction from previous activities and disruption of existing production chains and technologies

Source: The table was prepared by the author
Источник: составлено автором

industrial change, at least to define requirements for macroeconomic, investment, scientific and technical policy.

It is important to note that industrial development requires new technologies, as well as increased productivity and science intensity of production. In this case, the results obtained by science today will be applied after a while: only some of them will be used immediately. However, the effect of afteraction (hysteresis) should be mentioned in the influence of science on technological development. Fundamental results become technology far from immediately. Moreover, a whole set of these results is only partially transformed into technologies, yet providing some basis for their further development.

Today, no accurate methods for measuring the science–technology relationship are available, since the costs of R&D or technological innovation only indicate the activity scale. The number of introduced patents and developed technologies reflects activity in the field of applied research and development of engineering and technologies. Fundamental science is characterised by discoveries obtained by models, formulas, principles and developed theories that can only give space for further fundamental research instead of practical results. An important indicator of technological development may be the involvement of an already established technological basis in the production and development of new technologies. This requires a completely different statistical record for assessing the implementation and novelty of technical solutions. According to patent analytics, this can be done in part based on implemented technologies, i.e., license agreements.

The level of producibility as the ratio of volumes of innovative and non-innovative products, work and services is rather a non-universal solution; however, it reflects the general characteristics of innovative activity, as well as its structure in relation to production. The producibility level depends on accounting procedures. Nevertheless, it reflects the change in the industrial process and level of producibility, since the emergence of innovative products, works and services using old funds is still more problematic,

compared to the use of new ones. According to this indicator and investment in new and old technologies, it is possible to determine the types of economy industrialisation (Sukharev, 2020) and characterise the innovation process by the ratio of *creative destruction* and *combinatorial growth* effects. Let us transit to it in the next paragraph as part of the aggregate assessment in the form of innovation waves (Glazyev, 1993, 2018).

Modes of technological development and types of industrialisation in the innovator–conservative model

Innovators can be considered as agents engaged in research and development⁸. The workforce movement between different sectors can indicate the distraction effect (*creative destruction*) prevailing in favour of new technologies and productions. Creation of new workforce indicates a combinatorial effect.

Table 2 generally describes the modes of technological (innovative) development, demonstrating the difference between both innovators and conservatives who meet a particular development mode. In this regard, the

⁸ R&D personnel are a group of individuals whose creative activities systematically aim to increase the amount of scientific knowledge and find new areas of its application, as well as those engaged in the provision of direct services related to the performance of R&D. R&D personnel include four categories: researchers, technicians, support and other personnel (according to Rosstat <https://www.gks.ru/folder/14477>, https://www.gks.ru/labour_force, Knoema Global Data Atlas that provides the number of innovators <https://knoema.ru/GEMAP2019/global-entrepreneurial-behaviour-monitor?country=1000240&indicator=1000250> and Global Entrepreneurship Monitor, World Bank: <https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?view=chart>. The number of researchers is based on the World Bank and OECD database <https://data.worldbank.org/indicator/NY.GDP.MKTP.KD>, <https://data.oecd.org/rd/researchers.htm>). Researchers are employees who are professional in R&D and directly responsible for creating and managing new knowledge, products, processes, methods and systems. Technicians are employees who perform technical functions, typically together or under the direction of researchers. Support personnel are employees who perform support functions. If an innovator firm is an organisation that creates new products or services for at least individual consumers, and no other firms or only a small number of them create these products. The difference between the total number of firms and innovator ones will be the number of conservative firms (Sukharev, 2016, 2020). In the present work, a series of empirical studies was performed on the association of the growth rate and number of innovator firms and agents over the past ten years. The present article provides integral conclusions obtained for the Russian Federation.

identification of these modes and dominance of any of them in a certain period of time is a central task for determining the most significant tools of investment policy for development. It is important to take into account both the need to search for investments⁹ and willingness of economic entities to effectively master them, increasing the results, and distribute them in the most optimal way between the priority areas of innovative development. The latter two tasks comprise the sum of non-trough efforts, including research ones, to assess the movement of labour and capital resources between activities. This assessment should take into account the intellectual component in order to affect the replenishment of its losses where they occur and to reduce unnecessary redundancy where it arises from unjustified economic change policies.

