Boosting support for university research has become one of the most important strategic orientations of STI and education policies in the Russian Federation.

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A Soyuz rocket taking off in Kazakhstan and heading for the International Space Station
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INTRODUCTION

The end of long-term resource-led growth

The Russian Federation faces a variety of challenges in securing adequate investment in new knowledge and technologies and deriving socio-economic benefit from them. The *UNESCO Science Report* 2010 had observed that the global financial crisis of 2008 and the ensuing stagnation were exacerbating domestic weaknesses, such as the limited market competition and persistent barriers to entrepreneurship which were hampering the growth of the Russian economy. Despite some reforms since, these challenges have intensified since mid-2014.

The rapid growth of the Russian economy since the turn of the century had been largely fuelled by oil, natural gas and other primary products. Oil and gas alone account for more than two-thirds of exports and 16% of GDP. High oil prices have helped to improve the standard of living and accumulate large financial reserves. The growth rate slowed, however, in the aftermath of the global crisis in 2008, particularly after 2012 (Table 13.1). It has deteriorated further since mid-2014, driven by a vertiginous drop in global oil prices between June and December 2014, combined with the economic, financial and political sanctions imposed on the Russian Federation by the European Union (EU), USA and several other countries in response to events in Ukraine. This has fostered inflation and currency depreciation while curbing consumer spending. Capital outflows have become a major concern: the latest estimates are for outflows of US$ 110 billion in 2015. Growth stalled altogether in 2014 and the government predicts that GDP will contract by 2.5% in 2015 before a return to positive growth of 2.8% in 2016.

The government has been obliged to cut back on spending and to use accumulated reserves to prop up the economy, in accordance with its anti-crisis plan adopted in January 2015.[1] The difficult economic and geopolitical situation has also prompted the government to implement vital structural and institutional reforms to revitalize and diversify the economy. As early as September 2014, Prime Minister Dmitry Medvedev cautioned against the risk of reacting to the sanctions with measures that would reduce competition or stoke protectionism (Tass, 2014).

The growing urgency of innovation-led growth

Paradoxically, the rapid economic growth fuelled by the commodities boom between 2000 and 2008 actually weakened the motivation of enterprises to modernize and innovate. In the sphere of science, technology and innovation (STI), this manifested itself in a boom in imports of advanced technologies and a growing technological dependence on developed countries in certain areas, such as in pharmaceuticals and high-tech medical equipment.

In the past few years, the government has sought to reverse this trend by encouraging companies, public research institutes and universities to innovate. Some 60 state-owned companies were obliged to implement special programmes to boost innovation. As a result, their investment in R&D doubled between 2010 and 2014, rising from 1.59% to 2.02% of sales, on average. The share of innovative products in the total sales of state-owned companies consequently rose from 15.4% to 27.1%. Exports of innovative products also progressed, particularly in the aircraft industry, shipbuilding and chemicals, according to the Ministry

1. See: http://www.rg.ru/2015/01/28/plan-antikrizis-site.html

Table 13.1: **Economic indicators for the Russian Federation, 2008–2013**

Percentage change over previous year, unless otherwise stated

	2000–2007*	2008	2009	2010	2011	2012	2013
GDP	7.2	5.2	-7.8	4.5	4.3	3.4	1.3
Consumer price index	14.0	13.3	8.8	8.8	6.1	6.6	6.5
Industrial production index	6.2	0.6	-10.7	7.3	5.0	3.4	0.4
Capital investment	14.0	9.5	-13.5	6.3	10.8	6.8	0.8
Exports	21.0	34.6	-36.3	32.1	31.3	2.3	-0.8
Imports	24.2	29.4	-36.3	33.6	29.7	5.4	1.7
Consolidated public sector balance (% of GDP)	–	4.8	-6.3	-3.4	1.5	0.4	1.3
Public external debt (% of GDP)	–	2.1	2.9	2.6	2.1	2.5	2.7

*annual average growth rate

Source: Rosstat (2014); *Ministry of Finance (2014) Execution of the federal budget and budget system of the Russian Federation*. Moscow.

of Economic Development and Trade. Central to the national strategy was the decision to enlarge the government's arsenal of competitive research funding for leading federal and national research universities. Public institutes and universities also received grants to commercialize new technologies and create small innovative firms (start-ups). In parallel, the government introduced schemes to foster academic mobility and expose scientists and engineers to the best training that money could buy. For instance, public research institutes and universities received grants to enable them to invite top Russian and foreign professionals to work on their campuses.

A need for a new economy

The present conjuncture makes it difficult to tackle the domestic weaknesses outlined in the *UNESCO Science Report 2010*. These include inadequate intellectual property protection, the obsolete institutional structure of the R&D sector, the lack of autonomy of universities and the relatively weak infrastructure for research and innovation. These chronic weaknesses augment the risk of the Russian Federation falling further behind the leading countries in global development. It is this concern which has made national policy-makers particularly keen to galvanize STI-led recovery and development. Since 2010, the Russian authorities have adopted no fewer than 40 documents to regulate STI, including in the form of presidential decrees.

As early as 2012, President Putin acknowledged the need for a new economy. 'It is not acceptable for Russia to have an economy that guarantees neither stability, nor sovereignty, nor decent welfare,' he said. 'We need to create an effective mechanism to rebuild the economy and find and attract the necessary...material and human resources' (Putin, 2012). More recently, he called for a widening of import-substitution programmes in May 2014, during a presentation to the St Petersburg International Economic Forum. 'Russia needs a real technological revolution,' he said, 'serious technological renewal, the most extensive in the last half-century, massive re-equipping of our enterprises'.

In 2014 and 2015, action plans were launched in various industrial sectors, in order to produce cutting-edge technologies and reduce dependence on imports. Target products include high-tech machine tools, equipment for the oil and gas sectors, power engineering machinery, electronics, pharmaceuticals, chemicals and medical instruments. The federal Law on Industrial Policy adopted in 2014 provides a comprehensive package of supportive measures for companies, including investment contracts, R&D subsidies, preferential public procurement of the technologies produced, standardization, the creation of industrial parks and clusters and so on. A Fund for Industrial Development was established the same year to support highly promising investment projects initiated by companies.

The reforms implemented include a serious 'rationale' for partnerships with foreign countries, such as with the fellow BRICS countries – Brazil, India, China and South Africa – as well as other rapidly developing nations. At the sixth BRICS summit in Brazil in 2014, the five partners established a New Development Bank, to be hosted by China, and a Contingency Reserve Agreement (CRA) to provide them with alternatives to the World Bank and International Monetary Fund in times of economic hardship, protect their national economies and strengthen their global position. The Russian Federation is contributing US$ 18 billion to the CRA, which will be credited by the five partners with a total of over US$ 100 billion. The CRA is already operational. Currently, work is under way to develop financing mechanisms for innovative projects with the new bank's resources.

