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R&D Blended Financing to Ensure Technological Security: Problems and Prospects

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ABSTRACT

The relevance of this study is supported by the fact that the achievements of modern research are beginning to change the nature of sovereignty, strengthening the role of the technological component. This, in turn, requires updating the sources of R&D funding. **The aim** was to investigate the impact of public, private and blended financing on R&D, both in world practice and in the Russian context in an inextricable connection with the formation and preservation of state sovereignty, including technological sovereignty. It has been shown that the basic models of research and development (R&D) financing, focused exclusively on public or private sources, are insufficient in modern conditions. This necessitates the search for and justification of new approaches to funding. **Research methods:** a) are based on classical ideas about the role of R&D in shaping economic growth and, consequently, ensuring state sovereignty, including with regard to technological security; b) include an assessment of current R&D dynamics, including in the context of different countries. **The results** of the study indicate that R&D financing models are largely influenced by the historical path taken by each country. The historical and evolutionary generalization of the key paradigms for R&D financing has allowed us to identify the following models: the linear model, the system model, the triple helix model, mission-based models, unified landscape models, and ecosystem development models. The presented models allowed us to identify the advantages and disadvantages of blended financing for two types of models. It has been shown that blended financing can be both organizational and financial structuring. It has been **concluded** that, despite the development of approaches to attracting private capital, the state remains the “early-stage investor” that assumes the majority of risks. This allows it to strengthen its role in achieving technological security goals (especially with the linear model). It has also been shown that blended financing can be used to ensure investment attractiveness for private investors, accelerate market recognition, including the “reach out” of technologies. It has also been proven that blended financing schemes do not impose restrictions on achieving technological security, but rather require control over the distribution of intellectual property rights. **Keywords:** research and development (R&D); technological development; technological security; sources of financing; blended financing; public financing; private financing

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INTRODUCTION

The results (as well as the expectations of the results) of research and development (hereinafter R&D¹ or SREDT²) in all industries over a long historical period have determined and continue to determine the prospects for future development. These results have a significant impact on the very nature of state sovereignty and its components [1], including a direct impact on technological security. At the same time, they create new contradictions.

The revolutionary advancements in new technologies, such as quantum solutions, bio-production, neural interfaces, and artificial intelligence, as well as the progress in the creation of new materials, development of hydrogen, and thermonuclear energy, have expanded the scope of national control over independence. Foreign publications occasionally discuss the ethical dilemma of choosing between governmental and corporate control [2]. In our opinion, control should remain within the state's framework, which can find ways to interact with all participants in these modern transformations.

The technological uncertainty of the future is further reinforced by the variety of sources of research and development funding, which may affect the effectiveness of R&D. Therefore, the purpose of this study is to determine the impact of public, private, and mixed financing on R&D in world practice and SREDT in Russian practice in an inextricable relationship with the formation and maintenance of state sovereignty, including technological sovereignty. We believe that technological security should be established even at the earliest stages of financing research and development activities, including when choosing priorities.

According to the works of M. Mazzucato [3, 4], the success of well-known “breakthrough” project programs, which successfully coordinate the public and private sectors, ensuring collective value creation, requires a reconsideration of the role of government to restore the idea of a public purpose. The most significant role in coordinating large-scale projects, both in Russian and international practice, is played by organizing financing for such projects as a main framework for encouraging joint activities. Therefore, A.N. Klepach argues that “with a reduction in public funding for R&D in nominal terms, it is difficult to anticipate an increase in private funding” [5, p. 83].

Separate studies examine the potential of public-private partnerships and their challenges (as one of the forms of mixed financing) in ensuring technological sovereignty. For example, N. V. Morozova argues that “the demand for the concept of technological development for the demand for public-private partnership with the admission of state corporations on the side of the private partner and the qualitatively new role of the private partner has not been realized” [6, p. 182]. At the same time, there is a “re-tuning of public-private partnership mechanisms in terms of expanding public-private partnership facilities for industrial use and financial participation of a public partner” [6, p. 182] due to insufficient elaboration of organizational and economic mechanisms.

Considering the impact of financing on technological sovereignty and security, we rely on two main points:

1. Direct financing for technological security is not feasible, as security does not participate in economic activities and is instead a metric that determines compliance with specific requirements [7, 8]. Therefore, it can only be funded through financing other activities that lead to changes in the level of security.

2. The increasing complexity of research and development makes it almost impossible

¹ R&D Research and Development — translated from English: research and development — can include both basic scientific research and experimental development before prototyping.

² SREDT is the Russian equivalent of the international term R&D, covering all stages: scientific research and experimental work (SRE), development work (D), and technological work (T).

for a single entity to carry out a significant project funded by a single source (except for state-owned projects, considering budget constraints). This is especially true for critical and end-to-end technologies.

The above makes it possible to formulate a research question: Does the method of financing research and development impose any restrictions on achieving technological security? At the same time, we intentionally limit the scope of this research to R&D, without considering commercialization, as we believe that the results obtained through public, private, or blended funding have the same potential for future commercial use. While this may not always be fair, it is necessary to address the issues raised in this article.

RESEARCH METHODOLOGY

The methodological basis of this research is based on three main approaches:

- Study and analysis of regulatory documents that govern the financing of research projects.
- Examination of statistical data on research funding (including volume and sources) both in Russia and internationally.
- Interpretation of the results of fundamental research, which determine the direction of development in finding effective methods of financial support for research and development (R&D).

The theoretical basis of this research is formed by the following views and approaches: the concept of market failures and the theory of protected goods [9], the theory of national innovation systems [10], evolutionary economic theory [11], the theory of the entrepreneurial state [12], the theory of the triple helix [13], the theory of endogenous growth and endogenous innovations [14, 15].

