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R&D FUNDING TOOLS: CONTEXT AND APPLICATION WITHIN GLOBAL AND RUSSIAN PRACTICES

This paper is devoted to a comparative analysis of the typical ways (patterns) in which R&D financing instruments are used in four dozen countries of the world, including members of the OECD and some others. Russia is chosen as the protagonist for this comparison, since its economy is based on specific sources of growth under a specific regime of governance. The main results of the comparisons show certain contradictions (in comparison with other countries) between the scale and the structure of the Russian S&T system and the instruments used to finance science. These results can be used for policy recommendations and as a starting point for more in-depth analysis.

Keywords: S&T policy, S&T funding, R&D funding, science and technology, research and development

JEL Classification: JEL: O10, O25, O30, O38, O40, O50

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Introduction

The focus of this paper is set on national patterns of R&D funding tools and their relationship with broader systemic context. We assume the contribution of R&D funding (via further R&D expenditure) to economic growth and socio-economic development as a significant issue for long-lasting discussion and research (Mansfield, 1972; Romer, 1990; Stokey, 1995; OECD, 2015a; Soete et al., 2022).

In accordance with the standard research approaches to R&D and innovation activities (international guidelines for the observation of R&D, research personnel and IPR objects), financial, tangible, intangible assets, as well as personnel are considered as major components of research and development resources (OECD, 2015b; OECD/Eurostat, 1995; OECD, 2009; OECD, 2005). In the general case, financial resources can be relatively quickly and flexibly converted into any other, except for personnel (training and career development of researchers, technicians and equivalent staff is a long process, deeply integrated with many socio-economic, cultural and other factors and traditions). R&D funding tools, therefore, can be regarded as basic means of R&D policy. Of course, composition and application of such kind of a toolset strongly depends on the system context of a national STI domain. The national innovation systems (NIS) framework provides a popular and comprehensive conceptualization for such kind of national background to observe and explain cross-national differences and similarities (Freeman, 1988; Lundvall, 1992, 2007; Nelson, 1993).

Studying international experience in funding research and development (R&D) organisations[3], and comparing it with Russian practices certainly seems to be of interest, given the growing role of science in socio-economic progress, the need to meet global challenges, and respond to various current shocks such as, e.g., the COVID-19 pandemic. Also important is the steady growth of relevant expenditures, made by governments and businesses alike, from all sources. Taken together, these two factors lead to introduction of more stringent requirements for efficient use and allocation of such funds.

Various countries apply different schemes and tools to govern R&D organisations. While maintaining direct control and administration mechanisms in their policy arsenal for the public R&D sector, executive authorities also use “soft” tools to coordinate the streams of public R&D (co)funding, and adjust the conditions for its provision to target organisation groups. Efficient

[3] This is a study of science, and of R&D policy. However, a wider range of activities and policy tools is actually considered, aimed at knowledge and technology creation, commercialisation, and transfer. Therefore, such terms as “science”, “science and technology”, “science and innovation” and their derivatives are used in this document as equivalent ones. The analysed funding tools are applied not only to R&D, but also in part to innovation.

allocation of public funds in line with science and technology (S&T) priorities is ensured by comprehensive multi-level evaluation systems. Indirect measures (such as tax incentives) are also applied, along with special mechanisms for supporting and promoting R&D personnel, coordinating the activities development institutions, etc.

The review of various types of tools countries apply to financially impact organisations conducting R&D and innovation offered to the reader is based on international comparisons, a classification of financial mechanisms, and country-specific case studies.

1. Methodological framework and information base

As funding recipients, in the narrow sense R&D organisations can be defined as structures specialising in R&D (including research institutes (RIs), science and technology centres, etc.), or more broadly as all legal entities which spend money on R&D and employ R&D personnel. The second approach is most often applied to select observation objects in statistical surveys. In the latter case it is not the type of recipient organisations, or the sector they belong in that is considered to analyse R&D funding tools, but the types of funded activities.

For international comparisons in the field of science, standard criteria and definitions suggested in the Frascati Manual (OECD, 2015b; Gokhberg et al., 2020; Anopchenko et al., 2012) are typically used. This also applies to sources of / mechanisms for allocating public funds to finance R&D. The OECD have developed a classification which forms the basis of the STIP Compass knowledge base,[4] which describes about 6.7 thousand relevant science, technology, and innovation (STI) policy initiatives applied by sixty countries including Russia.

Methodologically, the STIP Compass database uses two approaches to structuring information: thematic and instrumental ones. In the first case, 8 thematic areas comprising more than fifty topics are classified (funding principles, competitive and non-competitive R&D funding, support for promising high-risk research, industry science, etc.). The instrumental classification comprises 5 groups of tools comprising almost thirty policy formats/initiatives (management, interaction, regulation, direct funding, indirect support). The last two types are directly used in this review.

Direct funding is a group which comprises eight specific tools (Table 1): institutional funding of public R&D, grants for public R&D projects, grants for business sector's R&D and innovation (in specific areas the state sees as important ones), etc. Indirect funding mechanisms (Table 2) include various kinds of tax incentives (mainly) provided for enterprises conducting R&D and creating

[4] For more detail on the STIP Compass database see OECD's official website (https://stip.oecd.org/stip/pages/about).

innovations, state guarantees to creditors, risk sharing mechanisms, etc. Internationally, indirect support tools are markedly less diverse than direct ones, not only in terms of their type but also the frequency of mentioning specific policy initiatives. This is most likely due to the fact that indirect tools cannot be considered as state science policy elements proper (though they are hugely important for the R&D sector), and are administered through other domains (e.g. tax legislation).

Breaking funding mechanisms down by the direct/indirect support criterion seems to be natural and logical. Still, when working with empirical data this approach does not yield sufficiently balanced distributions since the frequency of mentioning various tool types differs by more than an order of magnitude. Also, "public R&D" should be excluded from such division since indirect support is applied for it much less frequently than for R&D conducted by the private sector (and in some countries not applied at all). These considerations underlie the modified classification which comprises three levels rather than two (Fig. 1).

Table 1. Direct funding mechanism types included in the review

Funding mechanism type	Description
Institutional funding of public R&D	Subsidies provided to universities and public research organisations on the basis of institutional development criteria (e.g., research potential, overall performance), to accomplish their academic mission. The so-called. "block" funding is frequently provided, which allows recipients to steadily finance their R&D and gives then sufficient research autonomy.
Grants for public R&D projects	Direct subsidies to universities and public R&D organisations to partially or fully finance specific R&D projects. Includes both simple one-time subsidies and complex strategic programmes, various formats of public-private partnership, etc.
Grants for business R&D and innovation	Direct allocation of funds to firms to (co)finance R&D and innovation projects. Includes both simple one-time subsidies and complex strategic programmes, various formats of public-private partnership, etc.
Grants for centres of excellence	Competitive grants (based on performance evaluation) to provide financial support for core activities of universities and R&D organisations in order to promote advanced competitive world-class R&D.
Public procurement programmes for R&D and innovation	The process of public authorities' commissioning R&D or innovative products/services from third parties. Public procurement is carried out by government agencies of various national and regional levels, and by state-owned enterprises.
Loans and credits for enterprise innovation	State-backed loans available at better-than-market terms, enabling innovative companies to efficiently raise working or investment capital. Often provided for specific purposes such as stepping up exports (so-called "export credit"), purchasing new equipment, etc.
Equity financing	State-subsidised investments to help small innovative companies enter the market (issue shares). Such firms use the capital to finance their growth, since early in the entrepreneurial process opportunities to make profit are limited.
Innovation vouchers	Small grants provided for small and medium-size enterprises (SMEs) to procure services from external knowledge providers. Often used to pay for business consulting and technology transfer services, among other things.

Source: adapted by HSE ISSEK based on STIP Compass data.

In this case, a more balanced set of groups is achieved by including all public R&D organisations - recipients of financial support into a specific category: in the country sample compiled for the study "public" and "non-public" R&D organisations are represented approximately equally. For commercial R&D (including centres of excellence's activities) indirect financial support is also considered, in addition to direct measures.

Table 2. Indirect financial support mechanisms included in the review

Funding mechanism type	Description
Tax or social security incentives for firms investing in R&D and innovation	Incentives that reduce the tax burden of firms investing in R&D and innovation, including corporate profit tax incentives, reduced tariffs on imported research equipment, VAT refunds, reduced social insurance contributions, etc.
Tax incentives for individuals supporting R&D and innovation	Incentives that reduce the tax burden of individuals who donate money to fund R&D conducted by organisations (e.g. universities), or directly invest in R&D and innovation activities (e.g. in innovative start-ups).
Debt guarantees and risk sharing	Various arrangements to reimburse part of creditors' losses when firms have problems with servicing their debt. Can be used as funding tools to promote growth of small and medium businesses.

