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Technology foresight in Russia in historical evolutionary perspective☆

Leonid Gokhberg, Alexander Sokolov *

National Research University Higher School of Economics, Russian Federation, 20, Myasnitskaya Str., 101000 Moscow, Russia

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ABSTRACT

The paper aims to analyse the evolution of forward-looking activities in Russia vis-à-vis science, technology and innovation policy challenges and its development over the last century, with a particular focus on the period of transition to a market economy. With the development of more complex and elaborate policy instruments, demand for a better grounded long-term vision of social and economic trends has been growing both among policy makers and the S&T community. The study illustrates the emergence of technology foresight in Russia and its evolution along relevant stages of economic development, from an information source for S&T and innovation policy towards a fully-fledged anticipatory policy instrument.

1. Introduction

Forward-looking activities and technology foresight[1] in particular emerged initially as an attempt to identify future developments of science and technology (S&T). The first large-scale national S&T foresight studies conducted in Japan, and 15–20 years later in the US, Germany, and UK, were intended to better inform design and implementation of national S&T policies. Later, as S&T and innovation came to play a greater role in social and economic development, S&T policy became more complex and systemic. An upsurge of studies of national innovation systems (NIS)[2] have created a solid foundation for designing more elaborate policy tools, which require more substantial information not only about an existing situation but also future trends in the field of S&T. Traditional statistical, bibliometric and patent indicators reflecting the existing state-of-the-art had to be complemented with evidence-based insights concerning future challenges and opportunities.

When analysing the emergence and development of forward-looking activities in a particular country, it is important to take into account the relevant institutional settings (evolved over time) related to economic development, knowledge production, and distribution. This is because historical transformation of a NIS covers production structure, technology and institutions (Lundvall, 2005).

During the last few decades, foresight and S&T policies have been developing in tandem. The evolution of foresight can be considered as a process of institutional learning. Whereas at the initial stage it was driven mainly by the internal dynamics of technology (the first generation of foresight, see Georghiou et al., 2008, p. 15), over time it has been paying more attention to markets and the social dimension. The policy mix concept (OECD, 2010) aimed at a better coordination between different government agencies also influenced foresight programmes, which are more frequently coordinated by several sponsor agencies and more deeply integrated with strategic decision making. The structure, focus and design of national technology foresight studies vary significantly from one country to another. They are related both to the local context and, on the other hand, to the country's position on the "learning curve" with respect to S&T policy and foresight capacities. Different nations have to learn from each other, both in terms of policy design and allied foresight methodologies. "The learning economy is neither a pure market economy nor a pure planned economy; it is a mixed economy, in the fundamental sense of the term" (Lundvall and Johnson, 1994, p. 33). Therefore a comparison of knowledge production processes, modes of government intervention, and relevant anticipatory activities related to priority setting both in the free market and in the centrally planned economy might help to better understand the evolution of foresight activities.

During the last century, the theoretical approaches to technology-related forward-looking activities and practices of long-term strategic

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* Corresponding author.
E-mail address: sokolov@hse.ru (A. Sokolov).

[1] In this paper, we will consider technology foresight as: *"the process involved in systematically attempting to look into the longer term future of science, technology, the economy, and society with the aim of identifying areas of strategic research and the emerging new technologies likely to yield the greatest economic and social benefits"* (Martin, 1995).

[2] The concept of NIS first appeared in the 1980s and then widely diffused (see Freeman, 1987; Lundvall, 1992; Nelson, 1993). It focuses on the role of innovation activities (of different types) and learning processes in economic progress and takes into account organisational, social and political factors developing over time. Institutions are considered as a key component of the NIS; institutional learning is seen as a driver of knowledge production and distribution (Edquist, 2006).

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planning in Russia passed through several stages, which largely depended on the macroeconomic environment and institutional framework. The paper covers the period of 1921–2009, which we subdivide into the following historical phases related to particular features of national development:

- Catching up (1920s–1930s);
- Threat thinking (1940s–1960s);
- Stagnation and the crisis of the Soviet system (1970s–1980s);
- Strategic reforms and opportunity-thinking: towards innovation development (1990s–2000s).

Such a subdivision is related to the major economic and political problems facing the country and to the global evolution of knowledge production modes. According to Jamison (2003), knowledge production modes globally can be described as follows: "Little Science" (before World War II) dealing mostly with disciplinary type of knowledge (such as physics or chemistry) produced by academic research groups; "Big Science" (1940s–1960s) addressing wider multidisciplinary fields (like nuclear energy or space research) and based at large research institutions with much more engagement of national bureaucratic authorities in priority setting; and "Technoscience" (1970s–nowadays) with much more transdisciplinary studies aimed at commercial and entrepreneurial-driven applications and performed within both research labs and ad-hoc research networks.

The paper presents a brief overview of the emergence and evolution of forward-looking activities along with S&T development in the Soviet Union. The period of transition to a market economy during 1991–2009 is addressed with an in-depth analysis of the longer-term strategies based on solid expertise, using foresight as one of the instruments to enable this process. National foresight exercises are reviewed here relating to their contribution to building a more elaborate forward-looking S&T policy at the national level. Their outcomes and impact on major stakeholders of the NIS are also discussed.

The year 2009 was purposefully selected a boundary of our analysis given that the 2008–2009 economic crisis stipulated demand for a new widespread wave of foresight activities. We briefly mention some examples of post-2009 foresight at the end of the paper, but they require another detailed critical overview.

Foresight related activities in the Soviet Union and in the newly independent Russian Federation are not well known in the English-language literature. Only a handful of papers have analysed the Soviet forecasting programmes and extensive experience accumulated in this area in centrally planned economies. Most of them focused on criticism of the planned economy and were very sceptical, whereas in fact the Soviet experience contained many interesting ideas of value for the current day. Such "myopia" does not help to analyse objectively the aliens' experience.[3] In this respect, the paper could also help those interested in technology foresight studies to better understand the drivers and barriers of their evolution.

The paper is organised as follows. The first part contains a historical overview of the emergence of forward-looking activities and S&T foresight in Russia. Second, the more recent technology foresight activities in 1991–2009 are described in more detail with particular attention paid to the first large-scale national S&T foresight exercise. In the third section, new applications for forward-looking activities in Russia are discussed. Finally, the paper addresses the role of foresight under conditions of a global economic crisis.

[3] Erickson (1977) contains an example of such blinkers, where the author expressed his scepticism on the assessment of the role of "bionisation" and the use of automation and cybernetics, leading to the deliberate manipulation of "physical-chemical and biological phenomena" by Soviet futurist Grigoriy Gudozhnik. The progress of ICT and fast development of synthetic biology clearly shows who was right.

2. Long-term planning under the Soviet system

2.1. Catching-up (1920s–1930s)

It is difficult to imagine serious discussions about the future during the devastating World War I (1914–1918), October revolution (1917), and subsequent Civil War in Russia (1918–1921). Nevertheless, even in those hard times, the key role of science in industrial development was clearly understood by both researchers and the national leadership. In 1915, the famous Russian geologist Vladimir Vernadsky initiated the creation of the Commission for Study of Natural Productive Forces at the Russian Academy of Sciences, which was transformed in 1920 into the State Commission on Electrification of Russia. In 1918, Vladimir Lenin in his "Sketch of a Plan for Scientific and Technological Works" instructed the formation of expert commissions for quick development of an industrial reorganisation and economic growth plan. Lenin's idea incorporated rational territorial development and concentration of industrial enterprises with respect to the available natural resources and minimisation of losses within value added chains, electrification of industry, and transport (Lenin, 1974).

After the Civil War, Russian authorities attempted to introduce elements of the market economy to the centralised administrative policy of war communism. They were limited to fixed taxes for peasant farms, the introduction of gold-based currency, and the development of private small and medium size businesses in trade and manufacturing. In contrast, large enterprises continued to be under state ownership.

During the wars, the country faced economic decline, financial destabilisation, and disintegration of the political regime, which all had a profound negative impact on Russian science. To provide a basis for defence and accelerated industrial development, the government initiated a large-scale programme of building a network of academic and applied research institutes. In 1918–1927, some 800 such institutes were established, whereas in 1913 their number was 298 (Gokhberg, 2003).