Among the fundamentally important methodological prerequisites, the following should be highlighted:

- The effectiveness of the financing model depends “on the level of economic

development of the country, the quality of institutions, the structure of the economy and other contextual factors” [16, p. 23], which requires the specification of models in specific historical conditions;

- The validity of the crowding out effect, in which “budget subsidies lead to a reduction (crowding out) of private investment in innovation” [17, p. 133];

- The need to form a unified scientific research landscape, based on the approach adopted and implemented by the Russian Academy of Sciences and the Russian Science Foundation [18];

- The objectivity of the concept of technological connectivity (especially in high-tech sectors) [19];

- The current relevance in the conceptual approach of its own line of developments [20].³

At the same time, a significant methodological consideration for Russian practice is the need to take into account a level division: high and medium levels of technology. According to Yu.A. Krupnov and S.N. Silvestrov, this would help accelerate diffusion processes in the economy [21].

Alternatively, it is essential to identify an industry level without which neither federal programs nor corporate solutions can be effectively implemented, particularly in terms of import substitution and significant impact of standards [22].

THE RESULTS OF THE STUDY

To assess the variety of financial instruments used to support R&D projects, the authors compared the main differences in these processes between different countries. The analysis of the structure of R&D financing (*Fig. 1*) reveals significant differences in the priority of

³ The concept of technological development for the period up to 2030 is the Decree of the Government of the Russian Federation dated 20.05.2023 No. 1315-r (as amended on 21.10.2024). URL: https://mineconomy.orb.ru/upload/uf/6f9/wjv4jiu79t15llbuk66fakmslnqirx7/Rasporuyazhenie_Pravitelstva_RF_ot_20_05_2023_N_1315_r_red_o.pdf. (accessed on 05.03.2026).