Source: adapted by HSE ISSEK based on STIP Compass data.

A sample comprising forty countries was built for this review, almost all of them OECD members. Various financial indicators available from the open-access OECD.Stat database[5] were used to analyse a broader context of funding mechanisms' application.

[5] The home page of the open-access OECD.Stat database (relevant section of the official OECD website https://stats.oecd.org).

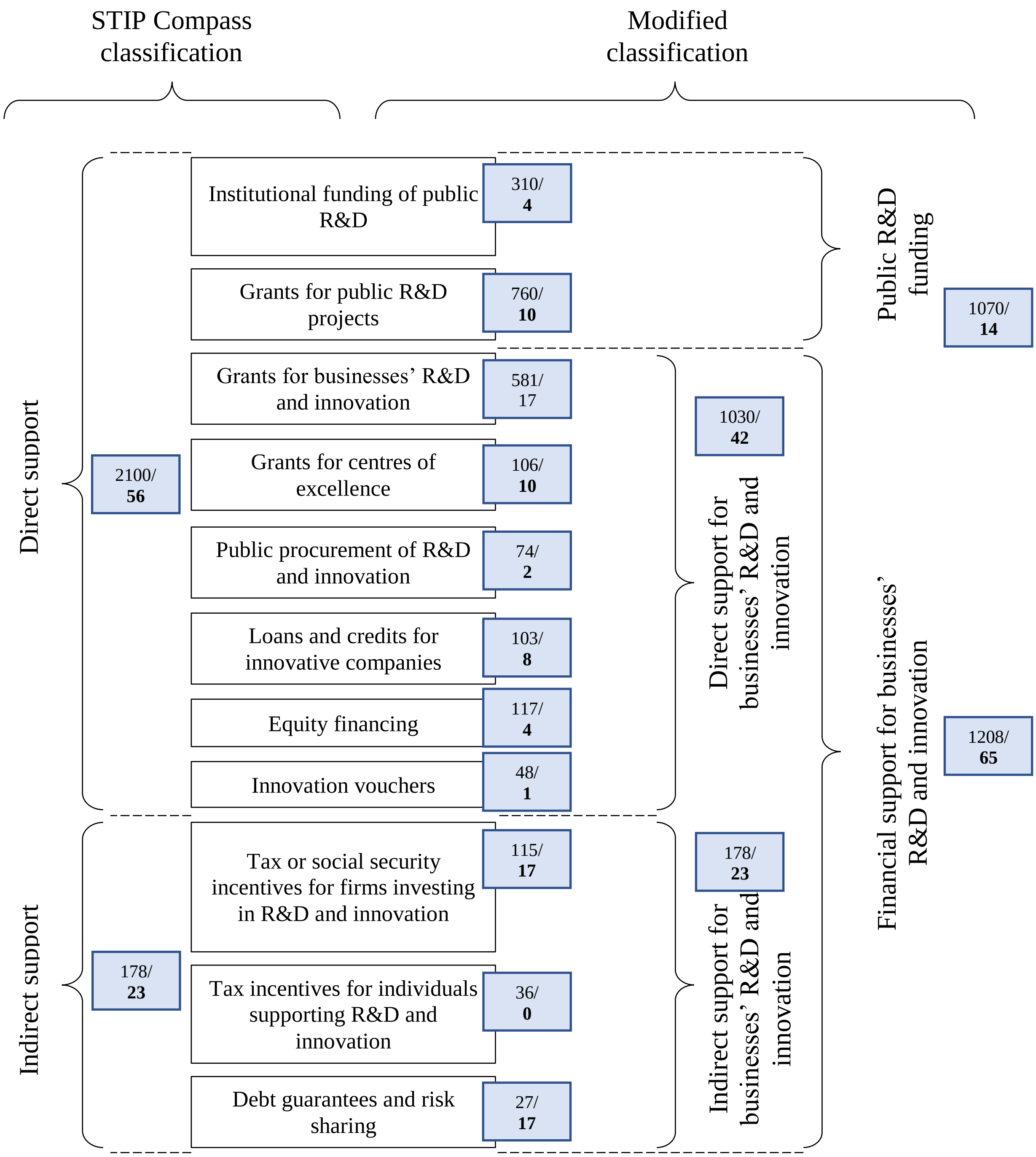


Figure 1. Original and modified financial mechanisms classifications (on the right is indicated the number of references to relevant measures for the whole sample / Russia)

Source: authors, based on STIP Compass materials.

2. The context of national R&D systems

Different countries' funding toolkits may significantly vary due to the different scales and capabilities of their governance systems, and different demand by the economy and society. When making international comparisons, it's important to be clear about whether specific cases are similar in terms of the overall context, or not.

For example, comparing economies by the ratio of relative innovation costs to R&D expenditures reveals their complementary nature (and that of the respective activities). For all selected countries this ratio is close to 1:1 (Fig. 2). Russia falls in a special group of countries outside the general trend: research intensity there is below the median, but the rate of innovation expenditures is higher. Apart from Russia, this is also the case in Italy, Lithuania, and Ireland. It may imply that in these countries R&D are underfunded compared with their "innovation ambitions". Another deviation is, countries where GDP research intensity is above the median demonstrate a markedly higher rate of innovation expenditures. Their behaviour can be described as "innovation leap", which in the future can provoke a bigger increase in R&D expenditures. The relative lack of R&D funding can be associated with a variety of structural and functional imbalances, which also need to be considered when explaining the context for the application of financial practices and mechanisms.[6]

[6] Indicators of Science: 2022: Statistical Digest. M.: HSE, 2022; Indicators of Innovation: 2022: Statistical Digest. M.: HSE, 2022.

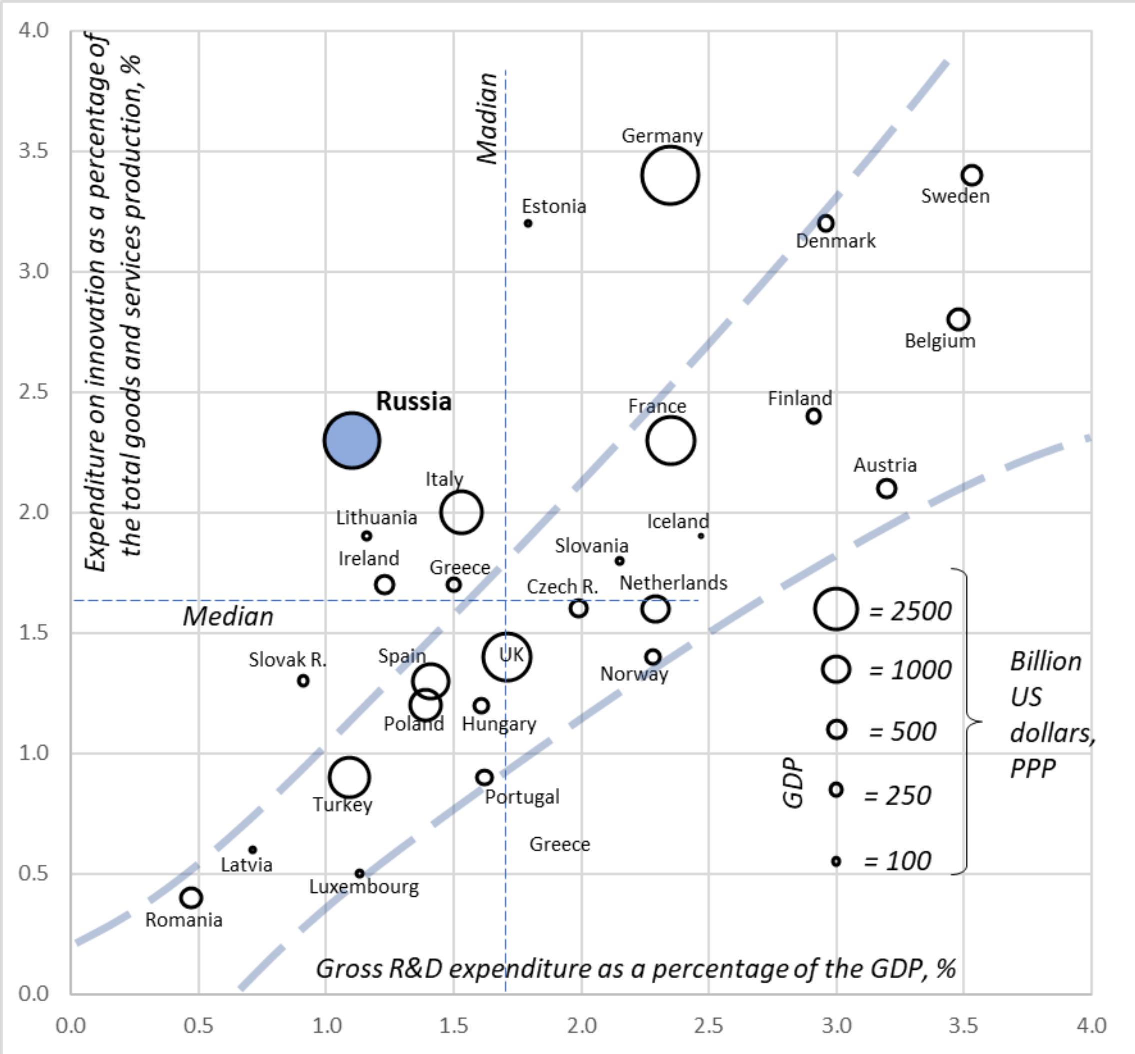


Figure 2. Ratio of knowledge intensity of the economy to the rate of innovation expenditures in selected countries (2021 or closest year for which data is available)

Source: authors, based on data from [Indicators of Science, 2022; OECD.Stat database; Indicators of Innovation Activity, 2022].