This period was marked by the first attempts to establish a longer-term planning system with particular attention paid to technologies as one of the key elements of economic development. Nikolay Kondratiev devoted great efforts to the study of economic conjuncture cycles based on the analysis of large statistical datasets. He developed the theory of long waves in economic dynamics (Kondratieff, 1984).[4] Later, in 1926–1927, Kondratiev developed the theory of planning in a market economy, although policy makers rejected it in the years following the New Economic Policy (NEP). He mentioned that "plans without any foresight are nothing" and they should be based on foreseeing trends and take account of their potential impacts (Kondratiev, 1993, p. 118).

The abovementioned State Commission on Electrification of Russia proposed the first state plan on the electrification of Russia (GOELRO), which had a horizon of 10 to 15 years and became the first large-scale strategic initiative in the Soviet economy. It envisaged accelerated development of the energy sector, construction of modern enterprises to create new industrial regions (such as the Kuznetsk coal basin), and building of a new transport infrastructures (railways, Volga-Don Canal, etc.). Construction of >30 new power plants meant that the production of electric energy increased seven-fold by 1931 compared to 1913 (Simchera, 2006). Technological modernisation of all sectors of the economy based on electricity was one of the plan's key elements.

The plans were so ambitious that even H.G. Wells, the British author who spoke about the necessity of "a professor of foresight" (Wells, 1932), was very sceptical about them after his discussions with Lenin on the future 10–15 years of Russia during his 1921 visit to Moscow (Wells, 1921).

In 1924, the Central Statistical Department launched a project to try to balance the national economy. It was reflected in Wassily Leontieff's

[4] Indeed, at the end of the 1990s, these ideas were further developed to include the concept of techno-economic shifts (see Perez, 2002, p. 23).

papers published in Germany and Russia in 1925 (see Leontief, 1964). These studies laid the foundation for his further work on Input-Output tables, which – when later combined with Schumpeter's theory of innovation – have been widely used in analyses of national production and innovation systems.

In anticipation of military actions in the near future, Soviet leaders needed to accelerate industrial development. The new model of economic growth was based on the full dominance of the state in all forms of economic activities, strong administration, and strict control over population. The industrialisation strategy aimed at technological catching up and independence from imports in all major sectors of the economy via the transfer of resources from the agriculture to extracting and manufacturing industries.

In 1929, the first five-year plan of economic development was approved. It continued and further detailed the abovementioned GOELRO plans and envisaged a set of actions to collectivise the agrarian sector and to transform the Soviet Union from an agrarian country to an industrially advanced nation.

The extensive development of the Soviet economy before World War II, fast growth of military production during the latter, and recovery after the war were to a large extent caused by the "exceptional high rate of national savings, stable in the long-term" (Mau and Drobyshevskaya, 2013). Focused on heavy industries, this growth (the B2B sector in modern terms) paid much less attention to consumers' needs.

The Soviet S&T mostly served the key political objectives of industrialisation and strengthening military capacities. Traditional universities, the centres of research in the pre-Soviet era, were transformed into "plants" for the training of "proletarian specialists", particularly engineers. At the same time, research and development (R&D) became increasingly concentrated in research institutes of the Academy of Sciences and sectoral applied research institutes. Employment in science grew very fast: from 35,000 in 1922 to 362,000 in 1940, and 714,000 in 1950. This increase was largely due to the growth of military R&D (Gokhberg et al., 1997, p. 10).

The organisation of the R&D sector followed the economy and was oriented towards needs of industrialisation. In this period, the major types of research institutions (central research institutes, sectoral institutes, enterprise S&T laboratories, agricultural stations, regional institutes, etc.) were established. Later on, they were subdivided into research, construction, design, and technological institutions. The military-oriented R&D sector was divided from the civil sector, and consisted of specialised research institutes and research units within several leading universities. Basic research was concentrated mostly in the Academy of Sciences of the USSR and to a less extent in several major universities.

At this stage, STI policy was primarily devoted to expanding a network of research institutions able to provide S&T support to the fast growing and extensive basic industries. Therefore, forward-looking activities were focused on the planned trajectories of military and industrial development and targeted accumulation of knowledge promising the rapid return of investment in those areas. At the same time, some efforts were made to develop the theoretical foundations of forecasting (rather than foresight) in the administrative planned economy.

2.2. Threat-thinking (1940s–1960s)

World War II and consequent Cold War gave another impetus to accelerating military threats for the Soviet Union. These threats were of a much bigger concern, especially after the bombing of Hiroshima and Nagasaki. S&T had become one of the most important sources of innovation-based industrial growth and military power. At the same time, new military-oriented, large-scale endeavours required integration and careful long-term planning of research activities. These years were marked by great successes of the USSR in military-oriented multidisciplinary areas of "Big Science", namely in the fields of nuclear energy and space research. For such reasons, the State Committee for Science and Technology was established in 1946 as a central government agency responsible for S&T planning and coordination across sectoral ministries. This Committee later played an important role in pursuing future-oriented programmes.

Nuclear related studies started back in the 1920s and the first cyclotron in Europe was built in the Radium Institute (in Leningrad) in 1937, and systemic research to develop an atomic bomb (the so-called Uranium Project) was initiated in 1943. The Uranium Project involved dozens of research institutes and industrial enterprises. Several so-called "closed science cities" arranged around those establishments and specialised in allied R&D and production activities were erected across the country. The first nuclear reactor in Russia started in 1946, while the first testing of the nuclear bomb took place in September 1949.[5]

Another case of a large-scale S&T initiative was the Space Project. In May 1946, a decree on establishing Special Committee on Jet Technology at the USSR Council of Ministers was issued. The underlying R&D in this sector was launched in the 1930s by a research group studying jet motion. This group was later reorganised into the Jet Research Institute. The first rockets able to carry up to 3 tons up to 1200 km were tested in 1948; by 1953, they were already able to carry nuclear bombs to a distance of 6000 km. In September 1953, the first space-related project started, devoted to the creation of the first artificial Earth satellite. This was successfully launched in 1957. Another monumental step was launching the first man in space in 1961.[6]

Both these projects had demonstrated the efficient management of large-scale research projects performed in a very limited time span. They were carefully planned and used many methods that are widely applied in foresight studies today.

The threat-thinking approach turned out to be effective in the framework of an administrative system for thorough planning of necessary activities aimed at resolving clearly stated large-scale problems in the medium and long term. Nevertheless, being ideologically predetermined it did not allow promoting more uncertain newly emerging technology areas. Such approach was strongly influenced by ideological biases, when the "future" was considered in the light of the dominating Communist Party doctrines as opposed to "speculations" (see Erickson, 1977). Among the fields "missed" by Russian science were crucially important areas such as biotechnology and computer science. The case of genetics where Russian scientists were initially among the global leaders can illustrate the development of ideology-driven S&T policies in the USSR. In the late 1930s, a political campaign against genetics scientists was launched. Several leading scientists were arrested and died in jails. Research was stopped and resumed only in the early 1960s. A similar case took place in the early 1950s when cybernetics was claimed as a "reactionary false science", which had a profound impact on causing Russia to lag behind in computer sciences and information and communication technologies (ICT).

Nevertheless, in the 1950s–1960s, the Soviet R&D sector continued to expand – although more in employment (which saw an increase from 362,000 in 1940 to 714,000 researchers in 1950) than in state-of-the-art equipment and research facilities. The sector was strongly focused on military research, whereas the gap between R&D and civil industry was growing.

With the vital need to move from extensive economic growth to intensification of production and innovation, the centrally planned administrative economy started to slow down. This deceleration occurred because the economic actors controlled by the government agencies were primarily interested in fulfilling their production plans (and accordingly, in minimising the planned target indicators) than in taking account of customers' needs.

[5] For details of the Uranium project history (see Kelly, 1988).

[6] For details of the Soviet Space Programme (see Glushko, 1973).