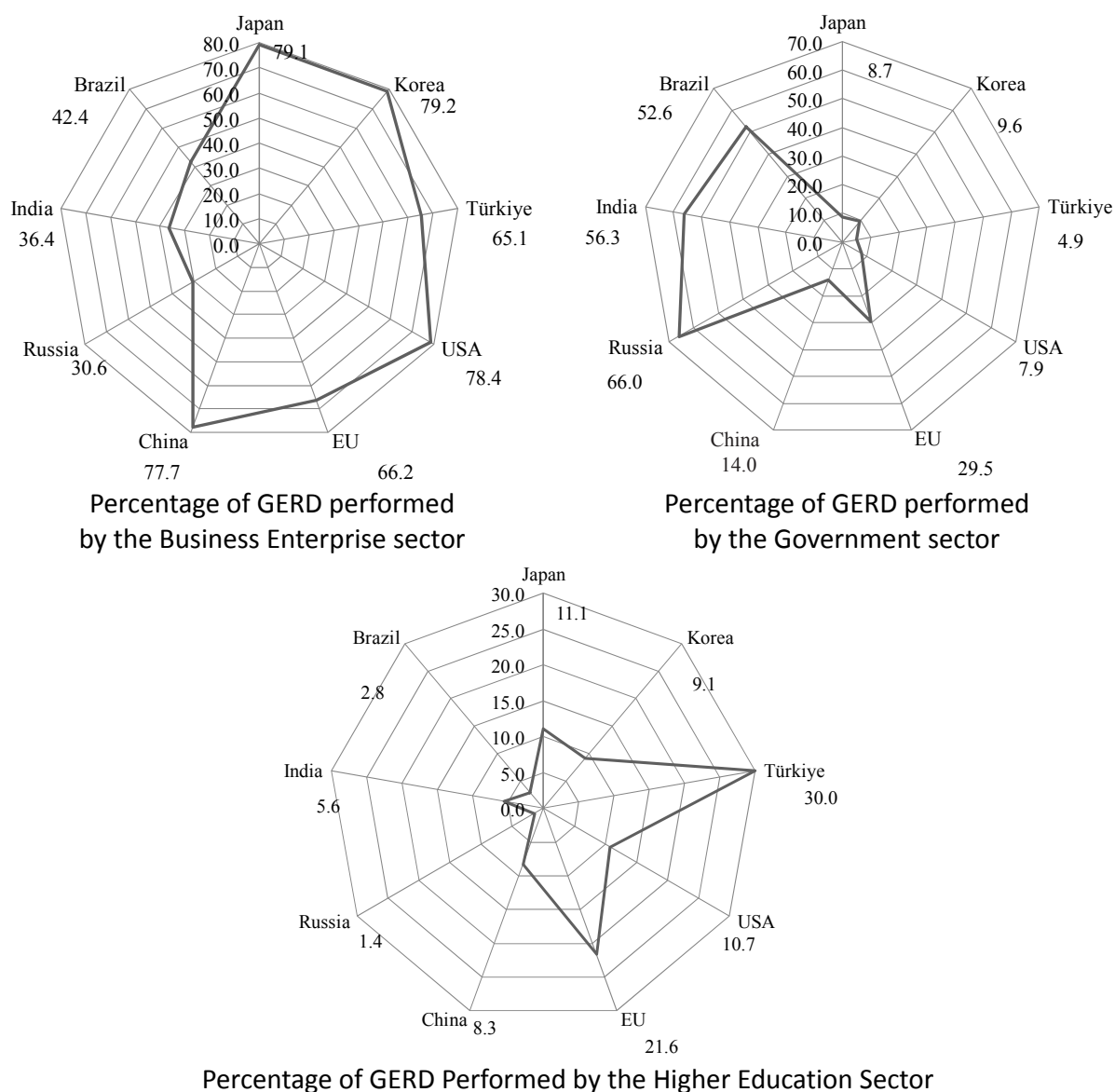


Fig. 1. Sources of GERD financing, %

Source: Compiled by the authors based on the data: OECD Data Explorer. Main Science and Technology Indicators (MSTI database), 2020–2024. URL: [https://data-explorer.oecd.org/vis?fs\[0\]=Topic%2C1%7CScience%252C%20technology%20and%20innovation%23INT%23%7CResearch%20and%20development%20%28R%26D%29%23INT_RD%23&pg=0&fc=Topic&bp=true&snb=19&df\[ds\]=dsDisseminateFinalDMZ&df\[id\]=DSD_MSTI%40DF_MSTI&df\[ag\]=OECD.STI.STP&df\[vs\]=1.3&dq=.A.G%2BT_RS...&lom=LASTNPERIODS&lo=5&to\[TIME_PERIOD\]=false](https://data-explorer.oecd.org/vis?fs[0]=Topic%2C1%7CScience%252C%20technology%20and%20innovation%23INT%23%7CResearch%20and%20development%20%28R%26D%29%23INT_RD%23&pg=0&fc=Topic&bp=true&snb=19&df[ds]=dsDisseminateFinalDMZ&df[id]=DSD_MSTI%40DF_MSTI&df[ag]=OECD.STI.STP&df[vs]=1.3&dq=.A.G%2BT_RS...&lom=LASTNPERIODS&lo=5&to[TIME_PERIOD]=false); World Bank. Research and development expenditure (% of GDP). URL: https://data360.worldbank.org/en/indicator/WB_WDI_GB_XPD_RSDV_GD_ZS?view=trend&average=WLD&country=BRA%2CRUS%2CIND%2CCHN%2CZAF&minYear=2008; UNESCO. Browse Data. Target 9.5 – Science, Technology and Innovation. GERD as a percentage of GDP. URL: <https://databrowser.uis.unesco.org/view#indicatorPaths=UIS-SDG9Monitoring%3A0%3AEXPGBP.TOT&geoMode=countries&geoUnits=CHN%2CIND%2CJPN%2CRUS%2CTUR%2CUSA%2CBRA%2CDEU&browsePath=EDUCATION%2FUIS-SDG9Monitoring%2Ft9.5%2Fi9.5.1&timeMode=range&view=line&chartMode=multiple&tableIndicatorId=EXPGBP.TOT&chartIndicatorId=EXPGBP.TOT&chartHighlightSeries=&chartHighlightEnabled=true> (accessed on 05.03.2026).

funding sources. In Japan, Korea, and China, business is the main source of funding, while in Russia and India, the government is more prominent. Universities play a significant role in financing in Türkiye.

The idea of the connection between financial security and technological independence is relatively new and has not yet been fully supported by statistical evidence. Therefore, the current statistical