The Russian Federation is also developing co-operation with Asian partners within the Shanghai Cooperation Organisation and the Eurasian Economic Union; the latter was launched on 1 January 2015 with Belarus and Kazakhstan and has since been extended to Armenia and Kyrgyzstan. Just a day after hosting a BRICS summit in the eastern city of Ufa in July 2015, the Russian Federation hosted a summit of the Shanghai Cooperation Organisation in the same city, at which the admission of India and Pakistan was announced.[2]

A new framework for innovation policy

In May 2012, the president approved several decrees proposing directives for STI development. These decrees fix qualitative objectives that are to be measured against quantitative targets to 2018 (Table 13.2). Although the potential for developing STI is relatively high, this potential is held back by weaknesses in private investment, low scientific productivity and incomplete institutional reforms. A fundamental lack of receptiveness to innovation and poor demand from many firms and organizations for scientific achievements and new technologies still hampers progress in this area. All stakeholders in the Russian innovation system, including economic actors, feel an urgent need for institutional change and more effective implementation of government policies. There are other bottlenecks too, which, if not overcome, could condemn state initiatives to being no more than a flash in the pan.

Since 2011, a number of policy documents[2] have identified the principal orientations of national policies for science and technology, as well as related implementation mechanisms. A wider format for promoting STI in Russia was provided by the report entitled *Strategy – 2020: a New Framework for Innovation Policy*. It was drafted by leading Russian and international experts. Some of the ideas put forward in the report have since been transformed into official documents and are outlined below (Gokhberg and Kuznetsova, 2011a).

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2. including the *Presidential Decree on the Approval of the Priority Areas for the Development of Science and Technology and the List of Critical Technologies* (2011), the *Strategy for Innovative Development to 2020* (2012), the *State Programme for Development of Science and Technology*, 2013–2020 and the Federal Goal-oriented Programme on Research and Development in Priority Areas of Russia's Science and Technology Complex (2012)

Table 13.2: **Objectives and quantitative targets to 2018 of the May 2012 presidential decrees in the Russian Federation**

Decree	Objectives	Quantitative targets to 2018
On long-term economic policy (No. 596)	To increase the pace and sustainability of economic growth and raise the real income of citizens	Labour productivity to grow by 150%
	To achieve technological leadership	Increase the share of high-tech industries in GDP by 130%
On measures to implement state social policy (No. 597)	To improve the conditions of employees in social sectors and science	Increase the average salary of researchers to double that of the average salary in the region
On measures to implement state policy in the field of education and science (No. 599)	To improve state policy in education and science and the training of qualified professionals to meet the requirements of the innovation economy To improve the efficiency and performance of the R&D sector	Increase total funding of public scientific foundations to 25 billion rubles Raise the GERD/GDP ratio to 1.77% (by 2015). Increase the share of GERD performed by universities to 11.4%. Boost Russia's world share of publications in the Web of Science to 2.44% (by 2015).

TRENDS IN R&D

R&D effort is primarily government-funded

Gross domestic expenditure on research and development (GERD) rose by about one-third at constant prices between 2003 and 2013. Federal budget allocations for civil R&D even tripled.[3] Nevertheless, R&D intensity remained relatively stable; in 2013, GERD accounted for 1.12% of GDP, compared to 1.15% in 2004 and 1.25% in 2009 (Figure 13.1). After rising steadily for years, state expenditure on R&D dropped slightly in 2010 as a consequence of the global financial crisis in 2008–2009 but has since recovered (Figure 13.1). The government fixed a target in 2012 of raising GERD to 1.77% of GDP by the end of 2015 (Table 3.2), which would bring it closer to the EU average: 1.92% in 2012. In absolute terms, government funding of R&D amounted to PPP$ 34.3 billion in 2013, on a par with that of Germany (PPP$ 32.1 billion) and Japan (PPP$ 35.0 billion) [HSE, 2015a].

The low share of industry-financed R&D is a perennial concern. Despite government efforts, the contribution of industry to GERD actually fell from 32.9% to 28.2% between 2000 and 2013 (Figure 13.1). This sector, which encompasses privately and publicly owned companies and large-scale industrial R&D institutes, nevertheless performs the bulk of GERD: 60% in 2013, compared to 32% for the government sector, 9% for higher education and just 0.1% for the private non-profit sector (HSE, 2015a).

The low propensity of companies to finance research is reflected in the modest place occupied by R&D in total expenditure on innovation: 20.4% overall in industry; 35.7% in high-tech sectors. On average, significantly less is spent on R&D than on the acquisition of machinery and equipment (59.1%). In EU countries, the situation is diametrically the opposite; in Sweden, the ratio is even 5:1 and, in Austria and France, about 4:1. In Russian industry, a low proportion of investment goes on acquiring new technologies (0.7%), including patent rights and licenses (0.3%). This phenomenon is characteristic of all types of economic activity and limits both the country's technological potential and its capacity to produce groundbreaking inventions (HSE, 2014b, 2015b). Normally, the generation of new knowledge and technologies would be expected to be driven by technology-based start-ups and fast-growing innovative companies, including small and medium-sized enterprises (SMEs). However, this type of company is still uncommon in the Russian Federation.

Lesser priorities: basic research and green growth

Figure 13.1 depicts a growing orientation of R&D towards the needs of industry since 2008 and a drop in non-targeted (basic) research, referred to in official statistics as the general advancement of research. The share of R&D allocated to societal issues has risen somewhat but remains modest. The thin slice of the pie directly devoted to environmental issues has shrunk further and that for energy-related research has stagnated; this is disappointing, given the growing interest globally in environmentally sustainable technologies. It also comes somewhat as a surprise, since the government has adopted a number of policies in recent years as part of an action plan for sustainable green growth that is aligned with the *Green Growth Strategy* of the Organisation for Economic Co-operation and Development (OECD, 2011).