Table 2 shows that restructuring policy and technological leap suppose the policy of increasing the results and preparing major changes in engineering, technology and production based on the combinatorial principle, using the Russian patent base (Saphennikov, 2024) and activation of applied research and development. For this, it is necessary to both significantly increase the financing of an already existing base together with the staff and security of the stock base, preferably creating it within the country along the general contour of subcontracting and counterparty works.

In the Russian Federation, the following trends have been observed over the past ten and a half years:

- the number of innovator agents (researchers) and innovator firms was reduced;
- the rate of resource diversion from obsolete industries and the rate of creating new resource types and technological combinations decreased, i.e., both modes of technological development slipped under a change in dominance from *creative destruction* to *combinatorial growth*;

- the value of the diverted resource decreased; the value of the newly created resource slightly increased and then began to decrease; these processes accompanied a decrease in the rate of economic growth until 2023 (Sukharev, 2016, 2020);
- the number of innovators (researchers) decreased with the growth of investment in new technologies and a decrease in investment in obsolete technologies, while the number of conservatives increased;
- the number of newly created new (new) and used new (conditionally old) technologies increased; however, the scale of creation for the first ones was extremely insignificant;
- the total producibility (the ratio of volumes of innovative and non-innovative products, works and services) from the number of new technologies slightly increased; from the number of old technologies, this value increased and then decreased, changing in a very low range (from 1–2 to 5–6% for the period 2006–2018);
- the producibility significantly increased due to the efforts of conservatives and old technologies, which confirms the extensive model of applying the results of science and development of innovations and technologies, as well as corresponding investment policy;
- the business risk increased, which hindered the growth of new technologies and total producibility, ensuring, after a slight increase, its further decrease by 2021 to the values of 2012. Moreover, the increase in risk was accompanied by a decrease in the number of innovators and increase in the number of conservatives who find their niches of activity even in conditions of increased risk.

Intensification of investment in 2023–2024 due to an increase in military spending changed the situation for the better. However, without creating a base for technological and innovative development in the form of innovator agents and firms, the prospects for industrialisation are still limited.

⁹ Discussions are typically developed around a source of funding, which can be the Sovereign Wealth Fund, as well as public debt, government and Central Bank reserves, banking system assets, natural resources rent in the form of export duty for the withdrawal of hydrocarbons, etc.

Table 2. Characteristics of technological development modes

Таблица 2. Характеристика режимов технологического развития

Characteristics	Technological development mode	
	Creative destruction	Combinatorial growth
Industrialisation type	<ul style="list-style-type: none"> – New industrialisation by the type of restructuring the national economy – Emergence of new high science-intensive sectors and activities distracting resources from old sectors 	<ul style="list-style-type: none"> – Re-industrialisation (technological) in the meaning of retrofitting or updating – Internal modernisation due to a combination of technologies and search for new opportunities to improve efficiency based on technological upgrades
Innovators	<ul style="list-style-type: none"> – Radical innovators demonstrate high activity and incentives of production transformation and established types of activity – They extract existing resource from old sectors 	Adapting innovators adapt existing technological capabilities, combining them and forming a new resource without large-scale resource distraction. This maintains the base of activities
Conservatives	<ul style="list-style-type: none"> – Active conservatives changing the behaviour to an innovative one. This is a way to ensure economic stability and viability. Otherwise, conservatives become bankrupt, joining the ranks of new innovators or other conservatives and unemployed – The <i>creative destruction</i> mode occurs in a crisis of the economy – Obsolete chains can be rejected, destroyed or drastically transformed 	Stabilizing conservatives increase efficiency and retain their positions, gaining the opportunity to become an innovator combining technologies
Technological sovereignty (innovative development) policy	<ul style="list-style-type: none"> – Significant investments in the industrial base of development – Creation of new technologies and conditions for innovators and patenting new developments – Economic Restructuring Management and New Industrialisation Policy 	<ul style="list-style-type: none"> – No large investments are required – this is the policy of the initial stage in the form of increasing the technological efficiency of the existing industrial base with the preparation of a resource for the development of production and replenishment of losses – Drivers of technological selection, expansion of R&D and combinatorial solution to technical problems