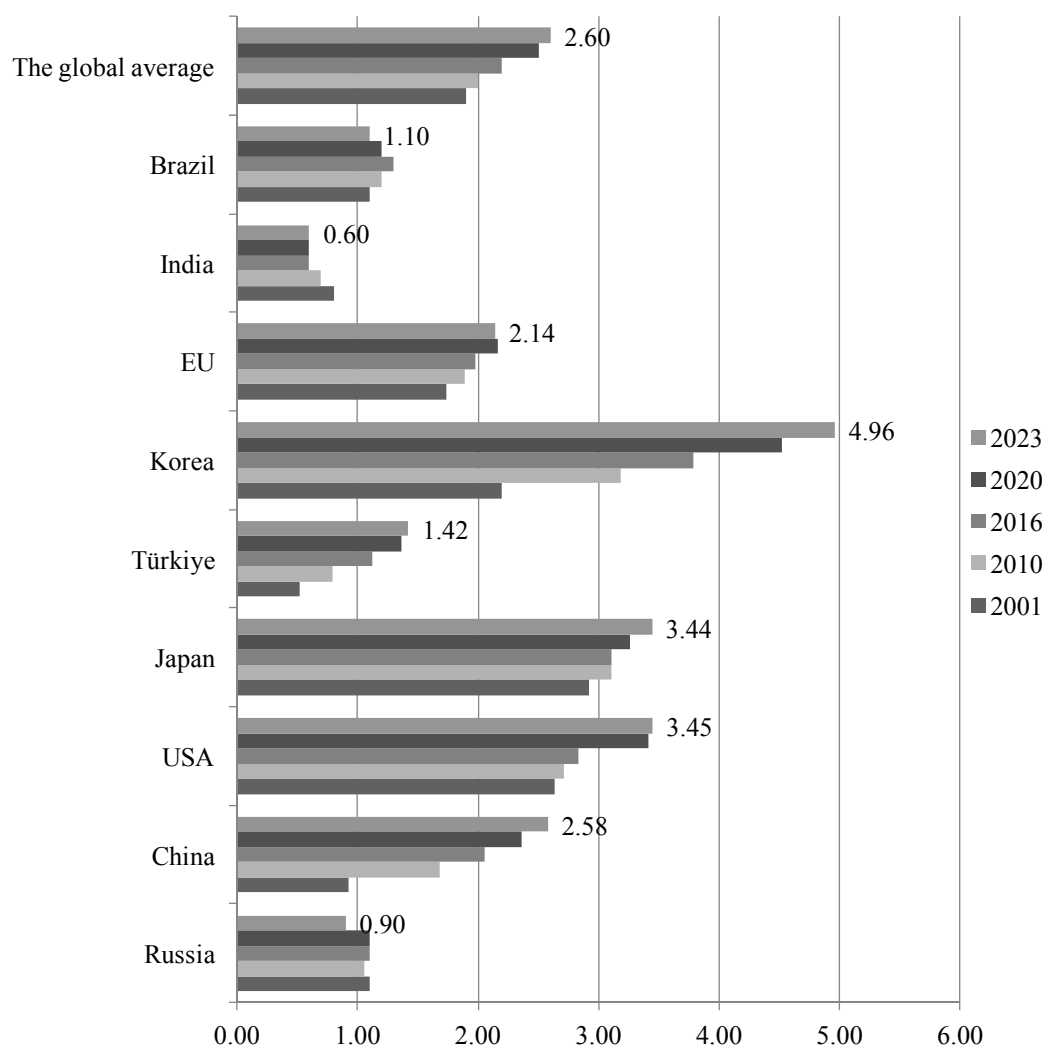


Fig. 2. GERD as a Percentage of GDP

Source: Compiled by the authors based on the data: OECD Data Explorer. Main Science and Technology Indicators (MSTI database), 2020–2024. URL: [https://data-explorer.oecd.org/vis?fs\[0\]=Topic%2C1%7CScience%252C%20technology%20and%20innovation%23INT%23%7CResearch%20and%20development%20%28R%26D%29%23INT_RD%23&pg=0&fc=Topic&bp=true&snb=19&df\[ds\]=dsDisseminateFinalDMZ&df\[id\]=DSD_MSTI%40DF_MSTI&df\[ag\]=OECD.STI.STP&df\[vs\]=1.3&dq=A.G%2BT_RS...&lom=LASTNPERIODS&lo=5&to\[TIME_PERIOD\]=false](https://data-explorer.oecd.org/vis?fs[0]=Topic%2C1%7CScience%252C%20technology%20and%20innovation%23INT%23%7CResearch%20and%20development%20%28R%26D%29%23INT_RD%23&pg=0&fc=Topic&bp=true&snb=19&df[ds]=dsDisseminateFinalDMZ&df[id]=DSD_MSTI%40DF_MSTI&df[ag]=OECD.STI.STP&df[vs]=1.3&dq=A.G%2BT_RS...&lom=LASTNPERIODS&lo=5&to[TIME_PERIOD]=false); World Bank. Research and development expenditure (% of GDP). URL: https://data360.worldbank.org/en/indicator/WB_WDI_GB_XPD_RSDV_GD_ZS?view=trend&average=WLD&country=BRA%2CRUS%2CIND%2CCHN%2CZAF&minYear=2008 (accessed on 05.03.2026).

measurement of the processes under study is considered within the framework of the key concept of the impact of R&D financing on economic growth. It should be noted that in world practice, the intensity of financing is most often studied as the share of R&D in GDP (GERD)^{4,5} (Fig. 2). This is

determined by the framework of classical economic theory based on economic growth (most notably, K. Arrow [23]). However, this theory also puts forward the thesis that the private sector systematically underinvests in R&D because it cannot fully appropriate research results due to their uncertainty, indivisibility and non-appropriability. These views were corrected by the establishment of

⁴ GERD (Gross Domestic Expenditure on Research and Development) is an indicator of total domestic expenditure on research and development (R&D).

⁵ Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development.

The Measurement of Scientific, Technological and Innovation Activities. Paris, OECD Publishing; 2015. 402 p. DOI: 10.1787/9789264239012-en

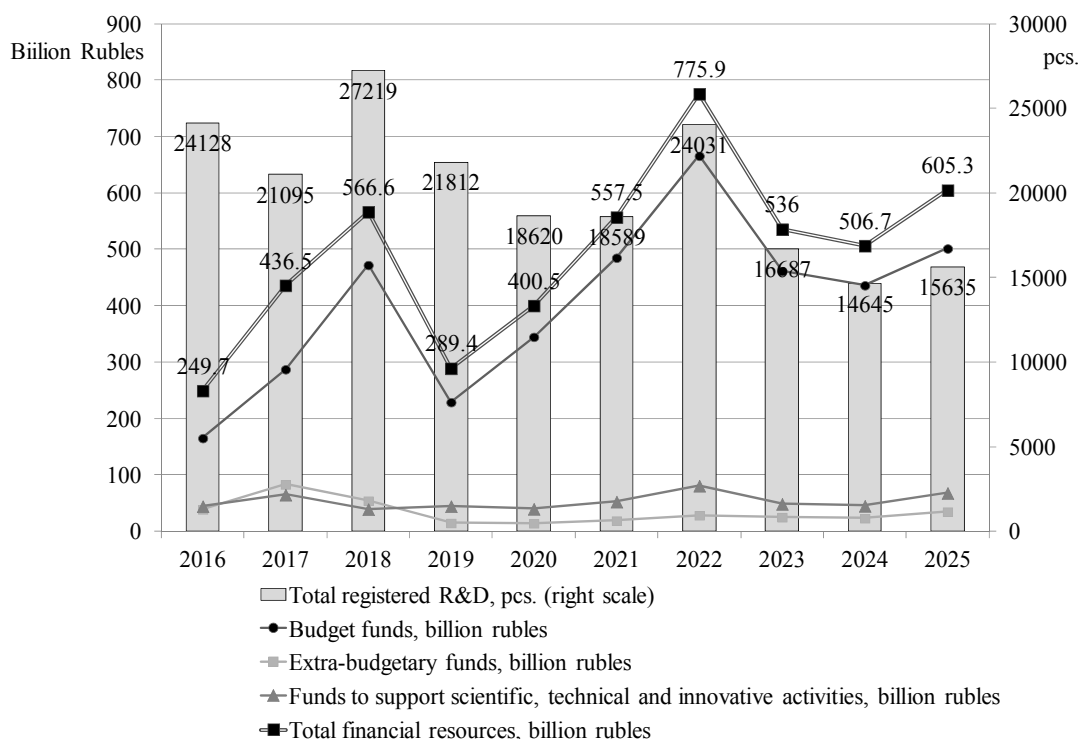


Fig. 3. R&D Indicators and the Structure of Financing in Russia

Source: formed by the authors on the basis of data from the domain "Science and Innovation" (based on the information resource of the Unified State Information System for Accounting for Research, Development and Technological work for civil purposes). URL: <https://gisnauka.ru/> (accessed on 05.03.2026).