Gross, or domestic (depending on the aggregation level) R&D expenditures (GERD) reflect the actual amount of R&D conducted in the country. This metric is convenient for comparing the scale of national R&D sectors (Fig. 3). Most countries have a public-to-business R&D ratio of about 1:6, with the gap widening in the long term. Russia differs from the majority of countries in this respect too: with a quite typical share of the business sector (up to 60%), the public sector's share is approximately three times higher than the typical values. One explanation is that the Russian public R&D sector covers the niches which in other countries belong in the higher education and non-profit (NPO) sectors. Perhaps this is the reason why financial tools associated with university science are less diverse, and less highly developed in Russia than, e.g., mechanisms for supporting public R&D. In this respect Russia is close to such countries as Romania, Argentina, and Mexico, though the scale of R&D is incomparably higher in Russia. On the whole, the share of the business sector R&D in the sample varies insignificantly; the main differences between countries are in the shares of university and public R&D sectors.

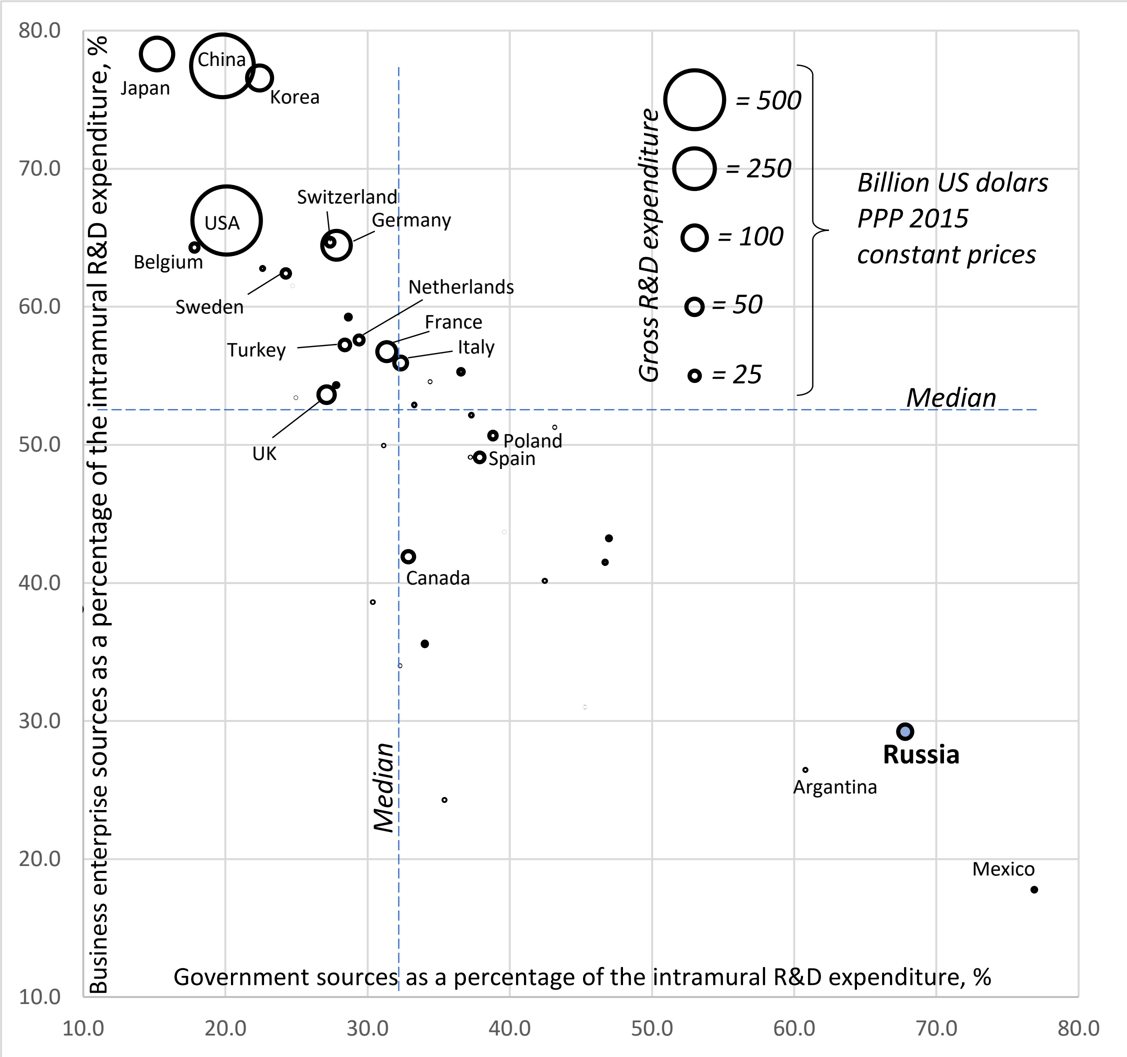


Figure 3. Shares of public and business sectors' R&D in selected countries (2021 or closest year for which data is available)

Source: authors, based on data from [Indicators of Science, 2022; OECD.Stat].

It is important to compare and evaluate the sectors not only in terms of the amount of GERD, but also of R&D funding sources. Universities' and NPOs' investments in science are quite limited in any country. Businesses and the state are the main sources of funds (Fig. 4), with the business sector clearly dominating (on average more than one and a half times ahead of the state). Russia, with its inverse proportion, violates both these patterns at once, but it's not the only nation to do so. Similar situations are observed in Argentina and Mexico.