*Source: The table was prepared by the author
 Источник: составлено автором*

Thus, the performed analysis confirms the need for a significant revision of scientific, technological and innovative development policy to ensure technological sovereignty (Jacob et al., 2023). In conclusion of the study, let us briefly consider the prospects of Russian industrialisation at the present stage from these positions.

Dynamics of producibility and innovation investment: prospects of industrialisation

As noted above, the present study defines producibility¹⁰ (level of producibility) as the

volume of innovative products, works and services related to the volume of non-innovative ones. Such an indicator is conditionally designated as “producibility” due to the fact that it reflects the dynamics of technological innovation, since innovative products, works and services involve their generation. In general, innovations can emerge on outdated equipment using obsolete technologies; however, the level of producibility correlates with the volume of innovative products, works and services. If the volume decreases, then the producibility will most likely increase insignificantly due to the narrow base for such dynamics. At least, the indicator used in this study is no less informative than the cost of technological innovation, which also fails to reflect the quality of innovation itself and change

¹⁰ Producibility or level of producibility applies here in an equivalent sense. The use of both terms is due to convenience of presentation. The “level” reflects more of a measurement (i.e., a value), while “producibility” assumes a general concept.

in the level of producibility, characterizing only the scale of activity. In addition, the costs are insufficient to characterise the effectiveness of any activity, including innovative and technological ones. Therefore, the share of R&D or internal research costs in GDP also implies a level of producibility (producibility).

Figures 1–2 reflect the change in the level of producibility γ_0 from the share of investment in new and old technologies in the total volume of investment in fixed assets in Russia for the period of 2010–2022. Investment in new technologies is understood as the costs of innovative activities of organisations; investment in old technologies is the difference between investment in fixed assets and innovative activities.

As can be seen from Figures 1–2, an increase in investment in new technologies failed to provide a steady increase in the level of producibility. A decrease in investment in old technologies was accompanied by a slight increase in producibility followed by a decrease. Increased investment in new technologies also slightly increased the producibility; however, it decreased further. It can be assumed that the low level of determination and connection of

investments in new technologies with the level of technological producibility is due to the fact that the decrease in support of old technologies in the event of technological chain breaks and the institutionally unclosed innovative cycle of creating new products, works and services fails to ensure a consistent improvement in producibility.

Figure 3 shows the level of producibility in Russia, Germany and China between 2009–2023. Germany and China had data available for calculation only up to 2017. The figure demonstrates a slight increase for Russia, followed with a decrease to around 2012 level by 2023.

Germany showed a significantly higher level of producibility than Russia. By 2018, China also considerably broke away from the Russian indicator, ensuring the re-equipment of its economy with new technologies in accordance with the “Made in China 2025” program, which is currently under completion. Figure 4 gives an idea of how the level of producibility reacts to the change in investments in new technologies in Russia and China for the periods of 2011–2023 and 2010–2017, respectively.