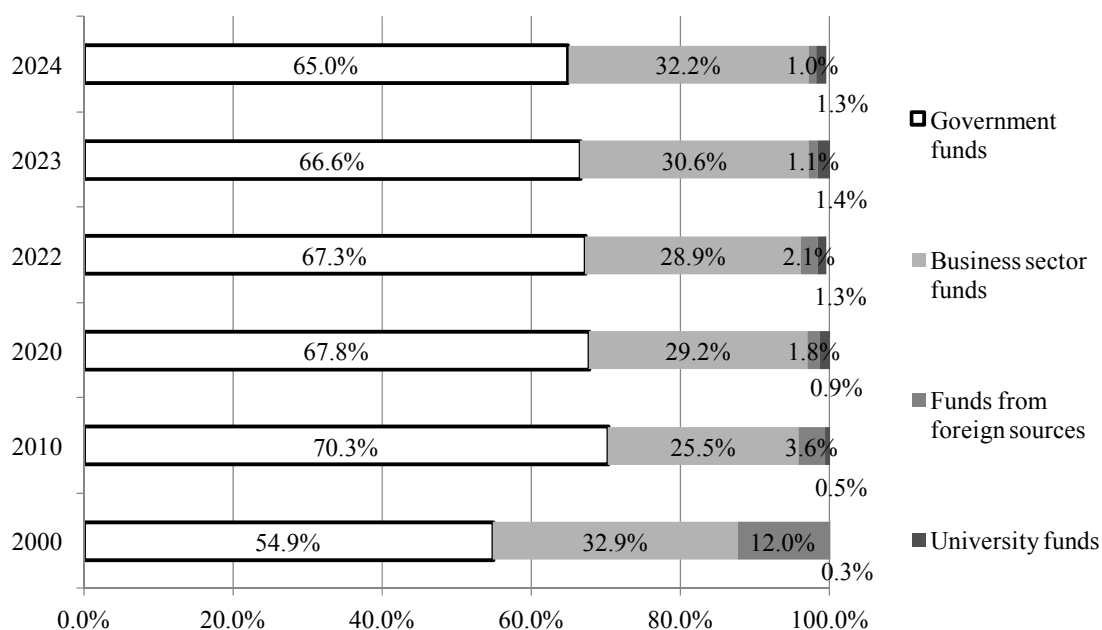


Fig. 4. Sources of R&D Financing in Russia, %

Source: Calculated and formed by the authors on the basis of data from: Science. Technologies. Innovations: 2026. Moscow: HSE; 2026. 116 p. DOI: 10.17323/978-5-7598-3044-3 (part 3.8).

the phenomenon of the national innovation system (NIS), which combines infrastructural opportunities for innovation, according to the initial ideas of K. Freeman [24] within the framework of neo-Schumpeterian and endogenous [25] approaches to economic growth.

Indicators of patent and publication activity are more of a reference in nature, making up a description of the Scientific Foundation, and are important for determining the criteria for financing, but not the impact on performance. In addition, econometric studies of social impact assessment also occupy a certain place, based on the claim that the social rate of return from R&D is significantly higher than the private return, which justifies government intervention [26]. Nevertheless, for comparative analysis, it is the indicator of the intensity of R&D financing that remains the basic one.

In Russian practice, R&D statistics⁶ show (Fig. 3) a stable correlation between registered R&D projects and total funding. At the same time, over the past ten years, the distribution by sources of financing (Fig. 4) demonstrates a significant prevalence of state budget financing with a slight increase in the participation of funds for scientific, scientific, technical and innovative activities.

The data presented above consistently identify several forms of financing.

Government funding includes:

- Institutional financing as the allocation of funds to scientific organizations based on the very existence of such an organization, achieving the advantage of maintaining the necessary infrastructure;
- Grant financing as a competitive mechanism for allocating funds through peer review of applications submitted by researchers or research teams;
- Targeted program financing as the allocation of funds for the implementation

of large-scale scientific and technological programs aimed at solving specific strategic tasks;

- Indirect financing through the mechanism of tax benefits and preferences (including spatial ones [27]) to organizations engaged in R&D;
- Government procurement.

Private financing is represented by the following types:

- Individual financing;
- Corporate investments;
- Private venture capital financing;
- Financing through private foundations.

Blended (or hybrid) mechanisms also include the formation of financial relations:

- Development institutions (as institutional intermediaries);
- Public-private partnerships;
- Co-financing on equal terms;
- Venture financing with government participation;
- Joint ventures (or strategic partnerships);
- Innovation clusters with anchor members;
- International consortia.

Public-private partnerships (PPP) should be highlighted among the blended forms of financing as an institutional form of cooperation between the public and private sectors. PPP allows combining the strategic vision and resources of the state with the market expertise and entrepreneurial initiative of the private sector. However, there is a high degree of uncertainty, especially in the area of the distribution of intellectual property results [28].

For a deeper understanding of the reasons for the modern heterogeneity of approaches to R&D financing, it is necessary to use a historical and evolutionary view of the dynamics of key paradigms for financing research and development, highlighting models: linear, systemic, triple helix, “state mission”-based, unified scientific research landscape, and ecosystem-based development models.

⁶ The domain “Science and Innovation” (based on the information resource of the Unified State Information System for Accounting for research, development and technological work for civil purposes). URL: <https://gisnauka.ru> (accessed on 05.03.2026).

The linear model (sequential logic). The explosive development of scientific research after World War II consolidated the contours of a consistent approach, which was adopted at that time by all the leading powers as a sequence of stages: fundamental research — applied research — development — commercialization. In the allocation of roles in the linear paradigm, the state turned out to be responsible for financing fundamental research, the results of which served as the basis for market implementation by private entities. In studies on this topic, an article by W. Bush from 1945 is often cited, emphasizing the need for a more effective use of accumulated knowledge in the form of a state-funded scientific reserve [29]. The article suggests that the state, with its potential for scientific knowledge, could be without the desired results if these are not achieved by corporations. It should be noted that, despite the criticism of the Soviet scientific system, the Soviet state achieved individual breakthroughs more often than other countries due to its consistent model. This was because it controlled most of the research and development chain. In contrast, in other countries, research and development were seen as the responsibility of the private sector, including applied research. The logical conclusion in the Soviet version of the linear model was the development of the CDNT cycle (creation and development of new technology) [30]. However, the implementation of this approach required the introduction of the institute of general designers, who had the authority to share responsibility and allocate funding in order to achieve the possibility of implementing full-life cycle projects [31].

The systemic model. The success of the cybernetic approach to corporate activities led to the need to implement strategic foresight of the results of future research, which required the rejection of linear logic (B. O. Lundvall, K. Freeman, R. Nelson) [32]. As a result, it was proposed to consider R&D as the result of complex interactions between

multiple actors within the framework of NIS (cointegration [33]), ensuring the process of knowledge diffusion into specific applied solutions. In this paradigm, the financing model is considered as one of the key institutional elements of the NIS that determine its effectiveness.