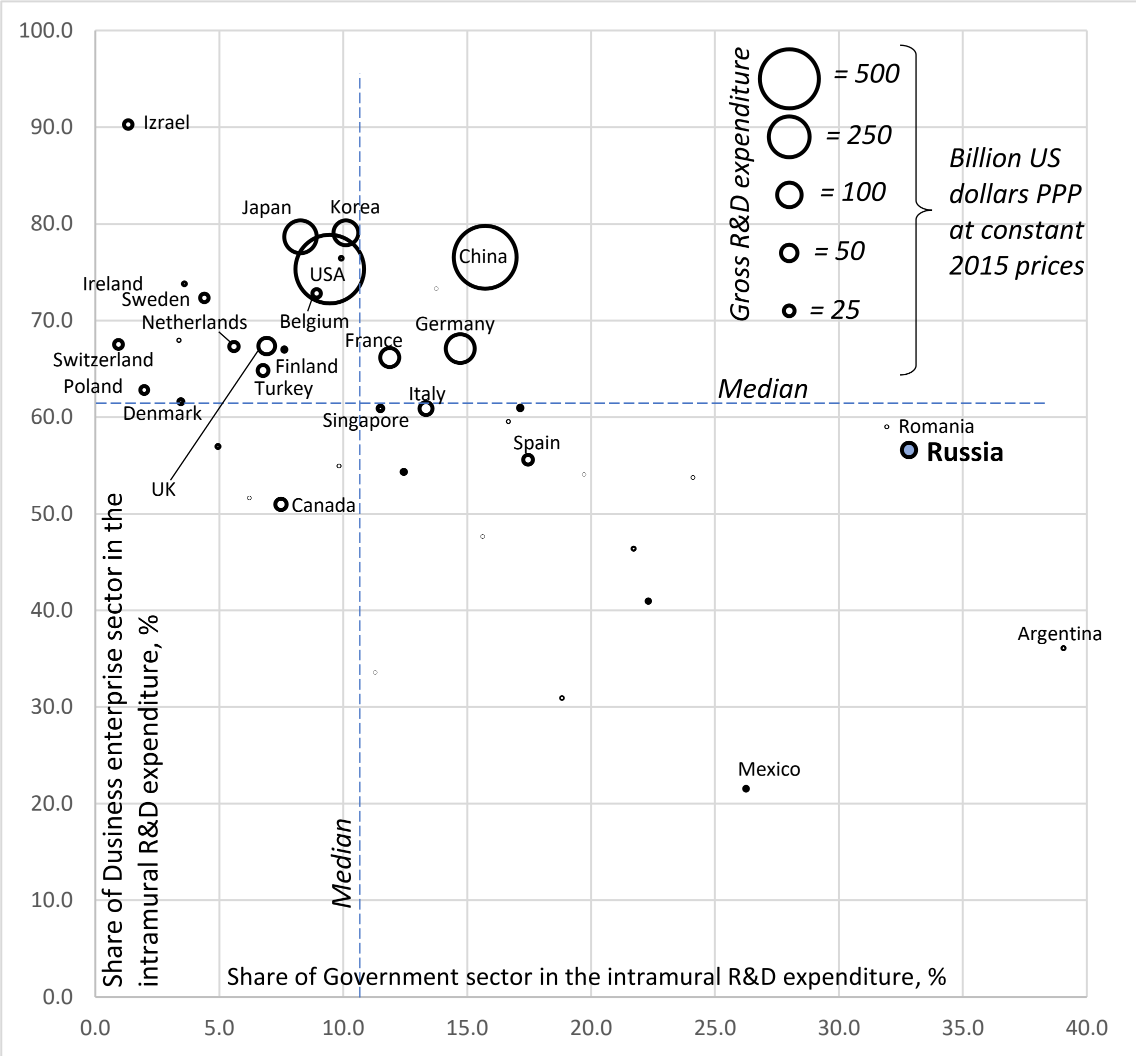


Figure 4. Shares of public and business R&D funding sources in selected countries (2021 or closest year for which data is available)

Source: authors, based on data from [Indicators of Science, 2022; OECD.Stat].

Taken together, all the revealed features paint a rather alarming picture of Russian science's future: relative "underfunding" is combined with a noticeable "overload" of the public sector, which has to expand its coverage and take on additional functions carried out in other countries by other actors (mainly universities). The public sector also has to act as the main "sponsor" of science and technology in the country.

Analysing and comparing the main public expenditure areas yields interesting results (Fig. 5). Though no clear pattern was found (e.g. in the US, Israel, and Sweden the state more actively supports corporate and university R&D, while in Japan and China it tends to stay within the public R&D sector), intermediate options seem to be more common (such as in Germany, France, UK, etc.).

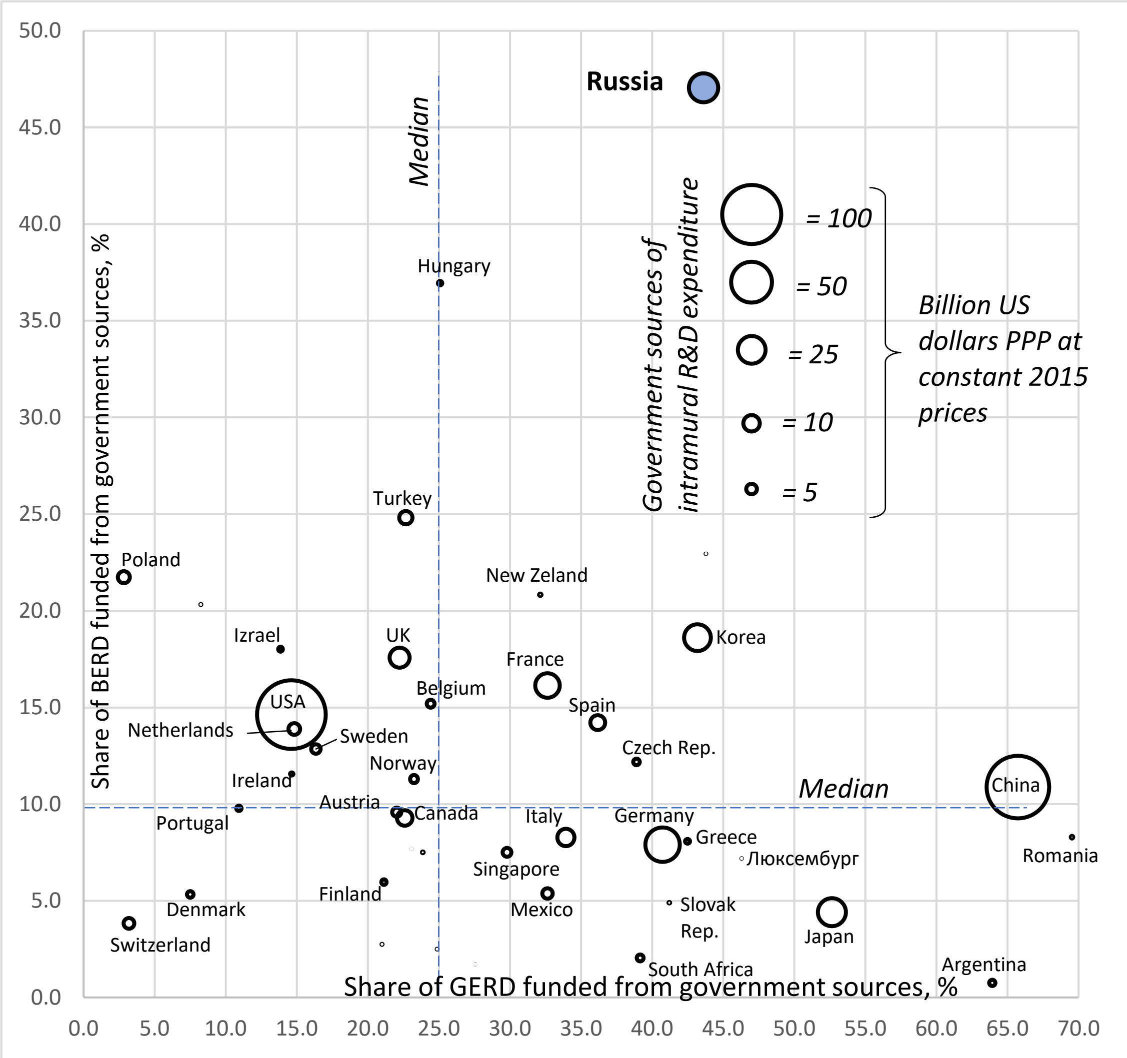
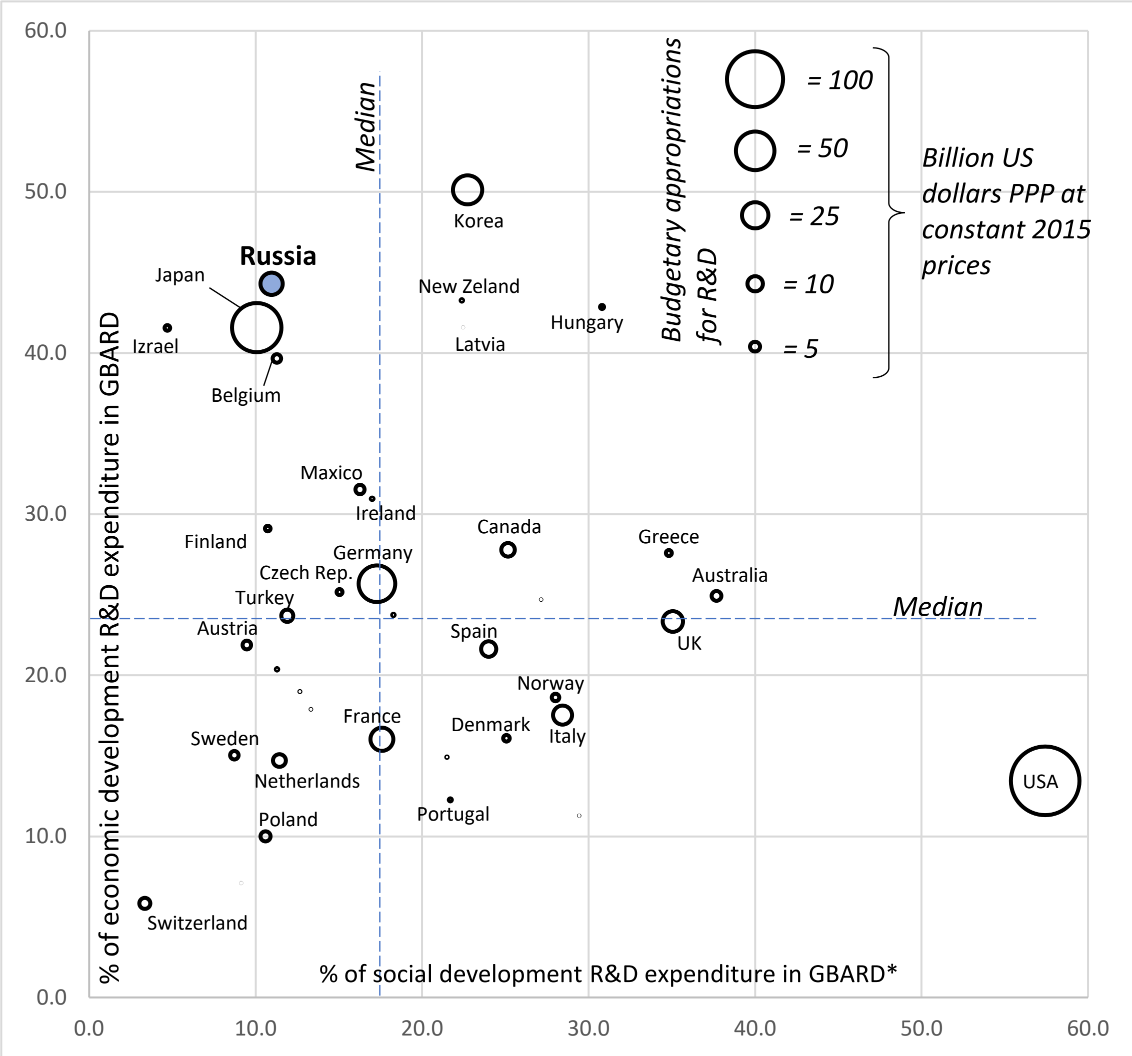