This led to intense debates among economists, in particular after the 20th Forum of the Communist Party in 1956 that allowed greater freedom of discussions. The debates centred on how to optimise planning of manufacturing activities and economic development in general. In this connection the first research labs for economic-mathematic methods were established in Novosibirsk and Leningrad (headed by Vasily Nemchinov and Leonid Kantorovich, respectively). In 1963, the Central Economic and Mathematical Institute was set up in Moscow. Overall, the Soviet school of modelling and planning of socialist economy consisted of several hundred scientists. Their studies were largely focused on computer-aided optimisation of economic plans on the basis of Input-Output tables. The mathematical models behind this research could be used for a wide range of economic applications. Some took into account technology-related parameters. In 1975, L. Kantorovich received the Nobel prize in economics for his contribution to the theory of optimal allocation of resources.[7]

In the 1960s, Genrikh Altshuller launched his research on the theory of resolving invention tasks devoted to the analysis of technological systems, commonly known as TRIZ (Altshuller, 1998). Altshuller's research was later widely used in various S&T foresight related activities.

2.3. Stagnation and the crisis of the Soviet system (1970s–1980s)

After the oil crisis of the early 1970s, developed market economies paid more attention to both funding S&T and elaborating new instruments of S&T policies to find ways to respond to emerging challenges. Overall gross expenditure on R&D (GERD) in developed countries grew from USD 97.2 billion in 1973 to USD 189.6 billion in 1980 (Arond and Bell, 2010, p. 29). Relevant policy measures provided a foundation for technology- and innovation-based intensive economic growth. A substantial focus on transdisciplinary studies aimed at commercial and entrepreneurial-driven applications required new more diverse forms of "Technoscience" research. On top of existing labs in R&D institutions and universities, ad-hoc research networks increasingly emerged.

At the same time, due to its rigidity, the Soviet economic and political system was unable to introduce adequate institutional changes to overcome resistance to innovation, and the country lagged behind developed nations with steadily declining growth rates. A resolution entitled "Means of increasing the effectiveness of academic organisations and means of speeding up the applications of S&T advancement to the national economy" adopted by the Soviet authorities in 1968 envisaged the drafting of long-term forecasts (for a 10 to 15 year horizon) for "the most important problems" of the national economy (Bestuzhev-Lada, 1986).

Russian economists clearly understood the necessity to promote S&T under transition from extensive growth of production to intensive development: "The bigger is the gap between the demand and existing capacities, the bigger is the load on S&T" (Anchishkin, 1989, p. 336). Extensive discussions of the role of S&T in economic progress, which started in the late 1970s, laid the foundation for the first large-scale attempts to forecast S&T development at the national level. The national forecast was considered as a system of studies covering particular technological processes and production methods, which envisaged identifying and assessing the following issues (ibid, p. 337):

- main S&T shifts during the last decades;
- technologies that are already developed but yet to be implemented;
- science results to be developed into new technologies;
- potential results of research that require significant funding;
- potential areas of basic research (with unclear results) that require significant funding.

Being incapable of making a transition from extensive industrialisation based on large production enterprises to an intensive, innovation-driven growth, the Russian authorities tried to capitalise on existing S&T capacities to make the centrally administered planned economy more efficient.

The Complex Progamme of Scientific and Technological Progress (CPSTP) for the period of 1991–2010 (published in 1988) included recommendations on: the dynamics, structure, and utilisation of national S&T and education capacities; proposals for structural policies in S&T and allocation of relevant human, physical, and financial resources; and background materials for the identification of economic, organisational, and other measures needed for S&T development. The Programme focused on the areas with the largest gaps between economic demand and S&T supply. Bridging those gaps was a mission of targeted S&T programmes designed to address key S&T related problems and justify their importance, as well as to identify parameters of prospective technology shifts, requirements for R&D, an assessment of the time needed to implement them and their expected effects, and finally, to propose recommendations on relevant financial and organisational measures.

The developments forecasted in the CPSTP were never realised. They were not even taken seriously into consideration by the then existing system of allocating resources for internationally recognized R&D areas as ICT, biotechnology, medicine, and broader life sciences. R&D institutions did not have modern equipment; by 1990, 60% of them were not supplied with their own buildings (Gokhberg et al., 1997). Nevertheless, the whole exercise provided a significant contribution to the forward-looking activities in Russia both organizationally and methodologically.

The Soviet school of forecasting used most of the methods applied by their Western colleagues, including such procedures as PATTERN, PERT, PROFILE, FAME, and SCORE. These quantitative models were applied together with a wide variety of expert methods in combination with quantitative models (Randolph, 1976; Erickson, 1977). This period was also notable for the elaboration of different forecasting mathematical models. One of the most widely discussed models examined the "Nuclear Winter" consequences of the global nuclear war (Moiseev, 1988).

3. From long-term planning to technology foresight

3.1. Transition to a market economy (1990s)

Russia's transition to a market economy was a long and harmful process. After the disintegration of the USSR, the country has faced numerous challenges – the economic crisis of the early 1990s, radical changes of basic institutions, privatisation, the default of 1998, acute demographic problems – this list is far from complete. At the very beginning of the reform process, there was a hope that most of the problems would be resolved automatically by the "invisible hand of the market" but this did not happen. In fact, it soon became apparent that the creation of a modern market system required deep transformation of the whole society as a long, complicated and sometimes contradictory process, influenced by multiple factors that interconnected the new and old systems.

In parallel to this transition process, the Russian NIS also underwent substantial transformations. The centrally-controlled organisational structure was completely reshaped after the privatisation in the early 1990s, and there was a clear need to build brand new S&T and innovation policies that would meet the new free market environment. The market itself – without a balanced policy – was unable to transform the system. A world-class stock of scientific knowledge was fast

[7] For details of his works see "Mathematics and Economics of Kantorovich" (http://www.math.nsc.ru/LBRT/g2/english/ssk/lvk100_e.html).

deteriorating without an efficient system of organisations and institutions capable of transforming it into commercial products and services.

The key trends during the first years of the transition period included the following:

- Decline of the centrally-planned economy system at the end of the 1980s–early 1990s led to an acute consumption crisis and destruction of established economic links.
- In the first half of the 1990s, low oil and gas prices combined with huge social responsibilities of the state led to a collapse of high-tech enterprises and applied R&D infrastructures related to heavy industries and the defence sector. This resulted in a drastic decline of GDP and shifted the economy towards extracting sectors.
- The development of the private sector was negatively affected by the dominance of an emerging oligarchic capitalism.
- Instability of the overall economic environment and newly-established institutions, shaken additionally by the financial crises of 1994 and 1998, made long-term investment very risky.

Under condition of an abrupt drop in R&D funding,[8] S&T policy was aimed at preserving the Russian S&T sector. The government had to react more to the immediate transition shocks rather than pursue proactive policies. In that period, there were very few activities related to the future of S&T. One of those attempts was a survey in 1991 of leading members of the Russian Academy of Sciences, which resulted in identifying 80 prospective research areas.

In 1994, the first solid efforts occurred to identify national S&T priorities as a basis for making decisions on concentrating public resources in the most important areas and on implementing the available S&T potential (Nikolaev, 1995). In 1996, eight Priority Areas for S&T Development and a list of 70 Critical Technologies of Federal Importance were formally approved by the Government Commission on Science and Technology Policy.

In 1999, a list of S&T priorities was submitted to a large-scale examination by >1000 leading national experts. Their analysis revealed that (i) Russia had largely slipped from the forefront of many applied research areas; (ii) the NIS was in a poor state; and (iii) there was a low demand for research results. The country still maintained strong positions in some areas of basic research and applications that were relevant for the energy sector or defence, such as space research and nuclear power engineering, as well as in some industrial technologies that either had no sufficient market prospects (for instance, pipelines for transporting liquid coal suspension) or were country-specific (e.g., open-pit uranium mining). In the rapidly progressing fields with the greatest demand for research outcomes (ICT, biotechnologies, etc.) Russian science turned out to be much weaker.