The system logic, which aims to eliminate the fragmentation of participants and the choice of financing in the linear model, has nevertheless turned out to be more descriptive than comprehensive from the point of view of financing. This logic views financing as an automatic process, as all participants in this model, recognizing the importance of conducting research and development, would make a decision to attract resources. In reality, decision-making is influenced by factors such as the desire to benefit from achievements without incurring costs, reduce responsibility after receiving funding, and prioritize budget deficits (at any level). The great theorization of the systemic model is due in large part to the fact that it arose from practical experience and was later given theoretical and methodological justification. The linear model, on the other hand, was developed as a generalization of this experience and then received theoretical and methodological support. The systemic model, meanwhile, went from hypothesis to practical implementation. In practice, in many cases, a systemic model is often represented by a number of overlapping linear processes that are controlled by key actors. As a result, the system model focuses on the organizational aspect rather than the financial one, paying special attention to seed funding in the form of start-up support. This shifts the focus to subsequent steps towards venture financing, which is actually preserving the idea of separating the roles in the linear model.

The triple helix model. The idea behind this is that universities are becoming an essential part of the knowledge economy. The interaction between these three development cycles creates new organizational structures

and social mechanisms for knowledge production, transfer, and application [34]. This idea was widely accepted by the Russian scientific community [35], which focused on the interaction of three institutional spheres — universities, business and the state — as a driving force for innovative development. It should be noted that this model assumes the need for mixed financing, in which each of the three areas makes its own contribution, but there is still no methodological justification for the principles of financing in the triple helix model for practical application. Despite its widespread popularity, the direct impact of this model on the effectiveness of scientific research has not been clearly established. In fact, the idea of a “triple helix” has become part of the system model (within the NIS framework), describing successful cases only without significant potential for creating future solutions.

The concept of the state mission (within the framework of innovation or scientific policy). Dissatisfaction with the outcomes of the systemic model and the triple helix model led to the fact that two research areas (the learning society of J. Stiglitz and V. Greenwald [36] and the idea of financing big challenges by M. Mazzucato [4]) began to consider the need to strengthen the role of the state. According to the concept of big challenges, the mission of the state allows it to overcome the fragmentation of innovation policy and ensure the strategic direction of public investments in science [4]. The idea of a learning society sees government funding of research as a tool for creating and sharing knowledge necessary for sustainable economic growth. This is because market failures in innovation are systemic [37]. Joint consideration of these approaches holds great potential for development. It is worth noting that the idea of revitalizing the role of public funding remains significant in Russian literature, for example, [38], including the need to integrate it into strategic planning processes.

*The model of a unified scientific research landscape (the modern Russian model proposed by the Russian Academy of Sciences and the Russian Science Foundation).*⁷ The proposed approach combines two models of public financing: institutional and grant-based, while providing the possibility for mixed financing. It assumes an assessment of achievements based on the practical needs of corporations [18]. At the same time, it retains the advantage of a linear model (solving problems through organizational structuring and extending the range of financial instruments to a range of studies related to a single topic). While there is undoubtedly still a lack of empirical evidence to fully understand the effects of the proposed model, the idea of a unified research landscape is significant in terms of restoring the importance of science after its role has been diminished by the focus on commercialization and market failures.

Ecosystem-based R&D financing models. Such ecosystems are characterized by venture financing at the state level [39] or internal corporate solutions. By now, research and development ecosystems aim to promptly eliminate imbalances in public research and development management, and are more likely to serve as coordination tools [40] rather than a complete concept. We also note that direct copying of such systems, primarily the forms used, will always be delayed, leading to an increase in additional costs. From this perspective, for example, an ecosystem that implements a “unified landscape of scientific research” would have an undoubted advantage over simply copying individual elements of successful global innovation ecosystems. It should be noted that the main advantage of such ecosystems will depend on technological connectivity, which will ensure the transition from project-based financing to portfolio-based financing [19].

⁷ Meeting with the President of the Russian Academy of Sciences Krasnikov. 15.07.2025. URL: <http://kremlin.ru/events/president/news/77446> (accessed on 05.03.2026).

The approaches listed above make it possible to establish various institutional solutions in the field of research and development financing:

- Centralized, with a strong state dominance, characterized by strict regulations and limited private initiative, and the ability to quickly mobilize resources, including for technological security purposes. Such an institutional solution focuses on various modifications of the linear model or the development of a single landscape concept, providing the highest level of technological security. However, this model has some disadvantages, such as a greater number of failed private initiatives in areas outside the state's interests;

- Decentralized, with a leading role for the private sector and venture capital, while also involving government coordination and flexibility in regulatory solutions. This institutional approach is focused on a system model, assuming that private research organizations are well-established and have the necessary resources, but requires significant government funding for major projects, as proactive allocation of resources alone may not be sufficient. From a technological security perspective, this approach allows for more effective financing of target areas where private initiatives have not been successful;

- Coordination, with a search for a balance between regulation and initiative, and an emphasis on standardization, assumes that a private initiative is provided with sufficient resources to achieve technological security. This is most often achieved through value chains within the proposed cooperation of private participants;

- Fragmented, characterized by the predominance of bilateral contracts, the lack of uniform regulatory mechanisms for R&D, but compensating for significant differences between different countries and participants, expanding the possibility of international cooperation.

Based on the analysis, it was possible to identify several types of research financing models within the framework of established institutional solutions:

- A market-oriented mixed model, as is prevalent in the United States, is characterized by the predominance of the private sector in research and development (R&D) financing, with a significant role for the state in determining priorities [32];

- The public-directed mixed model, as seen in China, is characterized by the state defining strategic priorities and providing significant direct and indirect funding, while actively encouraging the participation of the private sector. As B. Naughton [39], in this model, the government combines market incentives with policy planning to achieve both economic and technological goals, including those related to technological safety;

- The state-dominated model (as seen in India) is characterized by the state being the main source of funding and executor of R&D. The private sector plays a limited role, with rather weak connections between research institutions and industry. This is typical of many developing countries where the private sector has not yet developed sufficient incentives and opportunities to invest in R&D [41];

- A state-dominated model with elements of mixed financing, as seen in Brazil, where public financing predominates in attempts to encourage private sector participation through tax incentives and sectoral funds. However, there is general instability in financing [42];

- Multi-level mixed model (EC). The combination of supranational (framework programs), national and regional levels of financing ensures coordination between a significant variety of models of EU member states [43].