3. The relative figures in current prices are 4.4 and 10 times.

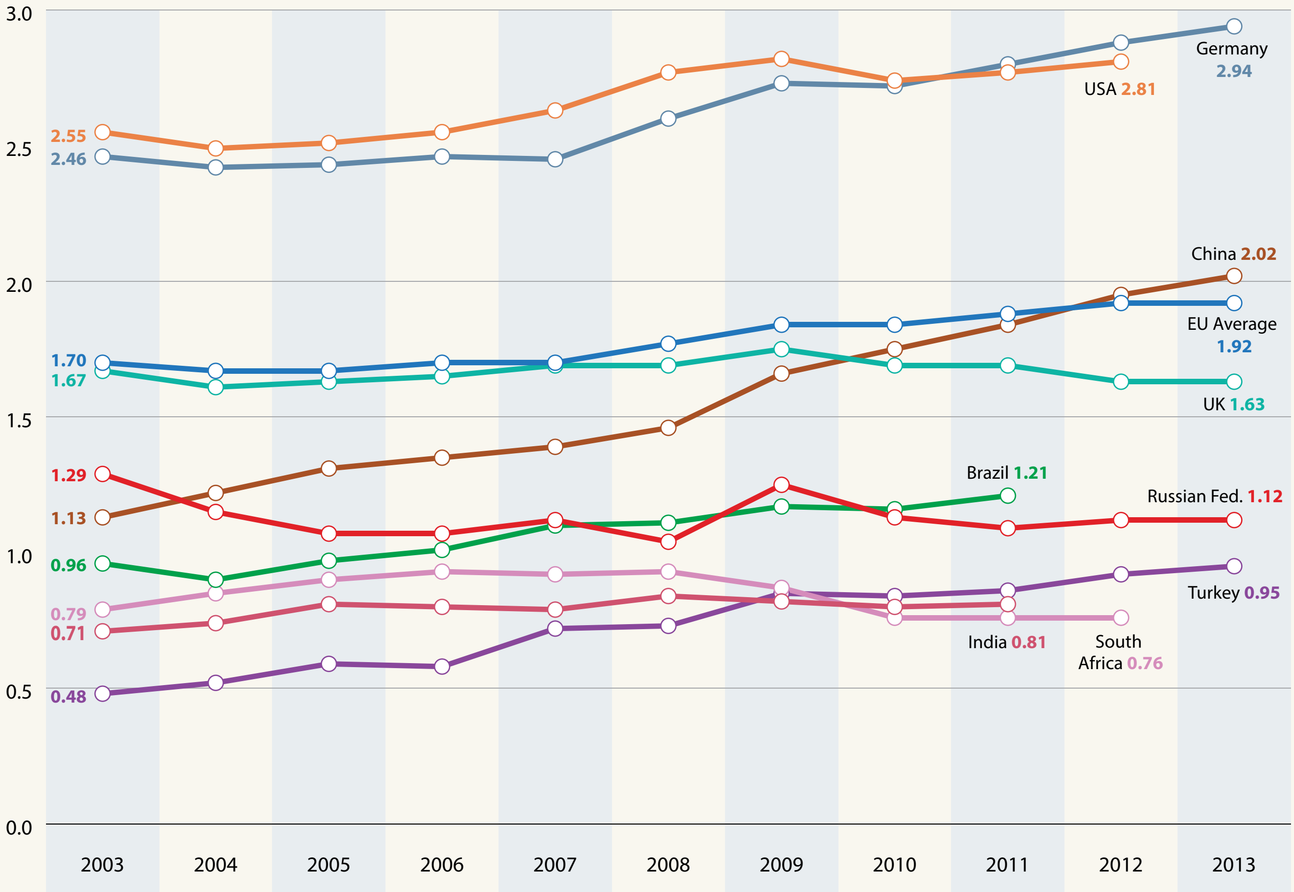
Figure 13.1: **Trends in GERD in the Russian Federation, 2003–2013**