Figure 5. Shares of public and business R&D sectors as recipients of public funds allocated to support R&D in selected countries (2021 or closest years for which data is available)

Source: authors, based on data from [Indicators of Science, 2022; OECD.Stat].

Here too Russia "acts" differently from other countries: almost half of the public funds allocated to support R&D goes in the business sector, slightly less remains in the public sector itself, and universities get just a few percent. Companies' own resources account for just over a third of total R&D expenditures. The Russian state has to substitute not so much companies, as market forces and mechanisms which promote innovation-based development in industrialised countries.

In the framework of science and technology policy the state carries out certain strategic missions, described in official documents and reflected in the open budget appropriations. R&D subsidies provided to develop production technologies, promote industrial production growth, etc. can be generally described as appropriations allocated to facilitate "economic development". Another funding mechanisms group pursue "social development" goals (such as education; healthcare; environmental protection; social policy; culture; physical training and sports (Fig. 6).



*Budget appropriations for R&D to promote social development include the following areas: *education; healthcare; environmental protection; social policy; culture (including cinematography); physical training and sports*.

Figure 6. Shares of budget R&D appropriations to promote social / economic development in selected countries (2022 or closest years for which data is available)

Source: authors, based on data from [Indicators of Science, 2022; OECD.Stat].

In many countries (e.g., Germany, France) the economic and social missions are largely seen as equally important, so their funding is balanced. In some cases (Netherlands, Sweden, Switzerland) both these aggregated areas are perceived as less important than other goals, such as general development of science or basic research. A group of countries stand out where, on the contrary, these areas account for the bulk of public R&D appropriations (Greece, Australia). The US appears to have a special place: more than half of budget R&D appropriations are allocated to promote social development, with healthcare research steadily remains at the core.

As for Russia, its “research” budget has an extremely high share of economic goals (almost 45% of all appropriations for civilian science); about 11% goes for social purposes (7.7% for healthcare, 3% for education, and less than 1% for other areas). A similar industrial/technological focus of civil research appropriations is also observed in Japan, Israel, and Belgium. Korea, New Zealand, Latvia, and Hungary manage to increase R&D funding for economic purposes while maintaining social interests, and reduce appropriations for R&D associated with supporting public administration, security, etc.

As the above comparisons show, most OECD countries share certain “typical” characteristics of the amount and structure of R&D and innovation funding, and maintain an optimised “portfolio” of financial policy initiatives. The observed deviations are most often due to the fact that the largest and most competitive economies sustain and increase the national research potential largely at the expense of businesses, and the markets they create. In more modest (in terms of scale and complexity) economies, the R&D sphere has a much more pronounced public dimension, especially regarding socio-cultural development and education.

In this context Russia appears to be far removed from both the “norm”, and “typical deviations”. The scale of its R&D sector is comparable to the leading countries, which cannot be said about the financial flows and institutional structure. This significantly complicates policy comparison, since it’s impossible to clearly define “similar” or “opposite” (most different) countries. Obviously, given such contradictory positions and characteristics, Russia should, in theory, implement a much wider, and more diverse set of R&D- and innovation-related financial initiatives than other countries.

3. Funding mechanisms for “public” R&D

A significant part of research and development in the world is carried out in the interests of the state in the broadest context, financed with public funds either fully, or through co-financing arrangements. Such R&D may be conducted by public and non-public organisations, so by “public R&D” many analysts mean a broader concept than “R&D conducted in the public sector”. Understanding this aspect is important when classifying financial mechanisms.

OECD distinguishes between project and institutional R&D funding from public sources. The first type includes grants and subsidies allocated to implement specific R&D projects. More often such funds are provided in streams in the framework of various targeted state programmes. In particular, in Russia the bulk of such tools is applied to support R&D in priority areas, including basic research (mega-grants to set up laboratories headed by leading scientists; grants from the Russian Science Foundation, grants to implement major world-class research projects, grants for synchrotron and neutron research programmes and relevant infrastructure), subsidies for R&D projects in the agri-industrial sector, grants for full-cycle innovation programmes and projects, etc.

Institutional funding is provided to support current operations, and promote further development of R&D organisations (or organisations which conduct R&D, including universities). Abroad, institutional funding is not always provided on competitive basis or involves selection of recipients. It's administered taking into account the scale of recipients' R&D, and their relevant performance. The so-called "block" grants are often used, comprising several funding components or streams, each covering a specific function, activity, or development areas. In Russia, institutional funding is not very diverse. It's mainly provided to support university research and basic research institutes (in the form of state R&D assignments to universities and academic organisations, funds to acquire materials and equipment for nuclear energy-related R&D, support for federal budgetary institutions, autonomous institutions carrying out educational, research and medical activities, etc.).

Despite the significant role of the state in supporting Russian science, the range of specific financial measures applied in the country is rather narrow compared with global practices. This is due to the predominance of project funding, which is believed to be more rigid, and less varied than institutional financing. Thus in countries similar to Russia in terms of the relative size of the public R&D sector and the scale of public R&D funding (Romania, Hungary, Argentina, and Mexico), institutional support is provided for public R&D organisations in line with their thematic plans and state assignments, and for organisations implementing long-term research programmes in areas set as national priorities.[7] The widest range of institutional financing formats is observed in countries where the business sector dominates (such as the US and Japan). The ultimate goal of the state there is not monitoring the implementation of R&D projects, but promoting R&D and ensuring scientific autonomy of organisations whose research is most consistent with the national mission, agenda, and priorities.[8]

International experience in this area indicates a trend towards dividing institutional R&D funding into two levels: basic and breakthrough ones. The first kind of funding is provided in line with a fairly broad system of priority areas, and is sufficient if not to fully support, then promote R&D

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[7] Official websites of ministries and national programmes of the abovementioned countries: Romania (https://www.research.gov.ro/ro/articol/3768/programe-na-ionale-programe-nucleu); Argentina (https://convocatorias.conicet.gov.ar/centros-cientificos-tecnologicos; https://www.argentina.gob.ar/ciencia/sistemasnacionales/computacion-de-alto-desempeno); Mexico (https://www.siicyt.gob.mx/index.php/normatividad/conacyt-normatividad/programas-vigentes-normatividad/4938-lineamientos-del-programa-presupuestario-f003-programas-nacionales-estrategicos-de-ciencia-tecnologia-y-vinculacion-con-los-sectores-social-publico-y-privado/file; https://conacyt.mx/convocatorias/apoyos-infraestructura-cientifica/apoyos-a-la-ciencia-de-frontera-fortalecimiento-y-mantenimiento-de-infraestructuras-de-investigacion-de-uso-comun-y-capacitacion-tecnica-2021); Hungary (https://www.palyazat.gov.hu/efop-361-16-intelligens-szakosodst-szolgl-intzmnyi-fejlesztsek).