The abovementioned study stressed an urgent need to reconsider the system of S&T priorities, concentrating on a small number of “breakthrough” areas. In 2000–2001, revised lists of nine S&T priority areas and 52 critical technologies were developed (see Sokolov, 2007). These revised lists aimed to reduce the number of priority areas in order to concentrate resources in the most important fields of innovation. The updated list was then approved by the President of Russia in 2002.

The formal priorities covered most economic sectors and did not emphasise particular key promising areas. Furthermore, there were no mechanisms behind them to ensure greater prioritisation of budget R&D funding on breakthrough S&T objectives and to encourage networking between R&D and industrial enterprises.

[8] Russian GERD in 1994 was only 23.1% of that in 1990 in real terms (Gokhberg et al., 1997, p. 21).

3.2. Opportunity-thinking: towards innovation development (2000s)

After the financial crash of 1998, depreciation of the national currency created favourable conditions for domestic producers. Increased oil and gas prices enabled a rapid growth of financial resources for investment in the most profitable sectors and led to a stable annual GDP growth of 6–7%. As a result, since the early 2000s, the domestic market for consumption goods has boomed, while substantial growth in public income stimulated a state interventionist policy, for example in establishing and funding earmarked development institutions to help modernise the NIS. On that basis, the first important strategic decisions were outlined for the future of S&T.

With the steady economic growth of the early 2000s, the Government initiated activities aimed at innovation based development in the longer-term. This period saw the first attempts to design strategies of S&T and innovation (such as the “Strategy of Science and Innovation Development until 2015” issued by the Ministry of Education and Science and a number of innovation-targeting sectoral and regional strategies). In 2002, the document “Basic Policies of the Russian Federation in the Sphere of Scientific and Technological Development up to 2010” was approved. It became an important element of the national socioeconomic strategy, with its goals of innovation-based economic growth, creation of an effective NIS, and making S&T progress one of the major national objectives. This period was characterised by government initiatives that aimed to support a transition towards a knowledge-intensive economy, increasing the efficiency of innovation and support to the best performers.

The implementation of the “Basic Policies” implied that all decisions relating to the support of S&T, the allocation of budget funds, and targeted stimulation of research and innovation should be founded on the defined S&T priorities. The document called for a regular review of S&T priorities in line with the goals set out in the broader governmental programmes of medium- and long-term socioeconomic development, while the S&T priorities and critical technologies themselves should be lined up to form “technological corridors” leading from research to technology commercialisation and manufacturing competitive products.

This approach reflected efforts to concentrate budget funding on the key S&T areas but the new list of priorities – although shorter than the previous one – included almost all areas of S&T (due to strong lobbying efforts by specific interest groups during the process of its formulation and negotiation). It simply could not be implemented in central and regional governments' practices as an instrument for efficient budget allocations and had to be revised again.

Against this background, a demand for new types of S&T policy instruments, and foresight in particular, to design proactive strategies emerged. The first step was to revise the S&T priorities with respect to national socioeconomic objectives. It was initiated by the President and sponsored by the Ministry of Education and Science. The revised list of critical technologies was based on a series of expert panels and broad consultations with all relevant stakeholders – government agencies, academies of sciences, businesses, the major research institutes, and universities (Sokolov, 2007). The subsequent list of S&T priorities – approved by the President of Russia in 2006 – was applied as a basis for revisiting the governmental S&T programme and for initiating a set of large-scale innovation projects (with the participation of private companies). As a follow-up to this initiative, it was decided to revise the lists of S&T priorities and critical technologies on a regular basis (every four years).

Given Russia's gradual change towards an intensifies economic development model, with its goal of increased competitiveness and diversification of the national economy on the basis of high technology penetration, the revision of S&T priorities had a practical purpose: to correlate the updated lists of priorities and critical technologies with industry's needs so that they could provide a basis for managerial decisions on intensification of innovation activities, practical implementation of the advanced research achievements and concentration of public R&D funding on the most important S&T areas. Critical technologies were selected for a 10-year horizon (up to 2015) of their economic application, with a particular focus on those nearest to the practical implementation stage.

In order to overcome factors hindering GDP growth and discontinuing the present dependence on energy and raw materials as the pillars of the national economy, the following two main criteria for revising the lists of S&T priorities and critical technologies were determined:

- contribution to accelerating GDP growth and enhancing competitiveness of the national economy on both traditional and emerging markets;
- capacity for enhancing national security and technological safety.

In selecting the critical technologies, it was decided to restrict their number to a relevant minimum due to the need to concentrate resources. Thus it would be made feasible to provide sufficient budget funding for each of the critical technologies through the federal goal-oriented programme "Research and Development in Priority Science and Technology Areas".

Each critical technology was accompanied with a set of recommended measures for obtaining necessary research outcomes and their further implementation. The evaluation of the priorities was organised as a series of surveys and expert panels with the participation of all interested government agencies, leading scientists, and experts from industrial companies.

The list of critical technologies also underwent major changes. It was reduced from 52 to 34 items and had become more focused both in terms of the score of technologies and in their substance. Finally, as a result of a multi-stage discussion process, revised lists of S&T priorities and critical technologies were established that contained areas enabling competitive capacity and fast growth of manufacturing in certain groups of technology-intensive products to be attained. Moreover, these revised lists paved the way for S&T outputs including a broad range of innovations intended for different economic sectors. Critical technologies were also instrumental in providing national defence and technological security.

The formal list of S&T priorities included the following areas:

- Information and Telecommunications Systems;
- Nanotechnologies and New Materials;
- Living Systems;
- Rational Use of Natural Resources;
- Power Engineering and Energy Saving;
- Transport, Aviation and Space Systems.

Although this list covered a broad range of technological fields and their application areas, the key outcome of the process was the identification of new product and service groups as well as allied technologies needed for their competitive production in Russia in the next 5–10 years. These groups included only products and services capable of providing the greatest contributions to GDP growth owing to their high competitive potential on domestic and foreign markets and significant production volumes.

The list of critical technologies (and of relevant innovative products) had multiple effects. The Ministry of Education and Science implemented it in initiating applied research in relevant priority S&T areas and for launching large-scale innovation projects with domestic high-tech companies (on the basis of matching funds). For companies, it also indicated that particular product groups and technology clusters could be a subject for public support in the future. To promote innovation, the government issued a special statement providing tax incentives for R&D aimed at the development of key technologies to be used for manufacturing of the abovementioned products.

During the 2000s, patterns of economic development changed considerably. Macroeconomic stabilisation (e.g. inflation rate below 10%, strengthening of the national currency, more transparent government economic policy) since the mid-2000s fostered foreign direct investment and technology-based projects in different industries and technological cooperation with foreign-based multinationals (Sokolov and Rudnik, 2014). However, growing companies' innovation expenditures were predominantly focused on purchasing new equipment and turnkey technology solutions, whereas businesses' investment in R&D was marginal with few exceptions. For similar reasons, organisational structure of R&D has not changed significantly since the Soviet times, neither in terms of a typology of its units, nor in terms of their ownership (Gokhberg et al., 1997; Gokhberg, 2003). The R&D sector remains dominated by the government-owned former branch R&D organisations and Academy of Sciences' research institutes while universities and industrial enterprises are still minor R&D players (Fig. 1).

After several years of steady economic growth (still owing to high oil and gas prices), discussions about the long-term prospects of the Russian economy had become more intensive. The general consensus among key stakeholders was that the only way of achieving sustainable growth involved a shift from a resource-based economy towards a knowledge-intensive one. The increasing investment in R&D by the government (in 2000–2007, GERD in constant prices had grown by 68%) did not reflect in any substantial change in innovation. The effect of S&T priority setting was rather limited because most enterprises still preferred to buy ready-available technologies mostly embodied in production equipment rather than invest in R&D. The majority of enterprises could survive without innovating since they were predominantly oriented towards local markets notable for poor competition. Therefore the gap between R&D and innovation continued to be a serious concern.