1.29%
Russian GERD/GDP ratio in 2003

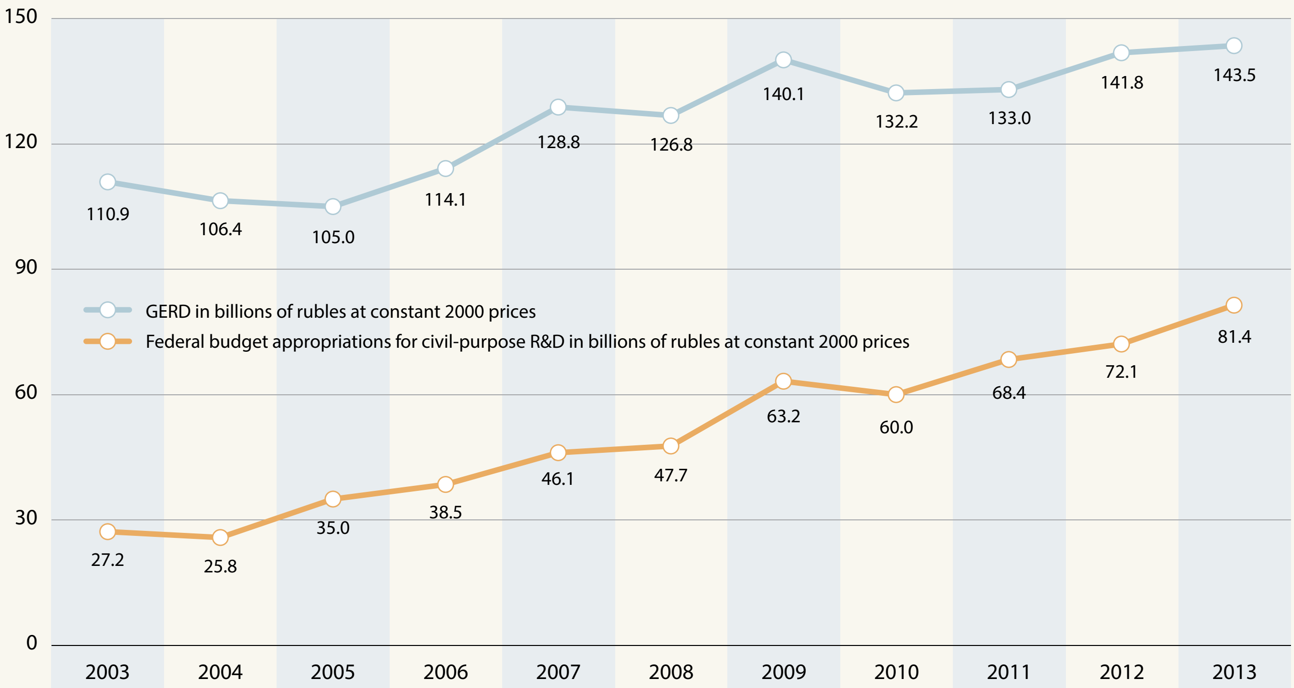
1.12%
Russian GERD/GDP ratio in 2013

The Russian Federation's R&D intensity has not progressed over the past decade

Other countries are given for comparison

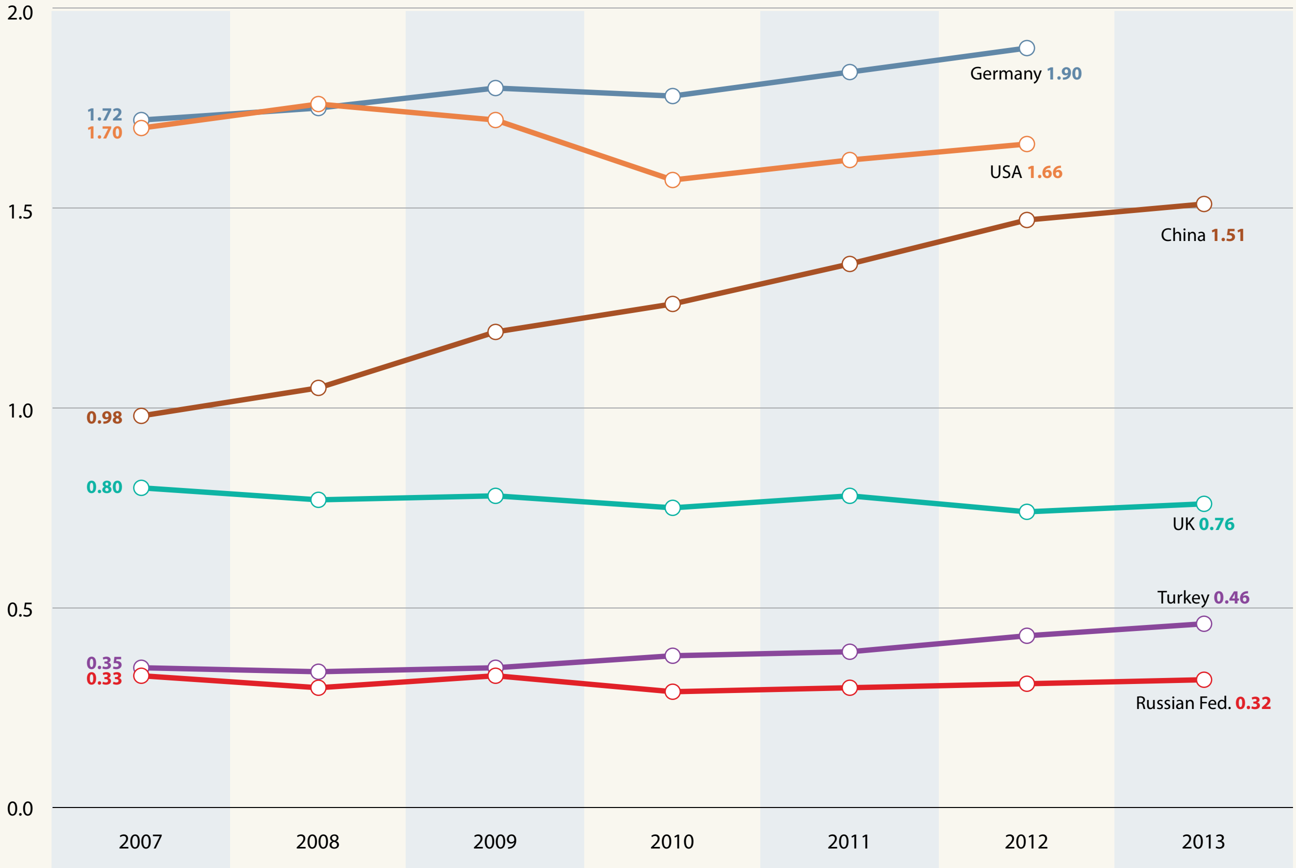


Federal budget allocations for civil-purpose R&D tripled between 2003 and 2013



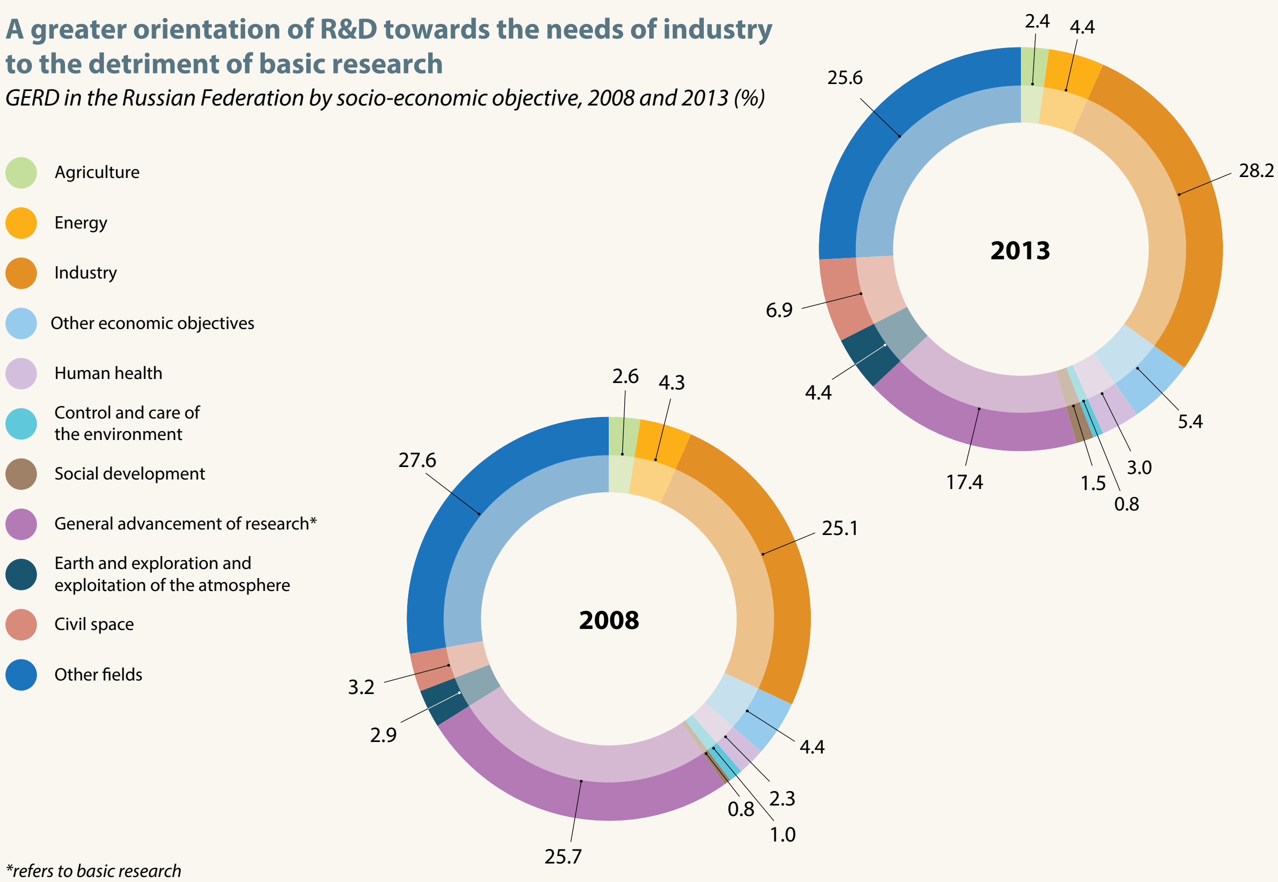
The low share of industry-financed R&D is a perennial concern

Share of GDP, other countries are given for comparison



A greater orientation of R&D towards the needs of industry to the detriment of basic research

GERD in the Russian Federation by socio-economic objective, 2008 and 2013 (%)



*refers to basic research

Source: HSE (2015a); OECD's Main Science and Technology Indicators, May 2015; for Brazil and India: UNESCO Institute for Statistics

In 2009, the government adopted *State Policy Priorities to Raise Energy Efficiency in the Electric Power Engineering Sector based on the Use of Renewable Energy Sources*, covering the period to 2020. In 2012, it adopted *Principles of the State Policy on the Ecological Development of the Russian Federation*, which is valid to 2030. The problem of green growth and social progress is addressed by four Russian technology platforms: Environmentally Clean Efficient Fuel; Technologies for Ecological Development; Biotech 2030; and Bio-energy. These platforms co-ordinate the activities of industrial companies, research centres and universities to promote R&D and technology in related areas. Collectively, these measures represent only the first leg of the journey towards sustainable growth, of course.