[8] Official websites of ministries and national programmes of the abovementioned countries: US (https://beta.nsf.gov/funding/opportunities/national-robotics-initiative-30-innovations-integration-robotics-nri-30; https://www.energy.gov/eere/fuelcells/h2scale; https://nsf.gov/cise/ai.jsp; US (https://www.energy.gov/eere/fuelcells/hydrogen-and-fuel-cell-technologies-office-consortia); Japan (https://www.mext.go.jp/content/20201214-mxt_kaikesou01-100014477-000_2.pdf; https://www.jst.go.jp/global/english/index.html; https://www.jst.go.jp/kisoken/en/index.html).

centres and laboratories focused on the relevant topics. Breakthrough initiatives are specific, unique, and few in number. They frequently provide full-scale support for recipients' operations, and further development. Various kinds of national "quantum" or "thermonuclear" programmes belong precisely in the second level, and can be integrated with "superiority initiatives".

In the world generally, a surprising at first glance trend is observed. Countries where the state, and the public sector play the least important role in science (such as the US, Germany, Japan, Canada) apply a more extensive toolset to fund public R&D, and a more modest one to support R&D in the business sector, compared with Russia too (Fig. .7). This is probably due to the fact that duplication, or substitution of market mechanisms by the state in the business environment increases the need for more sophisticated tools compared with managing the public sector. To test this hypothesis, financial toolsets applied to manage "public" and "commercial" science should be compared.

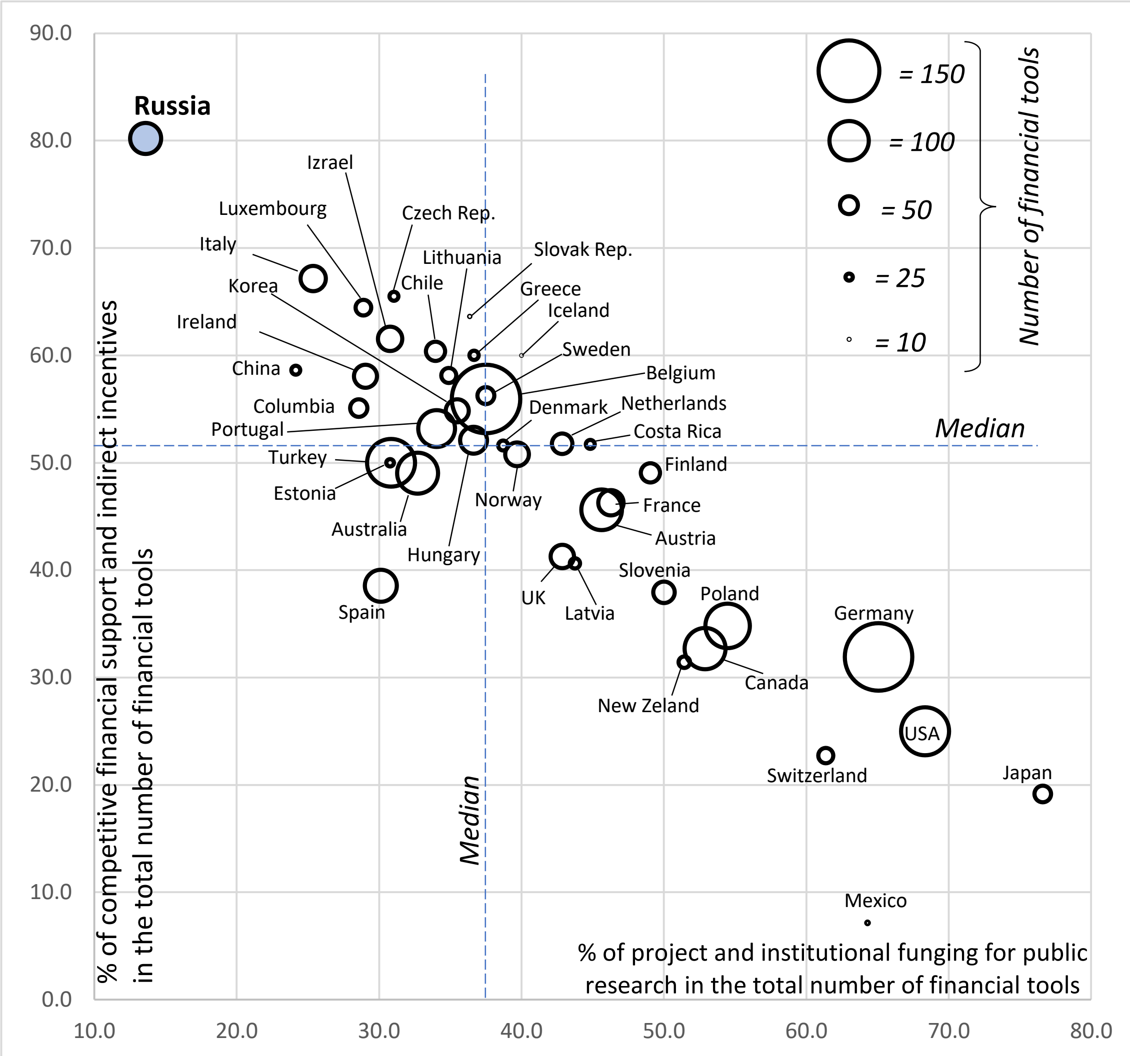

Figure 7. Application of financial support mechanisms for R&D and innovation in the public and business sectors in selected countries (2022 or closest year for which data is available)

Source: authors, based on STIP Compass data.

4. Mechanisms for direct funding of R&D conducted in the business sector

Shaping business sector policy is the most important and challenging task for relevant authorities, since interventions can disrupt market competition, distort the supply/demand balance, damage the natural ties between market players, and promote imitative behaviour. Mobility or restrictive measures, or declarative coordination of research and innovation activities of organisations outside the public sector seem to be rare and unusual exceptions. On the contrary, “soft” financial incentives allow to correct market failures, and promote R&D and innovation in socially significant areas.

The most common direct financial support format in this category is competitive grants for research and innovation projects. In Russia, a significant part of such funds is allocated through science foundations and other development institutions, such as the Innovation Promotion Fund, the Internet Initiatives Development Fund, the Russian Information Technology Development Fund, the Skolkovo Innovation Centre, the Corporation for Supporting Small and Medium Enterprises (SMEs), etc. Another format is targeted state programmes and initiatives. Among them are the National Technology Initiative, grants to support artificial intelligence technologies, and R&D subsidies for innovative enterprises and microelectronics companies.

Such practices are popular in many countries. Examples include the SBIR and STTR programmes in the United States, and industry initiatives to support innovation cycle, in particular programmes to promote the application of solar energy technologies; the activities of new development institutions in Germany, including the Federal Agency for Breakthrough Innovations and the BMBF programmes (Digital GreenTech, Transformational Biotechnologies); activities of the SITRA Foundation and Business Finland at different innovation cycle stages in Finland.[9] There are also numerous examples of S&T systems with structural parameters closer to Russia's: funding enterprises via ICT, bio- and nanotechnology platforms (Argentina), supporting companies which develop green energy storage facilities (Hungary), those applying artificial intelligence and "green" energy technologies, reducing carbon dioxide emissions, and efficiently recovering soil (Romania). However, the difference with the leading countries is that in the latter, such programmes and initiatives complement non-public investments at the innovation cycle stages where development and support bottlenecks would emerge otherwise.[10]

Competitive grants provided by various foundations to fund research and innovation projects give access to funding to a wide range of organisations and teams engaged in research, development, and innovation. The downside of wide coverage of target audience is the limited amount of funds available for specific participants. To provide large, concentrated amounts of funding to a small number of recipients, so-called "excellence initiatives" are implemented. These are intended to fund breakthrough R&D and world-class innovation projects carried out by the most advanced centres (usually established jointly by several leading in their industry, or subject area, organisations). In Russia such centres of excellence include, e.g., national research universities, universities participating in the 5-100 project (Priority 2030), world-class research centres, etc.

[9] Official websites of ministries, agencies, and programmes: US (https://www.sbir.gov/about; https://www.energy.gov/eere/solar/manufacturing-and-competitiveness); Germany (https://www.sprind.org/de/projekte; https://www.bmbf.de/bmbf/shareddocs/bekanntmachungen/de/2020/03/2879_bekanntmachung; https://www.bmbf.de/bmbf/shareddocs/bekanntmachungen/de/2020/05/2993_bekanntmachung); Finland (https://www.sitra.fi/osallistu; https://www.businessfinland.fi/suomalaisille-asiakkaille/etusivu.

[10] Official websites of ministries, agencies, and programmes: Argentina (http://www.agencia.mincyt.gob.ar/frontend/agencia/instrumento/60); Hungary (https://nkfih.gov.hu/english/open-calls/other-funding/promoting-innovative-electrochemical-storage-of-surplus-carbon-free-electricity-2021-211-ek/call-for-application); Romania (https://www.research.gov.ro/ro/articol/3781/programe-na-ionale-plan-sectorial). .