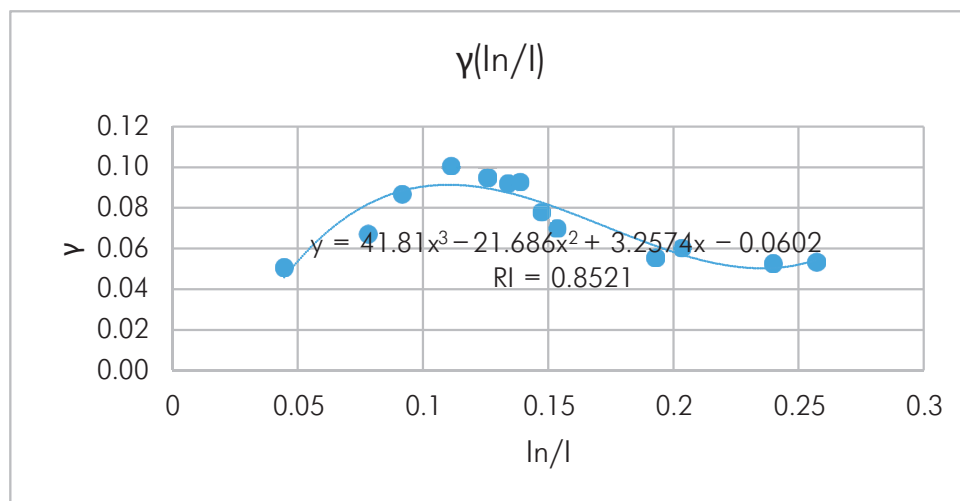


Figure 1. Producibility and investment in new technologies in the Russian Federation, 2010–2022

Рисунок 1. Технологичность и инвестиции в новые технологии в России, 2010–2022 гг.

Source: The figure was prepared by the author according to the data of Rosstat
Источник: рассчитано по данным Росстата

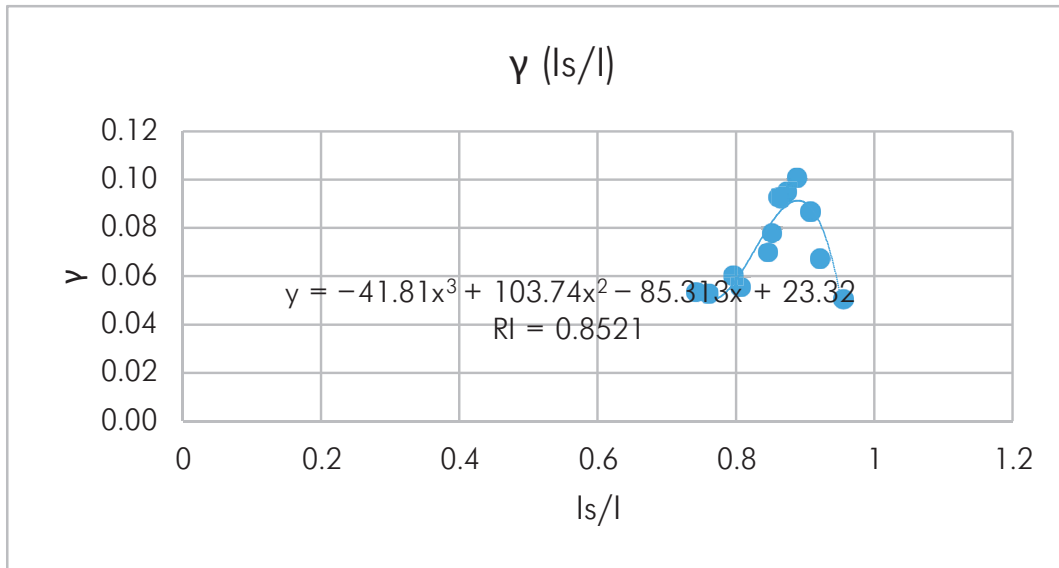


Figure 2. Producibility and investment in old technologies in the Russian Federation, 2010–2022

Рисунок 2. Технологичность и инвестиции в старые технологии в России, 2010–2022 гг.