The modest investment so far in sustainable technologies can largely be explained by the business sector's tepid interest in green growth. Empirical data show that 60–90% of Russian companies do not use advanced general-purpose and resource-saving technologies, or alternative energy-generating technologies and have no plans to do so in the near future. Only one in four (26%) innovative enterprises are producing inventions in the environmental field. Even when companies do have recourse to environmentally friendly inventions like energy-saving technologies, this gives them virtually no competitive advantage in the domestic market. Most companies are focusing their efforts on reducing environmental pollution, in order to comply with government standards. Very few are engaged in waste recycling or in substituting raw and other materials for more environmentally friendly ones. For instance, only 17% of companies use environmental pollution control systems (HSE estimates; HSE, 2015b). This state of affairs prompted the government to adopt a series of regulations in 2012–2014 which encourage usage of the best available technologies for reducing environmental waste, saving energy and upgrading technologies through a series of positive incentives (such as tax exemptions, certification and standardization) and negative ones, such as fines for environmental damage or higher energy tariffs.

Scientific productivity is stagnating

Scientific output has stagnated in recent years (Figure 13.2). Moreover, the average citation rate for articles (0.51) is just half the G20 average. Russian scientists publish most in physics and chemistry, reflecting traditional strengths and a certain dependence on domestic research, even though one in three articles had a foreign co-author between 2008 and 2014.

Although patenting activity is relatively high and has grown by 12% since 2009 – residents filed 28 756 applications in 2013, ranking it sixth worldwide – the Russian Federation only ranks 20th worldwide for the number of applications per million inhabitants: 201. Moreover, 70% of patent applications submitted by domestic applicants contain only minor improvements to existing technologies. This suggests that the R&D sector is generally not yet ready to supply the business sector with competitive and cost-effective technologies for practical applications, or to guarantee support during the development stages of technology.

Innovation largely confined to domestic market

In the course of its transition to a market economy, the Russian Federation has become an attractive destination for foreign technologies. Between 2009 and 2013, the number of patent applications submitted in Russia by foreign applicants increased by 17% to 16 149 (HSE, 2015a; HSE, 2014b). Patent activity by Russian applicants grew more slowly. As a result, the coefficient of technological dependence increased: the ratio of foreign to domestic patent applications submitted in the Russian Federation went from 0.23 in 2000 to 0.56 in 2013. If we take into consideration the low patenting activity by Russian applicants abroad, this sends a negative signal to national policy-makers as to the competitiveness of domestic technologies in the global market.

Less than 3% of technology transfer occurs through exports. Intellectual property titles represent only roughly 3.8% of technology exports[4] and just 1.4% of companies engaged in R&D earn revenue from exports of technology. The latter generated just US$ 0.8 billion in 2013, virtually the same as in previous years, compared to US$ 2.6 billion for Canada, US$ 5.3 billion for the Republic of Korea and US$ 120.4 billion for the USA (HSE, 2015a). The Russian Federation's membership of the World Trade Organization since 2012 should help to boost technology transfer through exports and related revenue.

TRENDS IN HUMAN RESOURCES

Four in ten research personnel are support staff

Although the Russian Federation ranks 49th in the latest Global Innovation Index and 30th in the sub-index for human capital development (Cornell University *et al.*, 2014), international competition for talent is intensifying. The issue of developing skills and behavioural patterns in line with the country's development strategy has never been more pressing in the Russian Federation. Policies introduced in recent years have addressed this urgent question.

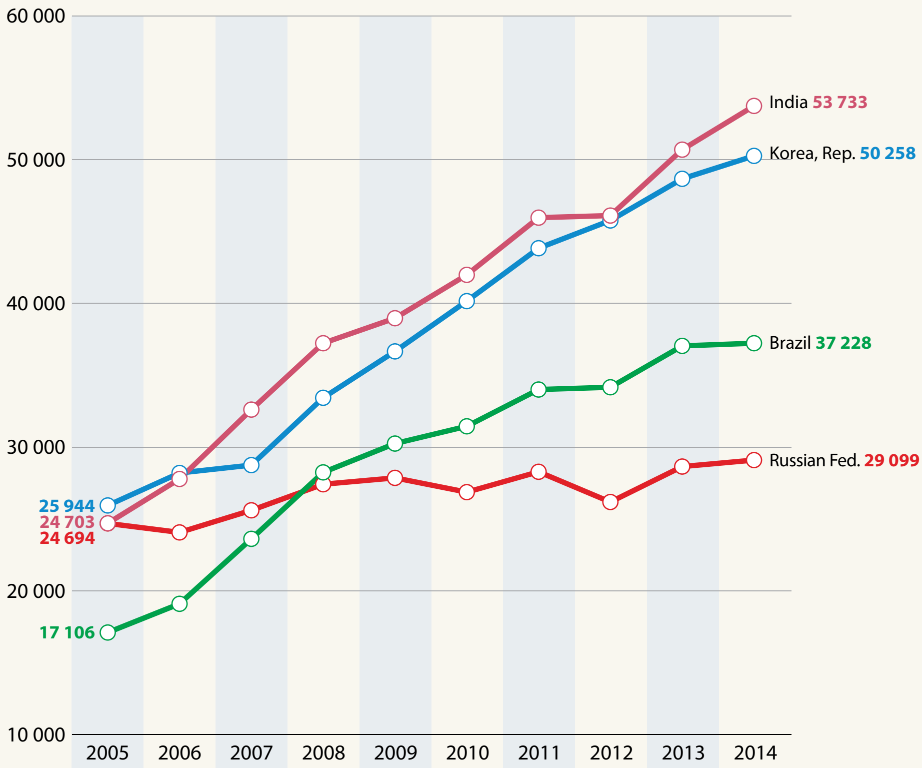
In 2013, there were 727 029 people engaged in R&D, a group encompassing researchers, technicians and support staff. Research personnel represented 1% of the labour force, or 0.5% of the total population. In absolute numbers, the Russian Federation figures among the world leaders for R&D personnel, coming only after the USA, Japan and China. However, there is an imbalance in the dynamics and structure of R&D personnel.

4. These official statistics are based on the balance of payments for technology.

Figure 13.2: **Scientific publication trends in the Russian Federation, 2005–2014**

Russian publications have grown fairly slowly since 2005

Selected large emerging market economies are given for comparison



Publications are making a small impact

0.51

Average citation rate for Russian scientific publications, 2008–2012; the G20 average is 1.02

3.8%

Share of Russian papers among 10% most cited papers, 2008–2012; the G20 average is 10.2%

33.0%

Share of Russian papers with foreign co-authors, 2008–2014; the G20 average is 24.6%

Russian scientists specialize in physics and chemistry

Cumulative totals, 2008–2014

191

Number of Russian publications per million inhabitants in 2008

204

Number of Russian publications per million inhabitants in 2014

Note A further 18 748 publications are unclassified.