In 2006, the Ministry of Education and Science initiated a foresight programme to create a solid foundation for future-oriented S&T and innovation policies. The goals of the programme were to identify key areas of research that can bring the most substantial benefits in the longer term, to assess potential demand for innovation, and to understand which policy instruments could be most relevant to promote innovation activities. The time horizon for the programme was 2025. It covered a macroeconomic forecast, S&T Delphi, and assessment of market demand for new technologies.

The macroeconomic component of the 2025 foresight programme aimed to analyse the major global and national macroeconomic trends and the anticipated limitations and opportunities envisaged for the future, as well as to assess the potential social and economic demand for new technologies with respect to the macroeconomic challenges (Apokin and Belousov, 2009). The study was largely intended to contribute to an S&T component of the governmental Concept of Long-term Social and Economic Development of the Russian Federation up to 2020 (adopted in 2008). The foresight for economic sectors covered basic manufacturing industries, transport, energy, and extraction of mineral resources.

The S&T Delphi study was proposed as a central element of the national foresight exercise.[9] It referred to future technology trends and challenges, and global market prospects. Identification of prospective S&T areas promoting economic growth stemming from emerging markets and products was expected to contribute to making the NIS more efficient via better grounded distribution of government R&D funding and promotion of business investment in S&T and innovation. The study addressed the key issues of S&T and innovation policies: quality of research, innovation prospects, and human resources.

The Delphi survey was closely inter-related with the macroeconomic and sectoral studies. The revealed macroeconomic trends and challenges were used to help identify and select the Delphi topics. The

[9] For detailed analysis of the Delphi results (see Sokolov, 2009).

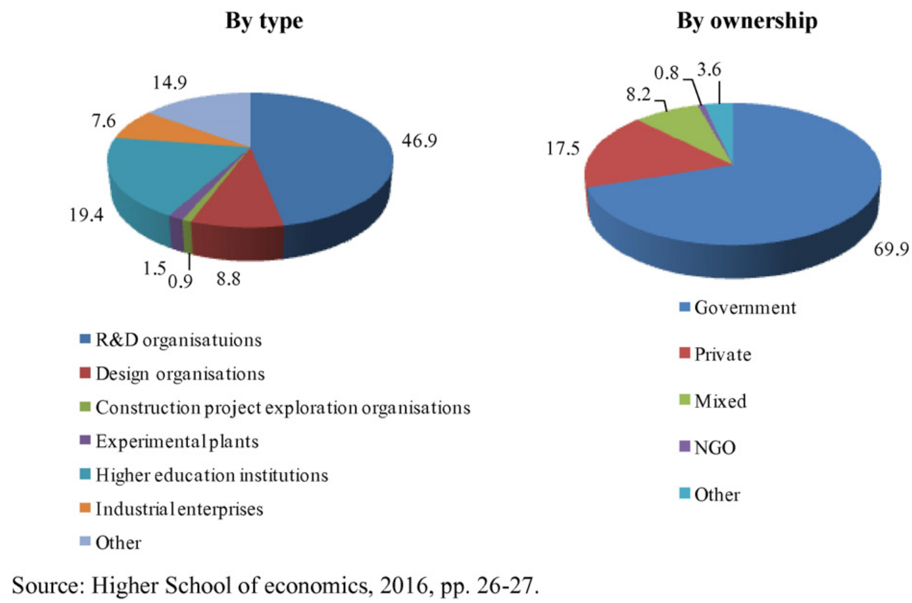

Fig. 1. Organisations performing R&D in Russia: 2014 (%).
Source: Higher School of economics, 2016, pp. 26–27.

Delphi results also served for follow-up surveys to assess the mid-term technology strategies of Russian companies.

The Delphi covered the following thematic areas:

- Information and Telecommunication Systems;
- Nanotechnologies and New Materials;
- Living Systems;
- Medicine and Health;
- Rational Use of Natural Resources;
- Transportation, Aviation and Space Systems;
- Power Engineering and Energy Saving;
- Manufacturing Systems.

They were deliberately correlated with the National S&T Priority areas. Each of them consisted of five to seven second-level specific technology areas and 80–100 detailed S&T topics. Technology areas also partly corresponded to the Critical Technologies. It gave an opportunity to compare mid- and long-term prospects for most technology fields and – based on the Delphi results – to develop a proposal for modifying national S&T priorities.

In total, approximately 900 S&T topics were covered. The preliminary selection of the topics was grounded on interviews with leading Russian experts who assessed the relevance of each topic to the following issues:

- human potential and quality of labour resources;
- economic development;
- institutional development;
- environment and safety.

The Delphi questionnaire was designed in line with similar exercises earlier implemented in Japan (NISTEP, 2005a, 2005b), Germany (Cuhls

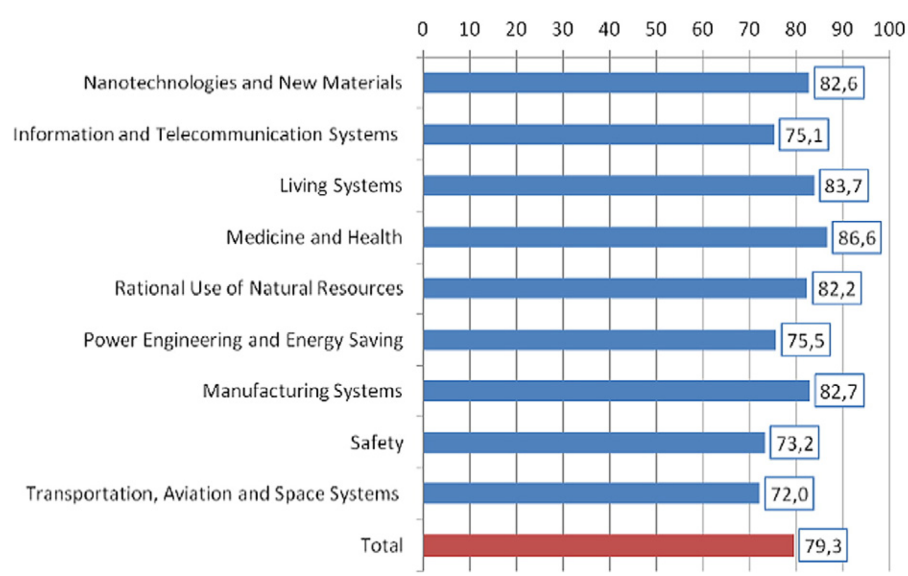

Fig. 2. Russian Delphi-2025. Index of importance by S&T area (% of respondents who assessed S&T topics as 'highly important').
Source: Authors' estimates based on the results of the Russian Delphi-2025 study.

and Blind, 1999) and the UK (Loveridge et al., 1995), and, at the same time, took account of policy issues specific to Russia. For each topic, experts assessed its importance, time of R&D realisation and commercial application, country's positions vis-à-vis the world leaders, policy measures required to support R&D and their implementation, and the expected impacts on the economy and society.

The Delphi results showed that all selected S&T thematic areas were felt to be relatively important: the latter measured as the average share of experts who assessed the importance of a particular topic as 'high' (Fig. 2). On average, in 80% of cases experts considered topics as important. This result can partly be explained by a thorough selection of topics and their rigorous discussions at the preliminary stage within the field-specific expert panels. The highest ranks were received by medicine and biotechnology. A much more diverse picture could be observed for particular topics, although 8 of the 10 top important topics were related to space and aviation, one to medicine, and one to safety.

The level of Russian research vis-à-vis the world leaders was estimated much lower. For ICT, medicine, and living systems, around 50% of experts assessed domestic R&D as 'strongly lagging behind' (Fig. 3). For energy technologies, aerospace sector, and manufacturing, around 20% of experts considered the level of Russian R&D as meeting the global state-of-the art level. In general, respondents mentioned the USA as the world leader in over 90% of the topics with few exceptions for the EU and Japan.

Regarding S&T policy measures, experts perceived the most needed as those related to creating innovation infrastructures, training personnel, and stimulating business R&D and innovation expenditure.

One of the principal issues for S&T policies was how to recognise promising technology clusters for public-private partnerships. The Delphi results were subject to further analysis in the expert panels with respect to identifying the areas of practical, large-scale coordinated interventions by the government and businesses.