Source: The figure was prepared by the author according to the data of Rosstat

Источник: рассчитано по данным Росстата

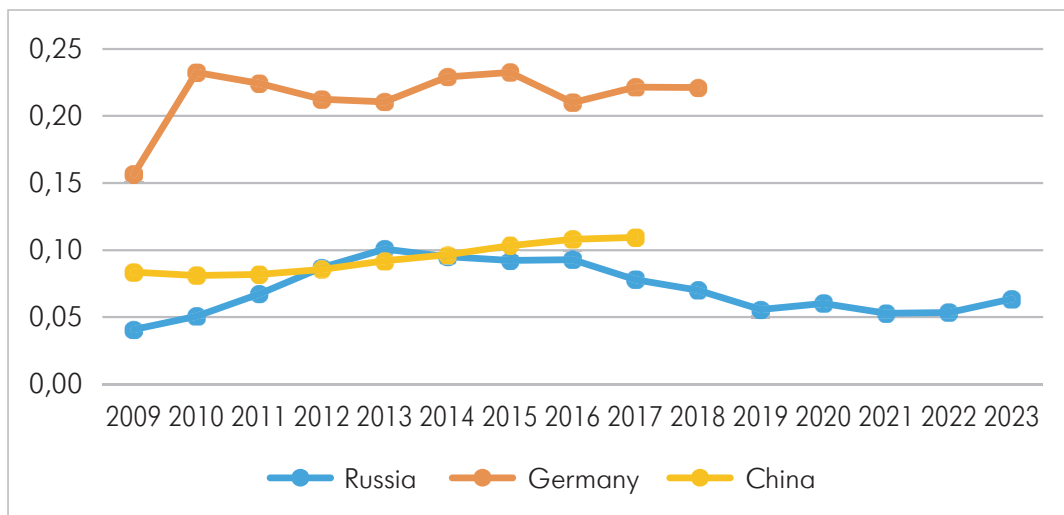


Figure 3. Level of producibility in Russia (2009–2023), Germany and China in 2009–2017

Рисунок 3. Уровень технологичности России (2009–2023), Германии, Китая 2009–2017 гг.

Source: The figure was prepared by the author according to the data of Rosstat (<https://rosstat.gov.ru/statistics/science>), Eurostat (<https://ec.europa.eu/eurostat/data/database>) and National Bureau of Statistics of China (<http://www.stats.gov.cn/english/Statisticaldata/AnnualData/>)

Источник: рассчитано по данным Росстата (<https://rosstat.gov.ru/statistics/science>); Евростата (<https://ec.europa.eu/eurostat/data/database>); Национального бюро статистики Китая (<http://www.stats.gov.cn/english/Statisticaldata/AnnualData/>)

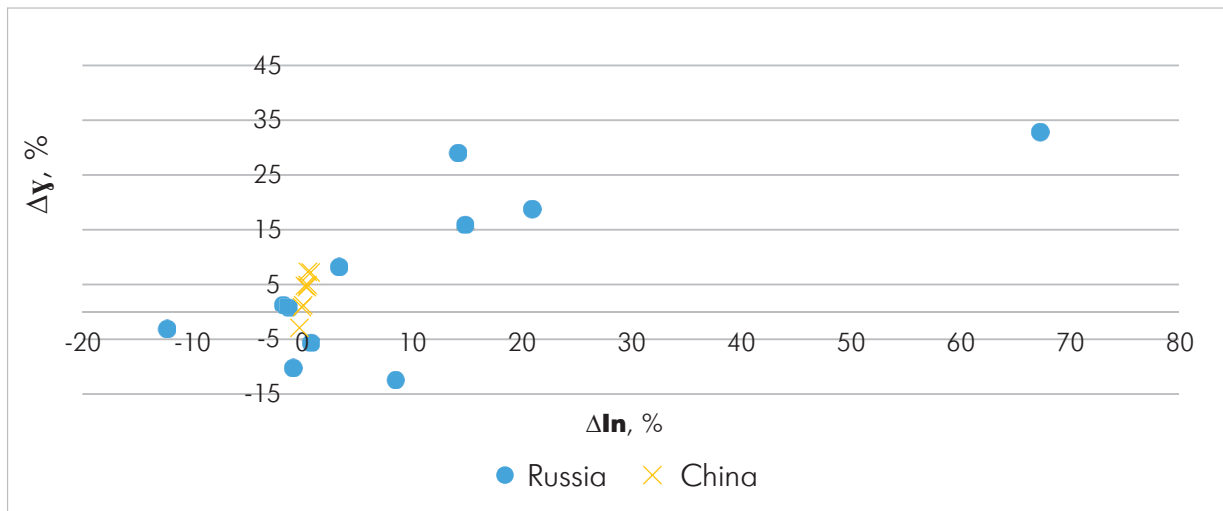


Figure 4. Change in producibility ($\Delta\gamma$) and investment in new technologies (Δln) in Russia (2011–2023) and China (2010–2017)