Germany and the USA are the Russian Federation's principal partners

Main foreign partners, 2008–2014 (number of papers)

	1st collaborator	2nd collaborator	3rd collaborator	4th collaborator	5th collaborator
Russian Fed.	Germany (17 797)	USA (17 189)	France (10 475)	UK (8 575)	Italy (6 888)

Source: Thomson Reuters' Web of Science, Science Citation Index Expanded; data treatment by Science–Metrix

Researchers (by head count) account for little more than half of R&D personnel (369 015) and support staff 41%, compared to just 8.4% for technicians. The large share of support staff can be explained by the dominance of R&D institutes, which have traditionally tended to function in isolation from both universities and enterprises and required labour-intensive services to maintain the premises and manage the institution's finances. The Russian Federation ranks 21st globally for the number of people engaged in R&D per 10 000 employees but 29th for the number of researchers. Over two-thirds of R&D personnel are employed by state-owned organizations (HSE, 2015a).

In the *UNESCO Science Report 2010*, we observed a worrying inversion of the age pyramid in the research population.[5] Between 2010 and 2013, there were some signs of improvement. The proportion of researchers under the age of 40 rose to more than 40% and has since stabilized at this level. This trend reflects absolute growth in two age groups: scientists under the age of 30 and those aged between 30 and 39 years. After a long period of growth, the share of researchers over the age of 60 has at last stabilized in recent years at roughly 25% of the total (HSE, 2015a).

A hike in researchers' salaries to spur productivity

In 2012–2013, several roadmaps were adopted to improve the attractiveness of careers in research, in order to stimulate productivity, redress the age pyramid and give research a greater economic impact. These documents introduced a new remuneration system primarily for researchers employed by public research institutes and universities. The corresponding target indicators were established by the Presidential Decree on Measures to Implement State Social Policy (2012). As for the implementation schedule, it is controlled by the government.

The action plan fixes the target of raising researchers' salaries to at least 200% of the average wage in the region where the researcher is based by 2018. There are also similar plans to raise the salaries of teachers in universities and other institutions offering higher education programmes. Currently, research institutes and universities receive annual subsidies from the federal budget to enable them to increase salaries, as happens also for secondary schools, hospitals and agencies managing social security. The average salary of researchers tends to be rather high in Russian research hubs like the Moscow region,[6] thereby contributing to the unequal distribution of R&D potential across the country. Reaching the aforementioned target in these research hubs may turn out to be problematic, as raising salaries that are already fairly generous will mean allocating substantial additional funding to R&D. Whatever their status, all regions may find it hard to reach the '200%' target, on account of budget shortfalls and the slowdown in the pace at which institutional reform is being implemented in the R&D sector. Of note is that (Gerschman and Kuznetsova, 2013):

> *In order to prevent the rise in researchers' salaries from becoming a goal in itself without any strong connection to their performance and the socio-economic impact of their work, the action plan also introduces performance-related pay mechanisms, implying that researchers will be regularly evaluated on their productivity.*

One in four adults holds a university degree

Russia has long had a relatively high level of education. In recent years, interest in pursuing higher education has not waned. On the contrary, a Russian could expect to spend 15.7 years in the education system in 2013, up from 13.9 years in 2000. According to the 2010 population census, more than 27 million people over the age of 15 years hold university degrees, up from 19 million in 2002. This represents about 23% of the adult population, compared to 16% in 2002. In the 20–29-year age group, the percentage is as high as 28%, although this is down from 32% in 2002. At 55%, the overall proportion of the population with some form of tertiary education – including those with non-degree qualifications – is well above that of any member of the Organisation for Economic Co-operation and Development (OECD). Moreover, the number of people enrolled in higher education per 1 000 inhabitants has risen sharply in the past decade from 162 in 2002 to 234 in 2010.

The rise in student rolls can partly be attributed to the hike in government spending on education in recent years (Figure 13.3). Federal expenditure on higher education has remained stable at about 0.7% of GDP and 3.7% of overall federal budget appropriations but public expenditure on education as a whole has climbed to 4.3% of GDP, or 11.4% of the consolidated budget (federal and regional levels). This has enabled spending per tertiary student to double since 2005 (HSE, 2014a, 2014d).

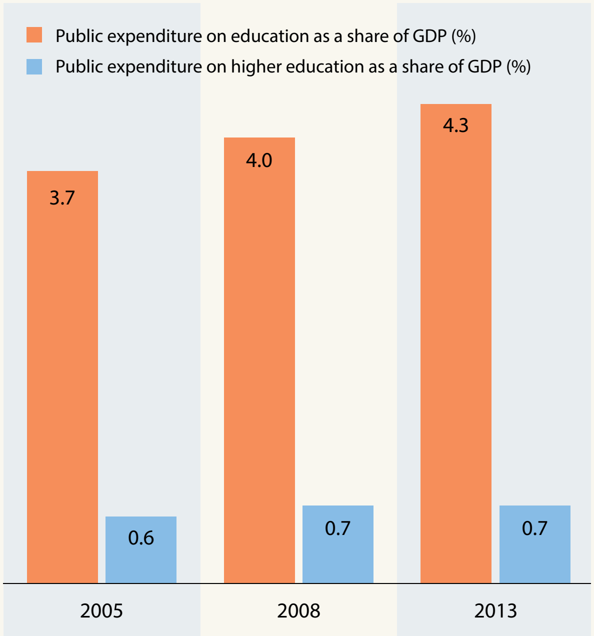
Training scientists becoming a core mission of research universities

As of the 2013/2014 academic year, 5.6 million students were enrolled in the country's tertiary institutions, 84% of which were state-owned: 2.8% of students were studying natural sciences, physics and mathematics; more than 20% engineering; 31% economics and management; and a further 20% humanities.

5. Between 2002 and 2008, there was absolute growth in the number of researchers aged 70 years and above. Simultaneously, the ranks thinned for such creative age groups as 40–49 year-olds (down by nearly 58%) and 50–59 year-olds (down by 13%). In 2008, researchers were 49 years old, on average, compared to 40 years old for those working in the national economy as a whole.

6. Roughly 60% of Russian researchers work in Moscow, the Moscow Region and St Petersburg. Six other regions together account for a further 20% of researchers: Nizhny Novgorod, Ekaterinburg, Novosibirsk, Rostov, Tyumen and Krasnodar.

Figure 13.3: **Public expenditure on education in the Russian Federation 2005, 2008 and 2013**



Source: HSE (2014a, 2014d)

Postgraduate programmes that confer a Candidate of Science degree (equivalent to a PhD) lead to the highest scientific degree, the Doctor of Science. In 2013, some 1 557 institutions offered postgraduate programmes in science and engineering, almost half of which (724) were universities and other tertiary institutions and the remainder research institutes. Some 38% of these institutions (585) also hosted doctoral courses, including 398 universities. Women made up just under half (48%) of the 132 002 postgraduate and 4 572 doctoral students in science and engineering. Most of the postgraduates (89%) and Doctor of Science candidates (94%) specializing in scientific disciplines are on the university payroll. The dominance of universities in postgraduate training is nothing new but the share of postgraduate students trained by research institutes was nearly three times higher in the early 1990s (36.4% in 1991) than today. This means that the education of highly qualified scientists is increasingly becoming a core mission of Russian universities. Engineering, economics, law, medicine and pedagogy are the preferred broad disciplines for postgraduate study.