Certain technology fields (Table 1) were proposed as areas for initiating the so-called "most important innovation projects", an instrument based on matching funding from private companies and from the federal goal-oriented programme "Research and Development in Priority Science and Technology Areas".

Table 1
Promising technology fields.
Source: (Sokolov, 2009).

Thematic area	Promising technology fields
Information and Telecommunication Systems	Intellectual navigation and control systems Computer element base Bio-information technologies
Nanotechnologies and New Materials	Membranes and catalysts Biocompatible materials, polymers, crystals
Living Systems	Integration of bio-, nano- and information technologies Biosensors, biomedicine Cell, biocatalyst and biosynthetic technologies
Medicine and Health	Preventive medicine Optimisation of medical services
Rational Use of Natural Resources	Creation of complex information resources Forecasting and assessment of admissible use of biological resources
Energy	Energy saving systems Energy generation from organic fuels
Transportation, Aviation and Space Systems	Materials for aerospace
Safety	Fire safety Safety at transport and public areas
Manufacturing Systems	Materials for industrial production

The results of the programme were presented to the government in the fall of 2008 and extensively discussed by S&T and business communities. Among the key outcomes for a future innovation policy agenda were recommendations to increase the NIS efficiency at different stages of the innovation cycle: from supporting particular promising research fields to public-private partnerships in technology-intensive areas with a strong economic growth potential.

The impact of the 2025 foresight programme was rather high, although it was mostly limited to the scientific community. There were intense debates concerning the level of domestic R&D and its importance for the national economy. For example, a very low overall assessment of the importance of such areas as renewable energy and hydrogen energy was a subject of criticism from particular field experts.

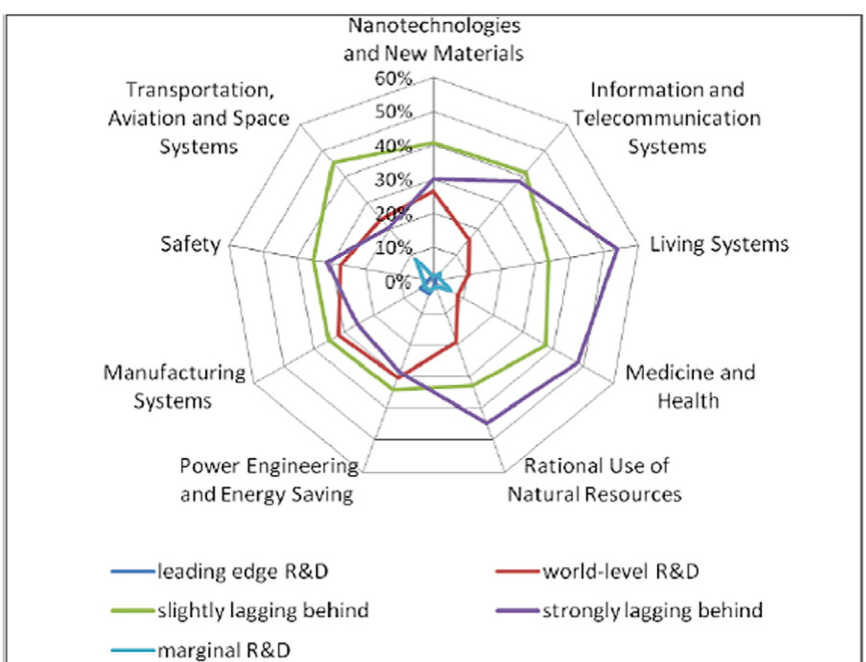

Fig. 3. Russian R&D vis-à-vis the technological frontier (% of respondents who selected one of the answers to the respective Delphi survey question).
Source: Authors' estimates based on the results of the Russian Delphi-2025 study.

Another example was underestimation of ICT. The results of the foresight were used as a pre-requisite for further revisions of the S&T priorities and critical technologies, and at a certain stage, some government officials proposed to exclude ICT from the list given Russia's relatively low positions in R&D for most ICT fields compared the world state-of-the-art level. The S&T community and experts from the relevant industry sectors strongly opposed this point of view and, in the end, ICT was kept on the list of priorities.

The 2025 foresight programme was criticised for relatively low industry participation. Although many companies were approached in the framework of the Delphi survey, their involvement was not very intensive which could be explained by several factors. One of those referred to a generally short-term strategy vision by industrial companies, even those R&D-intensive ones. Most Russian companies were also rather sceptical about the idea of an open discussion on technology related issues between potentially or actually competing companies, even at the pre-competitive stage. Beyond that, managerial hierarchies took its toll: representatives from large companies could often only be contacted after seeking the permission of senior managers. All these issues retained difficulties for further foresight activities.

4. New areas of foresight in Russia

A key recent trend in foresight applications in Russia is their diffusion to regional and sector-specific projects. The majority of such projects have been initiated by local authorities or particular government agencies as a means to support strategic planning. They generally take the results of national foresight studies as a starting point or otherwise are independently carried out and compared to the national level recommendations at the end.

As a foundation, certain foresight projects have used the mid-term (i.e. 5–10 year horizon) priorities presented in the list of Critical Technologies of the Russian Federation, as well as the longer-term (20 years) prospects highlighted by the national S&T foresight. These foresight activities are complemented by analyses of socioeconomic objectives and field-specific studies. The vision built on this basis identifies a number of promising production clusters. Further analysis can include scenario-building or technology roadmapping as well as other methods to identify strategic development options.

Russian regions are very heterogeneous for their socioeconomic characteristics. To date, foresight activities have mostly been performed in regions with significant S&T and industrial capacities: for example, Moscow, St. Petersburg, Krasnoyarsk, and Bashkortostan. Smaller scale activities at the local level have also emerged such as in science cities (e.g. Troitsk and Obninsk) and manufacturing centres (e.g. Cherepovets, the heart of Severstal metallurgic production). After the 2008–2009 economic crisis, these activities seem to be less intense as they are mostly funded by regional authorities, which have suffered from the economic situation.

A growing area for foresight in the forthcoming years is the corporate sector. Several moderate-scale projects for particular industries have been implemented (e.g. metallurgy, pharmaceuticals, nuclear energy, power engineering, natural resources, ICT and mass media, agriculture and food), initiated by different government agencies.[10] These projects lay the foundation for more detailed interventions by individual corporations.

One of the most interesting cases in this respect is related to the Russian corporation of nanotechnology (Rusnano), a state-owned corporation that initially considered foresight as a key instrument for priority setting (Sokolov and Karasev, 2009). Rusnano's business strategy up to 2020 pointed at the need to use roadmaps for building a vision of nanotechnology development. Rusnano commissioned a foresight project to identify key areas for long-term investment in nano-enabled products and services. It consisted of two major parts: a large-scale Delphi exercise covering over 1000 specific products with radically new nanotechnology-based components for 20 specific markets[11]; and roadmaps for specific nanoindustry market segments in Russia. The roadmaps had to reflect nanotechnology development prospects of particular product groups (e.g. carbon fibre, light-emitting diodes), whole economy sectors (spacecraft, aircraft, health and pharmaceuticals, etc.), or problem-oriented areas (energy saving, potable water purification). The results created the basis for further systematic activities linked to long-term investments taking into account alternative markets and technological solutions and ways to reduce investment risks. The roadmaps became practical instruments for sectoral strategic planning.

Later, foresight activities in Russia became more widespread and systemic. The above-mentioned national projects have been complemented with dozens of exercises at the corporate, sectoral and regional levels. Some have been focused on S&T; most, however, addressed broader issues and included S&T and innovation as one of their major foci. These activities contributed to a broader recognition of foresight as a tool of anticipatory policy design and stimulated national initiatives to institutionalise strategic planning and S&T foresight in particular. An Interministerial Commission on Technology Foresight was established in 2013. In 2014, a federal law “On Strategic Planning in the Russian Federation” was adopted. It highlights S&T foresight as one of the key forward-looking activities providing the basis for strategic planning nationally. The adoption of the law has affected promoting further foresight activities at different levels.