Only a small number of countries have such a wide range of excellence initiatives apart from Russia, and none of them are among the recognised leaders. These include Ireland (an interesting example of world-class centres funded by the country's Science Foundation), Norway (centres of excellence and R&D-based innovation centres supported by the Council for Science), Australia (centres of excellence established by research and innovation consortia).[11]

Most countries see this mechanism as a way to integrate into future global value chains, and apply it in very few areas. E.g. Germany created about four dozen "clusters of excellence" focused on purely applied, but breakthrough objectives (developing next-generation solid-state power elements, sustainable distributed energy systems based on "green" sources, next-generation catalysts for the chemical industry, etc.). Interestingly, the abovementioned Russian practice of supporting entire major universities as centres of excellence was not found in other countries (specific university-based centres and laboratories are usually supported; the "university of excellence" status awarded, e.g., in Germany, does not imply providing direct funding for the entire university).[12]

The results or effects of various tools for provision of public R&D and innovation funding are designed to produce are by no means limited to creating or implementing specific, high-priority for the country technologies, or achieving particular levels of S&T performance. Often the policy goal is to facilitate certain S&T-related functions or activities of organisations. E.g. targeted preferential loans and credits allow to correct investment markets' failures, and accelerate innovative companies' growth in certain industries.

To accomplish these objectives, Russia provides specially designed loans for launching production of import-substituting components, to promote development of conversion technologies, industry digitisation, development of high technologies, and activities of innovative and high-technology SMEs. In addition to the Industry Development Fund, VEB.RF Corporation plays a major role in providing such support. In other countries, various specially designed soft loans are popular in the economies facing problems with involving market investors in knowledge and technology creation. Good examples are Italy (support for SMEs implementing emerging and cross-cutting

[11] Official websites of ministries, agencies, and programmes: Ireland (https://www.sfi.ie/sfi-research-centres); Norway (https://www.forskningsradet.no/sok-om-finansiering/midler-fra-forskningsradet/sff); https://www.forskningsradet.no/utlysninger/2019/senter-for-forskningsdrevet-innovasjon); Australia (https://www.arc.gov.au/grants/linkage-program/arc-centres-excellence.

[12] Excellence strategy: information materials on the official website of the German Federal Ministry of Education and Research, BMBF (https://www.bmbf.de/bmbf/shareddocs/kurzmeldungen/en/excellence-strategy.html).

technologies), Spain (support for health technology platforms), and Belgium (sectoral innovation investment programmes in Flanders).[13]

Public equity financing is another tool that allows the state to act as a co-investor in innovative companies entering the market. In this case the objective is create growth opportunities for innovative businesses at critical stages. In Russia, as in many other countries, such mechanisms are not used often. Examples include the VEB.RF Corporation, and the Russian Venture Company (since 2021 integrated into the Russian Direct Investment Fund). Abroad, this kind of tools complements non-public investments rather than substitutes or duplicates them, and therefore is not commonly used either. The few countries which apply a wide range of co-financing formats include Belgium (V-Bio Ventuires foundation's biotechnology programmes); Korea (SME Technological Innovation Fund, Korea Growth Ladder Fund, a network of S&T holdings, etc.); Ireland (Development Capital Funds for Innovative SMEs); Turkey (Turkish Science and Technology Research Council (TUBITAK), Growth and Innovation Fund, Technology Development Fund). Often these are networks, platforms, or "ecosystems" supporting private and corporate investors with a minimum share of directly raised public funds.[14]

Innovation vouchers are another kind of targeted mechanisms for direct public investments in innovation. They allow to transfer funds to organisations to procure specific assets or services needed to create or disseminate innovations. In Russia, subsidies provided in line with the so-called "Regulation 218" can be considered as innovation vouchers, albeit with a certain stretch (to promote cooperation between Russian universities, state research institutions, and the real sector organisations to implement complex high-tech production projects).

Abroad, such practices are not very common either, but relevant cases can be found in many countries. In particular, in Italy SMEs can receive vouchers to pay for ownership registration, and in Belgium and Austria to commission R&D projects to third-party research organisations. [15]

There's another special format of direct funding mechanisms, which allows the state to become a direct consumer of knowledge and innovations: public procurement of products and services.

[13] Official websites of ministries, agencies, and programmes: Italy (https://www.mise.gov.it/index.php/it/27-comunicazioni/2040058-programma-di-supporto-alle-tecnologie-emergenti-5g); Spain (https://www.isciii.es/QueHacemos/Financiacion/Solicitudes/Paginas/default.aspx); Belgium (https://www.pmv.eu/en).

[14] Official websites of foundations, corporations, and programmes: Belgium (https://v-bio.ventures/about-us); Korea (https://www.kgrowth.or.kr/investfund/techinno_fund_intro.asp; https://eng.kgrowth.or.kr/page/fund_about.asp; http://www.kstholdings.co.kr/kor/company/menu_01.html; Ireland (https://www.enterprise-ireland.com/en/Invest-in-Emerging-Companies/Source-of-Private-Capital/Venture-Capital-Funds.html; Turkey (https://www.tubitak.gov.tr/tr/destekler/sanayi/ulusal-destek-programlari/icerik-1514-girisim-sermayesi-destekleme-programi-tech-investr; https://www.teknolojiyatirim.com.tr/tr/explore).

[15] Official websites of ministries, agencies, and institutions: Italy (https://uibm.mise.gov.it/index.php/it/incentivi); Belgium (https://innoviris.brussels/innovation-vouchers); Austria (https://www.ffg.at/programme/InnovationsscheckmitSelbstbehal).

Since governments or other authorities initiating public procurement must actually use or consume the purchased products, the scope for such activities is limited. Public procurement is conducted for two main purposes: to create a public good, or meet the public administration system's own needs. In the first case the Canadian procurement initiatives related to Covid-19 response can be mentioned, along with diesel generator replacement and procurement for sustainable development purposes in the Netherlands.[16] In the second case, examples include defence procurement in Australia and Canada.[17]

In certain cases a third option emerges: supporting specific R&D and innovation players. In particular, in Russia among more interesting cases are providing expanded access to public procurement for SMEs, and certain state-owned companies' obligations to procure innovative products.

Generally, economies outside the "first echelon" turned out to apply the widest range of mechanisms for providing financial support for "commercial" R&D and innovation, which are nevertheless focused on making technological "leaps" and "breakthroughs". Russia is no exception. However, the scale of its economic, R&D, and innovation systems is closer to that of the countries where markets are the main driver of S&T progress, while the state concentrates on correcting "market failures" (negative external effects). To get a complete picture, indirect support tools should also be considered.

[16] Official websites of governments, and affiliated structures: Canada (https://www.tpsgc-pwgsc.gc.ca/comm/aic-scr/ca-sc/crd-rod/index-eng.html; https://www.canada.ca/en/natural-resources-canada/news/2020/12/celebrating-indigenous-leadership-in-clean-energy.html); Netherlands (https://www.pianoo.nl/en/sustainable-public-procurement/developments/action-plan-responsible-and-sustainable-procurement).

[17] Official websites of governments, and affiliated structures: Canada (https://www.tpsgc-pwgsc.gc.ca/comm/aic-scr/ca-sc/crd-rod/index-eng.html; https://www.canada.ca/en/natural-resources-canada/news/2020/12/celebrating-indigenous-leadership-in-clean-energy.html; Netherlands (https://www.pianoo.nl/en/sustainable-public-procurement/developments/action-plan-responsible-and-sustainable-procurement).

5. Indirect financial support

Indirect support measures do not imply allocating or transferring public financial resources to support specific/target groups of organisations, or promote particular activities. Instead, support recipients are given an opportunity to reduce their tax, social security, and other fiscal payments, or debt obligations. Such measures are quite simple to provide and administer (although not everywhere), since they do not require examining or evaluating applications, and do not involve any direct contacts between authorities and beneficiaries at all. However, indirect incentives often provoke the latter to adapt and imitate the encouraged activities, so the support mechanisms and conditions need to be regularly updated.

Comparing the references to indirect support mechanisms in policy documents included in the STIP Compass database yielded curious results (Fig. 8). Interestingly, in this area Russia falls in the same group as Italy and China, showing a much wider range of initiatives than all other countries. This group is mainly focused on tax or social contribution breaks for firms investing in R&D and innovation. In particular, the RF Tax Code provides for a reduction in the taxable profit tax base in proportion to R&D expenditures; VAT tax base deductions for R&D and innovation activities; VAT deductions for publicly funded R&D projects; accelerated depreciation of research equipment, etc. Relatively new general-purpose indirect support mechanisms include the "tax manoeuvre" (benefits) for IT companies, and for intellectual property commercialisation. These measures are intended for a wide range of potential beneficiaries. Russia also has specific tax regimes for particular "players" (residents of special economic zones, S&T centres, and the Skolkovo Innovation Centre).