Boosting university research a top priority

The higher education sector has a long-standing research tradition that dates back to the Soviet Union. About seven out of ten universities perform R&D today, compared to half in 1995 and four out of ten in 2000, as noted in the *UNESCO Science Report 2010*. However, universities still occupy a fairly lowly position when it comes to the generation of new knowledge: in 2013, they performed just 9% of GERD. Although this is up from 7% in 2009 and on a par with China (8%), it remains less than in either the USA (14%) or Germany (18%). Although university staff are still insufficiently engaged in R&D, the situation has improved in recent years: the proportion of professors and teaching staff conducting research rose from 19% to 23% between 2010 and 2013 (HSE, 2014a, 2015a).

Boosting support for university research has become one of the most important strategic orientations of STI and education policies in the Russian Federation. This process has been under way for almost a decade. One of the first steps was the National Priority Project for Education, initiated in 2006. Over the next two years, 57 higher education institutions received competitive grants from the federal budget for the purposes of implementing innovative educational programmes and high-quality research projects, or acquiring research equipment.

Between 2008 and 2010, 29 institutions received the coveted label of national research university. The aim is to turn these 29 national research universities into centres of excellence. In parallel, eight federal universities are being turned into ‘umbrella’ institutions for regional education systems. This status entitles them to large-scale government support but there are strings attached – in return, they are expected to produce high-quality research, education and innovation.

Currently, the magnitude of support given to higher education and its main orientations are determined by the Presidential Decree on Measures to Implement State Policy in the Field of Education and Science (2012) and the State Programme for the Development of Education[7] (2013–2020). The presidential decree anticipates that universities will be performing 11.4% of GERD by 2015 and 13.5% by 2018 (Table 13.2). Moreover, the level of engagement of university staff in R&D has become a major criterion for proficiency testing and professional advancement.

TRENDS IN STI GOVERNANCE

Higher education must adapt to economic needs

Despite undeniable success in boosting university research in recent years, one urgent problem remains: the discrepancy between the structure and quality of professional training, on the one hand, and current economic needs, on the other (Gokhberg *et al*., 2011; Kuznetsova, 2013). This is reflected not only in the composition of educational programmes, graduate specializations and diplomas but also in the relatively small scale and low level of applied research, experimental development and innovation performed by universities.

7. This programme provides schools, colleges and universities with full-scale financing for equipment procurement, offers subsidies to the best secondary schools and technical colleges, finances advanced teachers’ training, etc.

In recent years, one of the most important steps towards modernizing higher education has been the adoption of the Federal Law on Education in 2012; it outlined the contours of a modern system respectful of international practices and standards, new developments in educational programmes and technologies, as well as new teaching methods and approaches to conducting experimental development and innovation.

Aligning degrees with the Bologna Process

In accordance with the *Bologna Declaration* (1999), which launched the process of developing a European Higher Education Area, the various echelons of the Russian higher education system have been aligned with the International Standard Classification of Education to give:

- at the undergraduate level, the bachelor's degree;
- at the postgraduate level, specialist training leading to a diploma or a master's degree;
- postgraduate study for academic staff leading to a Candidate of Science degree, equivalent to a PhD.

New legislation has raised the standards for a PhD and made the process more transparent. University consortia and networking have been introduced into educational curricula and universities have been given the right to set up small innovative firms to commercialize their intellectual property. Students may also apply for scholarships or earmarked loans to cover the costs of their education.

New funding mechanisms to boost training and research

The 5/100 Programme was adopted[8] in 2013 to raise the global competitiveness of Russian universities to the point where five of them figure in the top 100 (hence the programme's name) and the remainder in the top 200 of global university rankings. In 2013–2015, 15 leading universities[9] were selected on a competitive basis to receive earmarked subsidies to help raise their global competitiveness in both science and education. To this end, a total of over 10 billion rubles (RUB, *circa* US$ 175 million) were earmarked for 2013–2014 and RUB 40 billion for 2014–2016. The selection criteria included the university's publication output, international research collaboration, academic mobility and the quality of strategic programmes. These 15 universities are subject to a performance evaluation each year.

The Presidential Programme for Advanced Training of Engineers was launched in 2012. It offers training programmes and internships in leading research and engineering centres at home and abroad, with a focus on strategic industries. Between 2012 and 2014, the programme enabled 16 600 engineers to obtain higher qualifications and 2 100 to train abroad; the programme involved 96 tertiary institutions located in 47 regions. The 'customers' of this programme were 1 361 industrial companies which seized this opportunity to develop their long-term partnerships with tertiary institutions.[10]

The Russian Science Foundation[11] is a non-profit organization set up in 2013 to expand the spectrum of competitive funding mechanisms for research in Russia. The foundation received RUB 48 billion in state funding for 2013–2016. R&D-performing institutions may apply for grants to fund their large-scale projects in basic or applied research. To obtain a regular grant, applicants must include young scientists in their project team and guarantee that at least 25% of the grant will be spent on the salaries of young researchers. In 2015, the Russian Science Foundation launched a special grants programme to support postdocs and introduced short- to medium-term internships to increase academic mobility (Schiermeier, 2015). A total of 1 100 projects received funding in 2014, one-third of which were in life sciences. Among the thematic priorities announced for the next call for proposals in 2015 are: new approaches to identifying the mechanisms behind infectious diseases, advanced industrial biotechnologies, neurotechnologies and neurocognitive research.

In recent years, the government has augmented its arsenal for stimulating research funding. A special government programme has been offering 'megagrants' to universities and research centres since 2010 to help them attract leading scientists. So far, the programme has seduced 144 world-class researchers, half of them foreigners, including several Nobel laureates. All the invitees have been selected to lead new laboratories with a total staff of more than 4 000 scientists at 50 top Russian universities; this has led to the publication of 1 825 scientific papers, more than 800 of which have appeared in scientific journals indexed by the Web of Science. Just 5% of applications were submitted by women, which explains why only 4 of the 144 megagrants went to principal investigators who were women (Schiermeier, 2015). A total of RUB 27 billion in public funding has been allocated to the megagrants programme over 2010–2016, with recipient universities contributing about 20% of the budget.

In parallel, the government has increased funding for 'old' state foundations[12] which focus on basic research and humanities, as well as for innovative SMEs (Gokhberg *et al.,* 2011). It has

8. as one means of realizing the goals in the *Presidential Decree on Measures to Implement State Policy in the Field of Education and Science* (no. 599)

9. including St Petersburg Polytechnic, the Far-East Federal University and three national research universities: the Higher School of Economics; Moscow Institute of Physics and Technology; and Moscow Institute of Engineering and Physics

10. See: http://engineer-cadry.ru

11. not to be confused with the Russian Foundation for Basic Research, set up in 1993 to issue grants for basic research

12. The Russian Foundation for Basic Research, the Russian Foundation for Humanities and the Foundation for Assistance to Small Innovative Enterprises were all set up in the early 1990s.

also introduced grants to develop research networks and co-operation between universities and the national academies of science and industry, within the framework of the State Programme for the Development of Science and Technology for 2013–2020. Leading universities participating in this programme are expected to raise the share of their budget devoted to technology transfer from 18% to 25% between 2012 and 2020.