Table 2 aggregates an overall chronology of foresight-related activities in Russia during the last century.

5. The global economic crisis and future challenges

Innovation has recently become an oft-cited word by policy makers, experts, and the mass media in Russia. Despite some scepticism generated by such attention among professionals and despite the variety of meanings used and recommendations given, the innovation agenda seems to reflect not only a desire to follow the global trends but first of all attempts to find solutions that enable the national economy to address economic and social challenges. The economic crisis, expected to be longer and more profound in Russia than in many other countries, makes this problem even more acute although it follows a decade of the most intensive growth in Russian history (OECD, 2009a).

Economic growth in Russia between 1998 and 2008 was mostly driven by high prices for raw materials, while innovation activities stagnated at a rather low level. This can be explained by the macroeconomic conditions, market structure, and inefficient corporate governance. Moreover, the inefficiency of the NIS and inadequacy of innovation-supporting institutions also determined the poor innovation performance during that period (Gokhberg and Kuznetsova, 2011). Further prospects of dynamic and sustainable innovation-based economic growth are limited, on the one hand, by the weak capacities of Russian enterprises to absorb technological and non-technological novelties and, on the other hand, by a shortage of a critical mass of innovation projects supply that could be attractive for investors. The lack of competition aggravates the situation.

The economic crisis may have contradictory outcomes for innovation processes in the Russian economy. The inertia of the innovation

[10] See for example Giglavy et al. (2013); Shashnov and Sokolova (2013).

[11] These included food and beverages, textile and leather goods, pharmaceuticals, consumer chemicals and perfumery, computers and office equipment, lighting equipment, automobile transport, aircraft, spacecraft, power generation, water supply, heating, construction materials and equipment.

Table 2
Chronology of foresight-related events in Russia (1915–2014).
Source: Authors' analysis.

Years	Trends and events
1915	Commission for the Study of Natural Productive Forces set up at the Russian Academy of Sciences
1920	State Commission on Electrification of Russia established
1921	First state plan on the electrification of Russia (GOELRO) approved
1924	Central Statistical Department launched a programme to balance the national economy
1925–1927	Nikolay Kondratiev published works on cycles of economic conjuncture based on the theory of long waves in economic dynamics and developed a theory of planning in a market economy
1929	First 5-year plan of economic development approved
1939–1945	World War II
1943	Start of the Uranium Project
1946	Special Committee on Jet Technology at the USSR Council of Ministers established
1948	State Committee for Science and Technology established
1949	First test of the Soviet nuclear bomb
1956	20th Forum of the Communist party provided more freedom of discussions. Start of debates among economists about how to optimise planning of industry and economic development in general Genrikh Altshuller published his first work on a theory of resolving invention tasks (TRIZ) devoted to analysis of technological systems
1957	Sputnik – the first artificial Earth satellite – launched
1961	Yury Gagarin – the first man in space
1963	Central Economic and Mathematical Institute established in Moscow
1975	Leonid Kantorovich was awarded a Nobel prize in economics for his contribution to the theory of optimal allocation of resources
1978–1979	Start of extensive expert discussions on the role of S&T in economic progress
1983	The "Nuclear Winter" model developed by a group of Russian mathematicians headed by Nikita Moiseev
1988	Complex Progamme of Scientific and Technological Progress for the period of 1991–2010 published
1991	Demise of the USSR
1996	Eight Priority Areas for S&T Development and a list of 70 Critical Technologies of Federal Importance formally approved by the Government Commission on Scientific and Technological Policies
1999	First systemic assessment of the List of Critical Technologies
2002	Updated lists of 9 S&T priority areas and 52 critical technologies approved by the President of Russia
2006	"Strategy of Science and Innovation Development until 2015" issued by the Ministry of Education and Science
2006	Updated lists of S&T priorities (approved by the President of Russia) used as a basis for the federal goal-oriented S&T Programme and for initiating a set of large-scale innovation projects
2007–2008	Russian S&T Delphi – 2025
2008	The Concept of Long-Term Social and Economic Development (with an S&T Delphi-based section on the future vision of S&T) adopted by the government
2009–2010	National S&T Foresight – 2030 (the first stage)
2011	Revised lists of S&T Priorities and Critical Technologies approved by the President of Russia
2012–2013	National S&T Foresight – 2030 (the second stage)
2013	Interministerial Commission on Technology Foresight established
2014	Russian S&T Foresight 2030 approved by the Russian Prime-Minister
2014	Federal law "On Strategic Planning in the Russian Federation" adopted

system hampers change both in terms of scale and depth. The "transformation shocks" (Hart, 2009, p. 648) within the NIS (lock-in effects) have not reached yet a level to break the existing resistance to change. It can take years before exogenous economic shocks (e.g. those related to a decrease in oil prices) will make S&T and innovation an issue of "life or death" for Russian companies.

S&T and innovation may be a victim of the economic malaise given its cost, risky nature and procrastinated effects. An OECD report (OECD, 2009b, p. 5) cites the international evidence of decreasing R&D spending by companies, their shift towards less risky short-term innovation projects, shedding jobs for specialists, and decreasing venture capital investment, in particular in innovation start-ups. At the same time, Schumpeterian processes of "creative destruction" may lead business to better performance compared to incremental changes (Lam, 2006, pp. 135–136), and there is already certain evidence that the effects of "creative destruction" have intensified. Companies investing in R&D, new technologies, and business models can create new competitive edges. Efforts towards formulating new S&T and innovation strategies are also pertinent to Russia.

Can foresight contribute to overcoming the economic crisis? We believe that it can but it is imperative to pose new questions and search for new responses to those raised earlier.

The second cycle of the national S&T foresight launched in Russia by the Ministry of Education and Science and implemented in 2009–2010 was largely focused on crisis-related issues. The results obtained during the above described first cycle (2007–2008) laid the foundation for the analysis of particular S&T-intensive clusters that could provide a momentum to innovation. However, there were numerous policy issues to be addressed by foresight. They referred to a need in understanding the likely transformations of the global (and Russian) economy, new (collaborative and user-driven) ways of innovating, convergence among different technological platforms, etc. The latest national S&T Foresight – 2030 (Gokhberg, 2016; Sokolov and Chulok, 2016) also considered grand challenges, their impact on Russia's socioeconomic development, relevant markets, technologies, and prospective S&T fields. This study, together with recent sectoral foresight exercises, reflects the changing economic and institutional frameworks and employs more elaborate quantitative and qualitative methods to provide relevant information necessary for devising anticipatory S&T policies.

6. Conclusions and discussion

The emergence and evolution of forward-looking activities, as the case of Russia shows, has been closely correlated with the overall change in macroeconomic and political environment. Table 3 summarises this evolution. At the stage of accelerated industrial development that aimed to catch up with global leaders, the S&T sector evolved as an instrument producing applied results to feed the needs of fast growing industries. During that period, forward-looking exercises were focused on economic development, and S&T was considered as one of many factors in the overall process. S&T activities were mostly concentrated in research institutes and dealt with particular research fields. In the 1940s–1960s, due to political and military reasons and gradual exhaustion of resources for extensive economic growth, the need for S&T as a means for solving large-scale technology-related problems arose. This led to a more complicated S&T policy and the introduction of "Big Science" requiring establishing research facilities in complex multidisciplinary areas. Technology related forward-looking activities at this stage were focused on detailed short- and mid-term planning of large S&T projects with well identified final goals. At the same time, the lack of proper technology foresight approaches with respect to less clearly defined research fields led to substantial mistakes when emerging areas with great potential were ignored. At the macroeconomic level, a need to transition to intensive, innovation-based growth stimulated attempts to build national forecasts, although mostly based on formal economic and mathematic models.