Рисунок 4. Изменение технологичности ($\Delta\gamma$) и инвестиций в новые технологии (Δln), Россия (2011–2023 гг.), Китай (2010–2017 гг.), %

Source: The figure was prepared by the author according to the data of Rosstat (<https://www.gks.ru/folder/14477>, https://www.gks.ru/enterprise_industrial) and National Bureau of Statistics of China (<http://www.stats.gov.cn/english/Statisticaldata/AnnualData/>)

Источник: рассчитано по данным Росстата (<https://www.gks.ru/folder/14477>, https://www.gks.ru/enterprise_industrial); Национального бюро статистики Китая (<http://www.stats.gov.cn/english/Statisticaldata/AnnualData/>)

It is obvious that China has purposefully invested in new technologies that provide an increase in total producibility, as can be seen from the spread of points corresponding to the Chinese economy (Figure 4). Russia has a wide range of points: the increase in investments in new technologies is met by the points of a decrease in total producibility, which is caused by the local distribution of these investments and disruption of the innovative cycle and technological chains in the economy sectors.

Figures 5–6 reflect the dynamics of investment in innovative and non-innovative activities at an increase in the business risk. In contrast to innovations, investment in non-innovative activities decreases at increasing risk, yet remaining very high relative to innovative investment. This indicates the predominance of non-innovative activities, which is the basis for the absence of a significant increase in producibility.

Thus, industrialisation policy requires a large-scale increase in investment in new technologies, while maintaining and improving the quality of the outdated technological base to

prevent the failure of a standard set of technologies, as well as an open innovation cycle and technological chains. The way of distributing these investments is important, as well as what are their sources, efficiency, distribution results and how to manage this process. It will be necessary to take into account the changing conditions with the institutional organisation of interaction between science, education and production, coordinating the implementation of national projects and development programs by sectors.

A system of institutional impact on activities may reduce fluctuations in profits and a high difference in profitability (profits) of science-intensive and non-science-intensive activities, including salary alignment. All the above will constitute the policy of industrialisation from the standpoint of its structural analysis and method of implementation. This problem can be solved by differentiating interest rates on loans depending on the industry and creating special incentives for the banking system to direct its investments to the development of

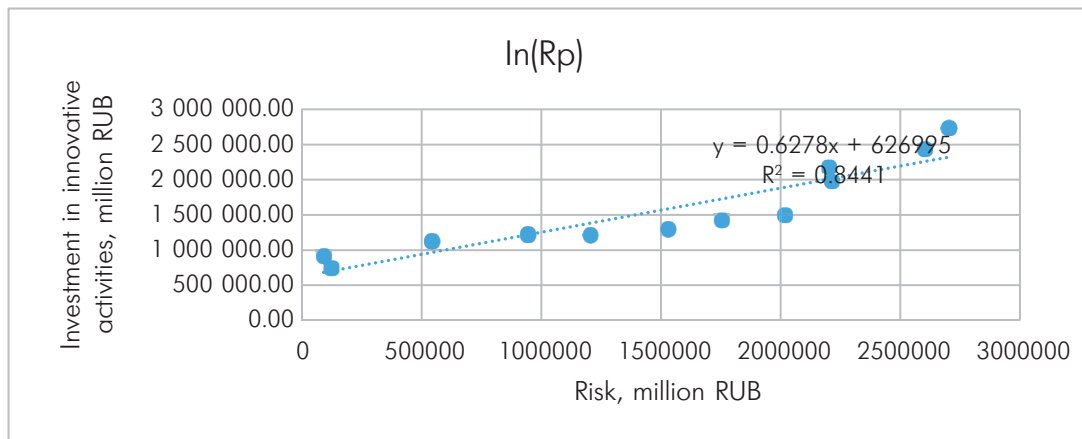


Figure 5. Investment in innovative activities and risk¹¹ in Russia, 2010–2022

Рисунок 5. Инвестиции в инновационную деятельность и риск¹¹ в России, млн. руб., 2010–2022 гг.