However, the above-mentioned institutional use of well-established R&D management models for institutional purposes is not unique to individual

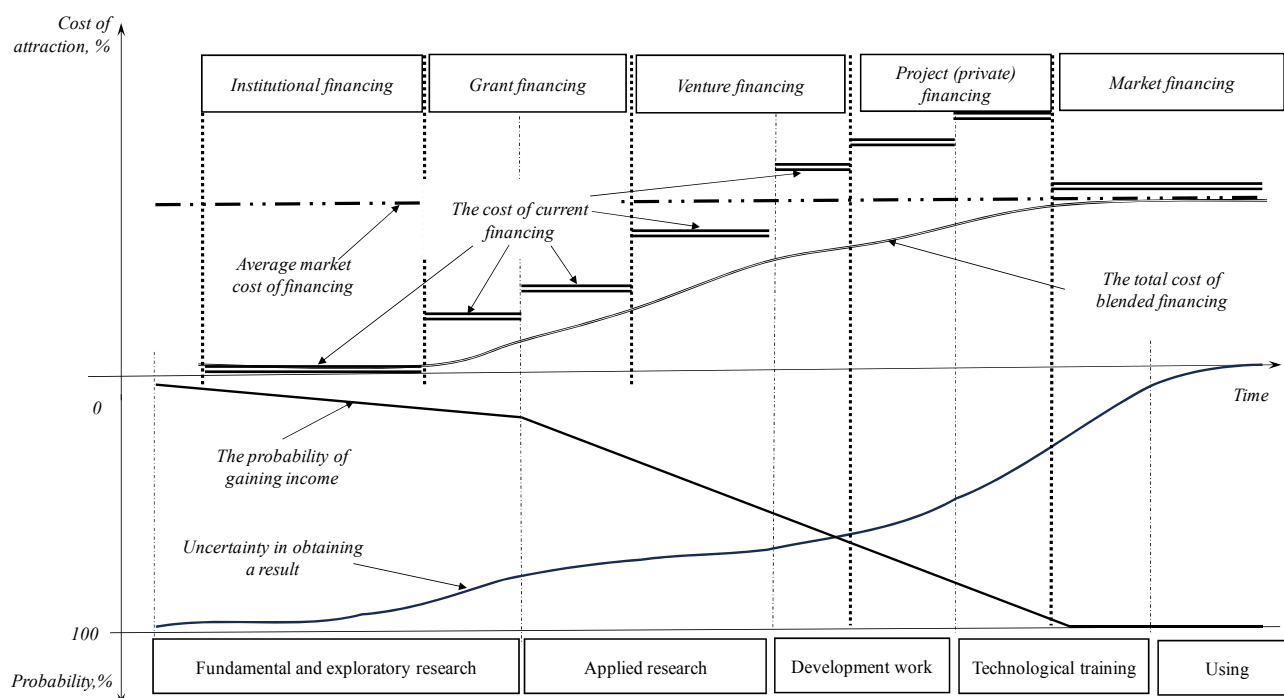


Fig. 5. Structural Blending of Finance

Source: Designed by the authors.

countries. For example, in Russia, alongside the idea of a unified approach to technological development, there is a design for mixed financing based on public-private partnerships and a project-based approach (i.e., a centralized and coordinated model)⁸ has also been proposed.

The above suggests that it is precisely the lack of evidence for an indisputable advantage of a particular model is what expands the possibilities for blended financing with the appropriate government initiative.

DISCUSSION OF THE RESEARCH RESULTS

Based on the idea that it is the financing mechanisms that determine the direction and intensity of knowledge flows [44], we present several arguments in favor of blended financing in solving the problem of ensuring technological security:

- Achieving complementarity of resources: The public and private sectors each have unique but mutually beneficial resources and skills. The government provides long-term funding, scientific infrastructure, and regulatory oversight, while the private sector contributes market expertise, entrepreneurship, and a focus on commercial success.

- Reducing information asymmetry: The participation of the private sector in research and development (R&D) financing can serve as a signal of the market value of a research project, helping the government allocate resources more efficiently. At the same time, government co-financing can signal the quality of a project to private investors.

- Risk sharing. Blended financing allows for the distribution of technological, market, and financial risks between public and private sectors, enabling projects that neither sector would be able to finance on their own.

Nevertheless, blended financing causes several problems, one of which is the

⁸ The Government has approved the Concept of Technological Development until 2030. The Russian Government. Documents, 23.05.2023. URL: <http://government.ru/docs/48570> (accessed on 05.03.2026).

Table 1

Price and Risk of Blended Financing Under Different Scenarios (Simulation Example)

Financing (sources)	The scenario pessimistic for the developer, optimistic for government funding			The scenario optimistic for the developer, and pessimistic for government funding			The most likely scenario		
	Amount of financing, percentage of need	Price, including insurance, in %	The risk of not getting results, in %	Amount of financing, percentage of need	Price, including insurance, in %	The risk of not getting results, in %	Amount of financing, percentage of need	Price, including insurance, in %	The risk of not getting results, in %
Institutional	0.05	0	20	0.4	0	20	0.2	0	20
Grant	0.05	3	10	0.1	3.1	10	0.1	3.1	10
Stock	0.40	5	5	0.15	5	5	0.1	5	5
Banking	0.15	15	7	0	15	7	0.15	15	7
Venture Capital	0.30	30	15	0.1	31	15	0.2	30	15
Private, including one's own	0.05	35	0	0.25	43.95	0	0.25	24.35	0
Total		1			1			1	
Weighted average price, %		15.15			15.15			15.15	
Leverage ratio		9			1			2.33	
Maximum damage (linear model), % of financing		9.05			11.25			9.55	
Maximum damage (portfolio model), % of financing		91.50			59.00			75.00	

Source: Calculated by the authors.