From the 1970s, continuous needs in innovation-driven (rather than resource-based) sources of economic growth have stimulated increasing demand for more complicated R&D oriented towards commercial applications and relevant policy instruments promoting both basic sciences and transdisciplinary applied research. This "Technoscience" approach, under conditions of limited resources that could be allocated for R&D, required concentrating them on a limited spectrum of research fields that could bring significant results for resolving the most urgent economic and societal problems. This led to the development of technology foresight, first of all at the national level, as a key instrument to address demand from S&T and innovation policies. In the years of economic growth, the Russian government started the first serious attempts to build longer-term innovation policies. In the 2000s, more sophisticated policy instruments based on the best international

Table 3
Evolution of foresight in the former USSR and Russia vis-à-vis economic development and S&T organisation until 2008.
Source: Authors' analysis.

Time periods	Economy	S&T organisation	Forward-looking activities
Catching up 1920s–1930s	Introduction of market economy regulations for SMEs (1921–1928), large enterprises owned by the state. Accelerated industrial development to prepare for military actions.	Fast growth of research capacities, establishment of sectoral scientific academies and hundreds of industry research units. Fast growth of R&D funding and R&D personnel. R&D is concentrated in the Academy of Sciences, a few large universities, and defence R&D institutes.	First attempts of longer-term planning. GOERLO plan. Kondratiev's works on planning of a market economy. Introduction of 5-year plans, planning of S&T contributions to industrial development.
Threat-thinking 940s – 1960s	Militarisation of the economy, start of large-scale nuclear and space projects. Slowdown of the economy (inability to switch from extensive growth to intensive innovation-based growth).	Management of large-scale, interdisciplinary S&T projects. Attempts to establish links between R&D and industry.	Large-scale space and nuclear programmes.
Stagnation and crisis of the system 1970s – 1980s	Rigid structure of the planned economy leads to steadily declining economic growth. Centrally administered planned economy became uncompetitive with more developed market economies. Consumption crisis, destruction of economic links.	Continuing growth of R&D funding, lack of adequate structural S&T policy, decreasing output of R&D.	Large-scale works on mathematical models for economic forecasting. Complex Programme of Scientific and Technological Progress for the period of 1991–2010 (1988).
Strategic reforms 1990s	Demise of the USSR. Abrupt fall of GDP, radical changes of basic political, economic and social institutions, privatisation, financial crisis of 1998.	S&T policies meeting free market environment and aimed to preserve the national R&D sector. Emergence of market-oriented forms of research activities.	First lists of national S&T priorities and critical technologies
Opportunity-thinking 2000s	Stable economic growth based primarily on high oil and gas prices. Boom of domestic consumption market.	Attempts of systemic transformation of NIS. Growth of GERD.	National foresight projects: updated lists of S&T priorities and critical technologies (2002, 2006). National S&T Delphi – 2025 (2008–2009).

practices and requirements of a market economy appeared. It created a greater interest in foresight by policy makers, and it has started to play a much more profound role among various tools to inform S&T and innovation policies. The initiatives in the late 2000s lay the foundations for the next stage of foresight activities as a tool for communication and coordination of efforts from key stakeholders, including the government, businesses, and S&T community.

An analysis of foresight activities vis-à-vis the demand from national S&T and innovation policies demonstrates how the scale and focus of foresight projects have increasingly incorporated policy issues.

The first large-scale foresight studies both proved a necessity for regular forward-looking efforts and revealed the gaps in their coordination, organisation, and methodologies that needed to be bridged. Policy makers, the business community, and foresight practitioners have to learn several lessons in this regard.

As an instrument for designing government S&T policies, policy makers have increasingly sought to identify thematic S&T priorities and critical technologies. The first lists of priorities mostly indicated promising areas of research, whereas the later ones increasingly assisted policy makers to structure national S&T programmes and build stronger linkages with industry. In addition, more recent priority lists were used as a tool to identify S&T fields that could be subject to tax incentives to stimulate corporate investment. Nonetheless, taking account of the real volume of R&D expenditures allocated to particular research areas, there are still significant discrepancies between the formally announced priorities and those receiving the bulk of government R&D funding.

Another problem to be addressed by policy makers is implementing priorities in practice. S&T priorities have to be more focused on resolving particular problems and considered in a broader context of innovation and socioeconomic policies. They should be embedded into policy instruments with respect to such issues as meeting social and economic challenges, the availability of financial resources and a skilled workforce (both in S&T and at other stages of the value chain), potential risks, and market entrance barriers.

A big issue is the coordination of forward-looking activities at national, sectoral, and corporate levels. For this purpose, an Interdepartmental Commission on Technology Foresight was set up in 2013 and a Federal Law "On Strategic Planning in the Russian Federation" was passed in July 2014. Despite some progress in this area, many barriers between government agencies and the business community have yet to be overcome to provide better grounded decision making and to implement particular policies for individual government agencies across the whole spectrum of government policy (OECD, 2010). Another challenge is the need for evaluating the increasing number and scale of foresight studies (Sokolova and Makarova, 2013), in particular for carrying out a rolling programme of quality evaluation on a regular basis.

The intense growth in foresight exercises implemented by large companies clearly reflects the interest of the business community in longer-term strategic planning. This growth was to a large extent conditioned by the 2008–2009 crisis when many "big players" found their positions very unstable.

The first corporate foresight efforts in Russia have shown a clear need for addressing a wider scope of challenges beyond a traditional agenda. This has led to greater participation of businesses in national foresight studies, in particular when it comes to identifying the grand challenges and discussing a cross-sectoral and interdisciplinary agenda. The creation of technology platforms (a new innovation policy instrument, see Rudnik, 2011) has also stimulated forward-looking thinking in particular sectors with the participation of government, businesses, and the S&T community.

Many companies, especially the large ones, started their own foresight exercises as a part of their corporate strategic planning, which were mostly focused on the practical implementation of companies' strategies in the mid-term. Those studies revealed a lack of competences related to the organisation and methodologies of foresight as well as a need for systemic coordination efforts at sectoral and corporate levels.

Several additional lessons have to be learnt by foresight practitioners. A crucial key issue is better integration into processes of public policymaking and corporate strategy design. Often, new policy instruments are developed in parallel to foresight studies or even prior to them; ultimately, it paradoxically transpires that the foresight outcomes sometimes may lag behind the current policy agenda (Gokhberg and Sokolov, 2013). On the other hand, new policy instruments often fail to take account of important future trends. In this respect, the involvement of policy makers at the earliest possible stage (even when planning and scoping a foresight exercise) becomes critical for the overall project success. Better arranged engagement of key experts is also of vital importance. In particular, it relates to the involvement of the business community and international experts. The smart integration of adequate quantitative and qualitative methods for foresight purposes also strongly contributes to its final impact on policy- and strategy making.

Taking account of the abovementioned issues will enable foresight studies to be made more efficient and to be more focused on real problems of the NIS. Finally, tackling the challenges discussed in this article will enable foresight to help transforming crisis-caused consequences into opportunities that can enhance competitive advantages stemming from technological progress and innovation.

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Professor **Leonid Gokhberg** is the First Vice-Rector of the National Research University Higher School of Economics (HSE) – one of the most prominent research universities in Russia – and Director of the HSE Institute for Statistical Studies and Economics of Knowledge. He has authored over 350 publications in Russia and internationally devoted to S&T and innovation indicators, analyses, foresight and policies; co-ordinated dozens of national and international projects sponsored by various national authorities, regional agencies, and industrial companies as well as by the OECD, European Commission, World Bank, UNIDO, IIASA, etc. He is also Editor-in-Chief of the Moscow-based, Scopus-indexed journal "*Foresight and STI Governance*" and is a member of several high-level advisory groups on technology foresight, S&T, and innovation policies and indicators at the OECD, Eurostat, as well as other international and national agencies.

Professor **Alexander Sokolov** is the Deputy Director of the Institute for Statistical Studies and Economics of Knowledge and Director of the International Foresight Centre at the National Research University Higher School of Economics.He has authored over 140 publications in Russia and internationally. The main field of his research is foresight and innovation policy. Alexander Sokolov has managed many large-scale foresight projects in Russia including "Identification of National S&T Priorities and Critical Technologies" and several national S&T foresight studies. He also participates in many international projects and is a member of expert groups at the OECD, UNIDO, and other international organisations.