Source: The figure was prepared by the author according to the data of Rosstat
Источник: рассчитано по данным Росстата

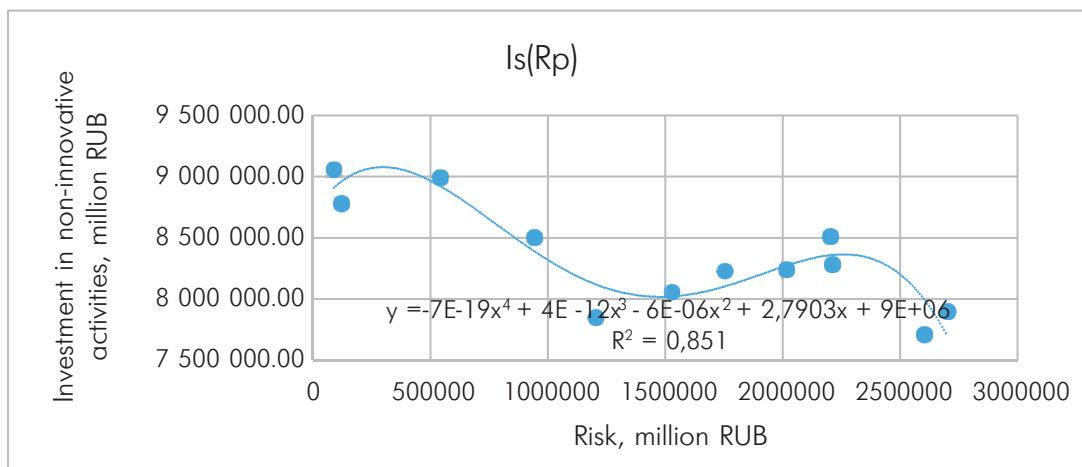


Figure 6. Investment in non-innovative activities and risk in Russia, 2010–2022

Рисунок 6. Инвестиции в неинновационную деятельность и риск в России, млн. руб., 2010–2022 гг.

Source: The figure was prepared by the author according to the data of Rosstat
Источник: рассчитано по данным Росстата

certain activity types. This will form an industrial-financial capital union rather than an antagonistic co-existence that has developed in Russia over the past decades.

Conclusion

In summary, let us identify the two most significant findings.

First of all, the article presents a scheme for studying innovation and technological development based on the assessment of the structure of innovator and conservative agents. The scheme is appropriate to determine certain relationships of relevant parameters by their effect on economic growth and industrialisation process. The modes of technological

¹¹ Risk is estimated as the standard deviation of gross profit.

development are singled out to provide fundamentally different content of the innovator and conservative model, depending on the nature of obtaining a new result. These findings seem to be highly useful for the practice of the "Strategy for Scientific and Technological Development until 2030," since it excludes the identified circumstances and additional conditions.

Secondly, the analysis of the relationship between producibility and investment in new and old technologies in the Russian Federation shows a low level of determination, which indicates the need for a systematic policy to stimulate such activities at the domestic technological base, reducing the risks and deploying conservative production chains where they have been disrupted. A number of these results were obtained in the previous studies almost two decades ago; however, they are still relevant to Russia.

Thus, the obtained dependencies and estimates give an idea of a high complexity of

formed, largely broken and low-performing links, which can only be partially changed by the typical distribution of financial resources or their search. This option is only possible if a significant, massive infusion is given to cause inflationary pressure on economic growth with an apparent return of the neoclassical policy of structural degradation. This scenario is clearly unacceptable for the Russian Federation that should focus on the deployment of creative activities in a combination of science and production, purposefully allocating all types of resources and measuring them against the formation of this combination.

Competing Interests

The author declares no conflict of interest.

Конкурирующие интересы

Автор заявляет об отсутствии конфликта интересов.

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