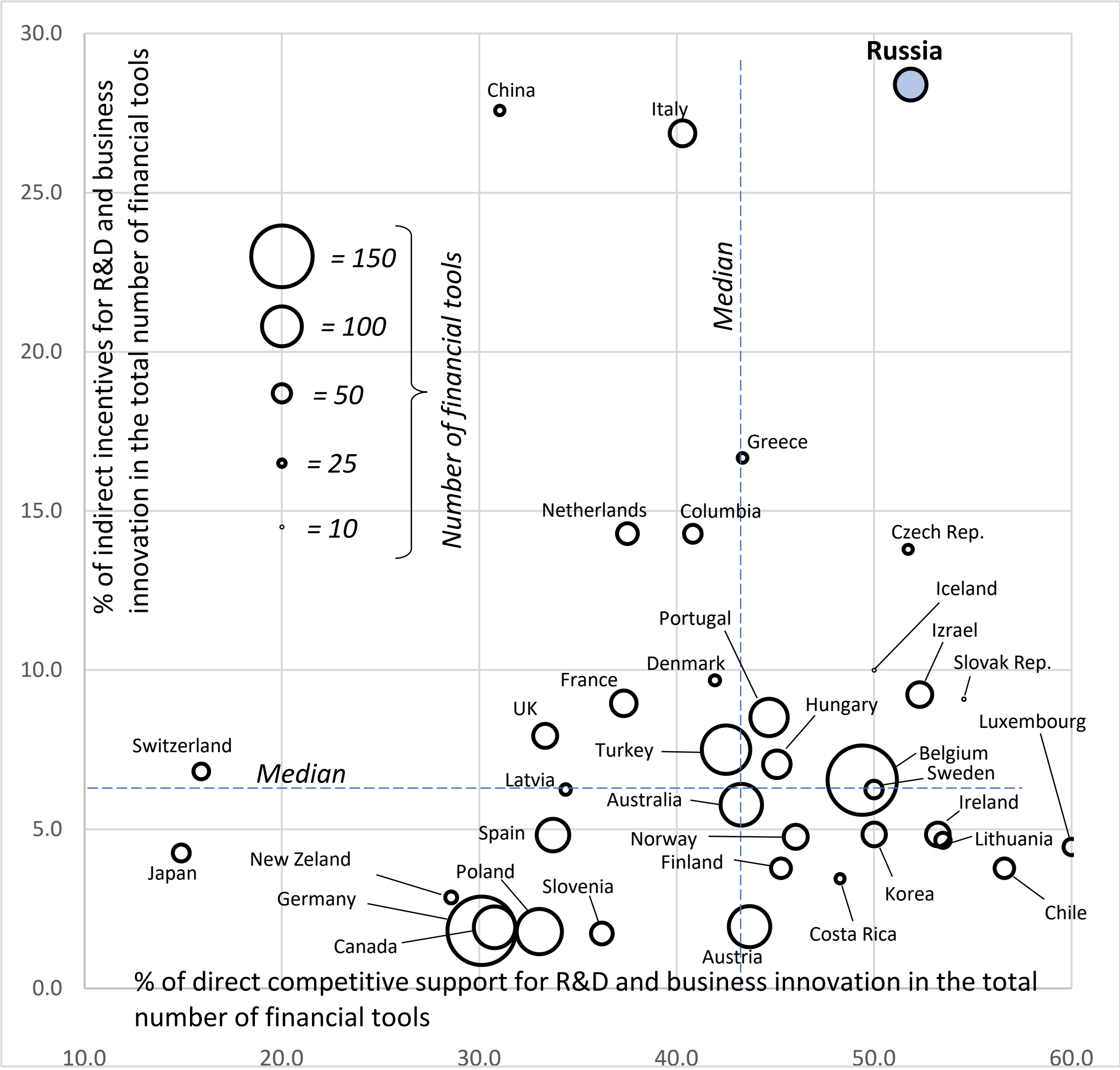

Figure 8. Use of direct and indirect financial support for companies' R&D and innovation in selected countries (2022 or closest year for which data is available)

Source: authors, based on STIP Compass data.

Tax incentives for organisations are also commonly applied by other countries. In the UK they are provided for internal, and separately for capital R&D expenditures, for SMEs conducting R&D, and for venture investors. In France a multi-component system of tax incentives for R&D and innovation activities is applied ("CIR-CIR", "CIR-CII", "CIR-CIC").[18] Turkey uses seven tax incentives for R&D and innovation, including special tax incentives zones. However, relatively few countries apart from Russia apply special tax regimes for specific organisations or territories.

[18] Official websites of government agencies: UK (https://www.gov.uk/guidance/corporation-tax-research-and-development-tax-relief-for-large-companies; https://www.gov.uk/government/publications/evaluation-of-research-and-development-tax-credit; https://www.gov.uk/guidance/corporation-tax-research-and-development-tax-relief-for-small-and-medium-sised-enterprises; https://www.gov.uk/guidance/venture-capital-schemes-raise-money-by-offering-tax-reliefs-to-investors); France (https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000018035690/2008-02-18; https://www.legifrance.gouv.fr/loda/id/JORFTEXT000028387221; https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000043682643).

Debt guaranty and risk sharing tools are also used increasingly often. They were most actively implemented during the acute crisis caused by the Covid-19 pandemic, but successful relevant experience goes back to the global crisis of 2008. In Russia, bankruptcy and audit moratoriums should be mentioned in this regard, along with support for backbone enterprises and entire economic sectors most affected by Covid-19. Outside the pandemic context, guarantees and collateral provided by the SME Corporation and VEB.RF are sufficiently popular. Internationally, the example of Belgium seems to be very interesting, where investment companies such as finance&invest.brussels, the Flemish Participation Company, PMV, and SOWALFIN implement programmes in this format. Similar tools are also applied in Denmark, Israel, Italy, the Netherlands, and Sweden.[19]

Finally, another group of tools to indirectly promote R&D known in many countries is tax incentives for individuals who support (invest in, or donate to) organisations engaged in R&D and innovation. E.g. Italy issues so-called "investor visas"; Norway applies tax deductions for individuals who donate funds to conduct R&D; Turkey offers tax deductions for business angels.[20] In Russia this effective mechanism is just emerging.

Generally, the Russian practice of using indirect support measures seems to have very good prospects. It is very diverse, and developed even higher than in many OECD countries. The shortcomings include closed nature of many such initiatives (they are inaccessible for many nominally eligible potential beneficiaries), they are not always obviously connected with the activity being encouraged, and procedures for obtaining and using the benefits are often complicated.

Conclusion

The review presented a variety of mechanisms related to financial impact the state makes on organisations conducting R&D. The compact scheme applied by the authors to analyse the financial toolsets allowed to systemically examine and evaluate various international practices.

Funding mechanisms are not only the main state policy format in the scope of modern S&T systems, but also key toolsets for exerting the state's influence in a knowledge-based economy in general. According to STIP Compass, in sixty countries of the world exactly 50% of measures

[19] Official websites of companies: https://www.finance.brussels/nl; https://www.vlaanderen.be/organisaties/administratieve-diensten-van-de-vlaamse-overheid/beleidsdomein-economie-wetenschap-en-innovatie/vlaamse-participatiemaatschappij; https://www.sowalfin.be/financement/garantie-sowalfin.

[20] Official websites of ministries and other government agencies: Italy (https://investorvisa.mise.gov.it/index.php/it); Norway (https://www.skatteetaten.no/en/person/taxes/tax-return/find-item/3/3/7); Turkey (https://ms.hmb.gov.tr/uploads/2020/03/Bireysel-Kat%C4%B1l%C4%B1m-Sermayesi-Hakk%C4%B1nda-Y%C3%B6netmelik.pdf).

they take in the field of science and innovation (6.7 thousand policy initiatives in total) involve the use of funding tools of the kinds described in this review. In fact, information on each of them can be extracted and analysed individually. At the same time there is no clear boundary delineating, e.g., R&D and innovation activities, or R&D organisations and enterprises conducting R&D. Moreover, the measures themselves can be combined, or seen as belonging to different types or regulation formats at the same time (including non-financial ones).

A review of the financial levers for the state's interaction with R&D organisations is only part of a complex picture that cannot be considered complete without examining the feedback (evaluation tools), measures to support and promote R&D personnel, and in the future also other aspects (such as providing relevant materials and equipment, maintaining and developing infrastructure, communication channels and networks, etc.).

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