Table 2

Possible Design Schemes for Blended Financing for Technological Security Purposes

Cash flows [financing (“+”) and disbursements (“-”)]	Scheme 1 Exploratory research (new technologies)	Scheme 2 Modernization (technological)	Scheme 3 R&D (measurable results)	Scheme 4 R + D (breakthrough technologies)	Scheme 5 Full cycle (critical technologies)
Institutional	✓		✓	✓	✓
Grant (state)		✓	✓	✓	✓
Grant (private funds)			✓	✓	
Guarantees		✓	✓	✓	
Banking		✓	✓		
Venture Capital		✓	✓	✓	✓
Leasing (equipment)		✓			
EPC contracts (equipment and technology)		✓			
Private investors		✓	✓	✓	
Own sources	✓		✓	✓	
Insurance payments		✓	✓	✓	
Results-based payments		✓	✓		
Debt payments		✓	✓		
Remuneration to investors		✓	✓	✓	
Equity participation			✓	✓	
Assignment of intellectual property (in favor of the state or the investor)	✓		✓	✓	✓

Source: Systematized by the authors.

previously mentioned crowding-out effect, when public financing replaces rather than complements private investment, despite the fact that well-known studies indicate that this conclusion is not fully proven [45]. Secondly, blended financing can create

complex intellectual property management issues due to conflicts between public and private partners. This can lead to difficulties in managing the rights and responsibilities of each party involved. Thirdly, there is a risk that government programs may be

monopolized by individual large corporations who use government co-financing as a way to subsidize research they would have done anyway.

The above justifications, factors, and approaches provide a basis for considering the possibilities of combining finance with research and development, including for purposes related to technological security.

The analysis of R&D financing paradigms allows us to identify two approaches that are not mutually exclusive: structural (organizational, step-by-step) and portfolio mixing. These approaches can be used simultaneously for large projects, without prioritization between them.

With structural mixing (*Fig. 5*), a sequence of research is initially established and performers are identified for each stage. As uncertainty decreases, the potential for return on investment and remuneration increases, taking into account the fact that at the early stages of basic research, there is a zero probability of a return on invested amounts. This is due to uncertainty about the sources of refunds and payments for using them. Therefore, state institutional financing for organizations according to their status as scientific organizations is the most attractive option. If the initiator of the research is not a scientific organization, it should identify one as the executor.

Reasonable amounts of funding should be supported by criteria or key performance indicators (KPIs), including within the context of the task of enhancing technological security. Typically, financing at the early stages does not involve a return on financial resources (including compensation) in case of unsuccessful project development, as these funds are allocated to support the operation of the organization (payment for labor, operational expenses, access to infrastructure, etc.). Therefore, the allocation of resources at this stage is irrevocable, given the future social and technological implications. The justification for expenses in the early stages of fundamental research

is controversial, and we believe that the criterion for financing a scientific organization based solely on its existence should be strictly adhered to. In subsequent stages, conditions should resemble those of market-based financing, allowing for the blending of private and public resources.

Grant financing, which is conceptually non-refundable, involves the possibility of incurring costs for servicing the funds raised. Firstly, it should be noted that grant financing has more measurable indicators than institutional financing. The necessary KPIs (or criteria) are determined by the applicant themselves. In the event of a failed project, it is possible to request a refund of grant amounts or revise them at their own expense. This risk allows us to consider the actual cost of grants to be non-zero, including due to insurance.

The initial tranches provide attractiveness for private investment in the subsequent stages (as shown in *Table 1*), significantly exceeding the market profitability.

Similar calculations can be done for the portfolio attraction of financial resources for a project, estimating the weighted average cost of capital. It is possible to start with the initial mix with the minimum cost of financing (zero, by analogy with the situation discussed above) and the desired cost for equity or a private investor. Some researchers equate institutional financing with their own, but this approach is incorrect, as a rule, a scientific organization has the right to manage funds, but not to use them as their own.

An important indicator of financing is the level of leverage. This is calculated as the amount of private investment to the amount of concessional financing (most often institutional and grant), which is also calculated for reference in *Table 1*.

Table 1 also demonstrates that the linear model is more advantageous than portfolio financing, as termination of financing in the event of failure at any stage reduces overall losses through a consistent approach.

In light of this approach, *Table 2* provides possible schemes for organizing combined financing for various research and development options.

It should be noted that the presented schemes allow us to answer the question about the impact on technological safety.

- Firstly, the blended financing schemes do not impose any restrictions on achieving the chosen priority with an increase in the amount of funds raised.
- Secondly, control over the distribution of intellectual property rights is required in the case of attracting financing, which allows us to positively answer the second part of the research question. However, the distribution of intellectual property in research projects [46] with blended funding still requires further research.

CONCLUSIONS

The results obtained allow us to draw the following conclusions:

- The government continues to act as an “early-stage investor”, particularly in blended financing models for areas with high levels of uncertainty and long payback periods, such as DeepTech, fundamental research, and knowledge infrastructure. This is due to

market failures and underinvestment by the private sector in the early stages of research and development.

- Blended financing can help reduce risks, accelerate the commercialization process, create markets, and move technologies towards implementation.
- The effects of blended financing are complex and depend on the specific goals of the program, including economic growth, social impact, attracting private investment, reducing private R&D spending, and shifting the focus towards short-term objectives.
- When using blended financing schemes, it is important to consider a comprehensive set of tools that are adapted to specific goals and contexts. The efficiency of these schemes is achieved through the combination and quality of interactions between scientific institutions, universities, and industry. It is not simply the presence or absence of certain tools that determines the success of a scheme.

In conclusion, we can say that blended financing has become an essential part of the research support system in modern times, regardless of the specific model or institutional design used. This is true for both linear, systemic, and unified landscape models as well as ecosystem models.

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