A Basic Research Programme has been designed for 2013–2020 to co-ordinate national efforts. It is part of the overarching State Programme for the Development of Science and Technology and contains specific provisions for selecting priorities in basic research and for an open public evaluation of scientific achievements. These provisions include the presentation of the programme's results in a freely accessible database and the mandatory publication of open-access articles on the internet.

Funding mechanisms to stimulate business R&D

Since 2010, the government has also introduced a number of schemes to stimulate innovation in the business sector. These include:

- programmes that make it mandatory for state-owned enterprises to develop innovation strategies and co-operate with universities, research institutes and small innovative businesses; to qualify for this programme, state-owned enterprises must raise their spending on R&D and actively produce innovative products, processes or services;
- a Federal Law on Public Procurement (2013) providing for the purchase of high-tech and innovative products by the state and promoting state procurement of goods and services from SMEs;
- state technology-oriented programmes supporting particular industrial sectors (aircraft, shipbuilding, electronics, pharmaceuticals, etc.) and overarching areas, such as biotechnology, composite materials, photonics, industrial design and engineering; and the
- Small and Medium-sized Enterprise Development Programme covering 2013–2020, which includes the distribution of federal budget subsidies to cofinance regional SME development, support local clusters of engineering and prototyping centres and provide credit guarantees through the national system of guarantor institutions, the core of which is the new Credit Guarantee Agency (est. 2014).[13]

In 2015, two schemes were announced to drive technological development. The first is the National Technology Initiative; it introduces a new long-term model for achieving technological leadership by creating novel technology-based markets, such as in non-piloted drones and automobiles for the industrial and services sectors, neurotechnological products, network-based solutions for customized food delivery and so on; technological projects will be coupled with support for the training of schoolchildren and students in these promising areas. The second scheme targets major traditional sectors and consists in funding a series of national technological projects with a high innovation component through public–private partnerships, with a focus on smart power engineering, agriculture, transport systems and health services, among other areas.

A key issue for businesses concerns how to demonstrate tangible results from their research. One possible mechanism would be for the state to allocate budgetary funds to businesses on the condition that expenses be cofinanced by interested companies and that effective partnerships be established between research institutes, universities and business enterprises (Gokhberg and Kuznetsova, 2011a; Kuznetsova *et al.*, 2014). It is also important to ensure co-ordination between government programmes targeting STI and programmes implemented by institutions oriented towards development, in order to build the so-called 'innovation lift' needed to carry novel technologies, products and services along the entire innovation chain from the initial idea to the market. It goes without saying that it would be vital to monitor the performance of these programmes in order to make timely adjustments.

Tackling the insufficient carry-over of patents into the economy

The national intellectual property market is still at the developmental stage, with research output taking years to impact the economy: only 2–3% of all current patents are in use and patenting tends to be done more intensively than licensing of intellectual property. This is a pity, as it is precisely during commercialization that the real competitive advantages emerge, such as income from the use of protected inventions and the accumulation of know-how. In the Russian Federation, however, the development of intellectual property is often disconnected from specific consumer needs and industrial demand.

Hence the need to improve the legislative framework for intellectual property. The main regulation in this area comes from Section VI of the Civil Code, which is specifically devoted to issues related to intellectual property and the enactment of legislation. New norms developed in this area over the period 2009–2014 include:

13. In 2015, it was renamed the Federal Corporation for the Development of Small and Medium Enterprises, a public company with 100% state ownership.

- assigning intellectual property rights generated by public research to the Russian Federation and establishing the principle of the free transfer of intellectual property from the public sector to industry and society, making it easier for research centres and universities to deal with licenses or other forms of commercialization of intellectual property;
- regulating the conditions, amount and procedures relative to the payment of fees to authors for the creation and commercialization of in-service research results and technologies; and
- establishing an exhaustive list of the conditions under which the state may obtain exclusive rights to the fruit of intellectual creativity.

An action plan adopted by the government in 2014 contains additional measures for protecting intellectual property rights at the 'pre-patent' stage and on the internet and introduces specialized patent courts, as well as better professional training in this area. Steps are also being taken gradually to improve the conditions under which R&D is capitalized upon, including by placing intellectual property on company balance sheets. This is particularly important for SMEs, as it allows them to increase their balance sheet value, for example, or to attract investment and use their exclusive rights as a pledge to obtain credits.

New tax incentives to foster innovation

All fiscal affairs have been governed by a single document since 2008, the Russian Tax Code. The most important amendments in recent years concern new rules for calculating R&D expenditure and classifying certain specific types of spending by organizations as R&D expenditure, along with new regulations concerning the creation of reserves for forthcoming expenditure.

New tax incentives have been introduced since 2011 in favour of innovative SMEs, start-ups and spin-off companies, in particular:

- Zero tax (for three years) on profits channelled into developing intellectual property; in parallel, taxes on transactions involving intellectual property have been removed;
- Benefits and extensions to patent duty payment deadlines are offered to SMEs, as well as to individual inventors (enterprises);
- Residents of the Skolkovo Innovation Centre have been given a 'tax holiday' for up to ten years (Box 13.1).

In the near future, there are plans to introduce tax incentives for individuals, such as business agents, inventors or entrepreneurs, who invest in projects developing innovation (or innovative companies) and for companies desirous to expand their intangible assets.

Box 13.1: **Skolkovo Innovation Centre: a temporary tax haven near Moscow**

The Skolkovo Innovation Centre is currently under construction in the city of Skolkovo, near Moscow. This high-tech business complex has been designed to attract innovative companies and nurture start-ups in five priority areas: energy efficiency and energy saving; nuclear technologies; space technologies; biomedicine; and strategic computer technologies and software.

The complex was announced by the president in November 2009. It consists mainly of a technological university and a technopark and is headed by Russian oligarch Viktor Vekselberg and co-chaired by former Intel head Craig Barrett. In order to woo potential residents, a bill according the residents of Skolkovo special legal, administrative and fiscal privileges was adopted by the State Duma (parliament) in September 2010.

The law granted residents substantial benefits for up to ten years, including exemption from income tax, value-added tax and property taxes, as well as reduced insurance premiums of 14% rather than the going rate of 34%.

The law also made provision for the establishment of the Skolkovo Fund to support development of the university and thereby give personnel the skills that companies need. One of the centre's biggest partners is the Massachusetts Institute of Technology in the USA.

Once corporations and individuals become 'residents' of the city, they are entitled to apply for grants from the fund. Residents also have access to the centre's legal and financial infrastructure. In 2010, the government published a decree granting highly skilled foreign nationals who secured employment at Skolkovo a three-year work visa.

The Skolkovo Innovation Centre is financed primarily from the Russian federal budget. Its budget has increased steadily since 2010 and amounted to RUB 17.3 billion in 2013. A brand new motorway has been built linking Skolkovo to Moscow.

Today, more than 1 000 companies from 40 Russian regions have set up shop in Skolkovo. In 2013, 35 agreements were signed with major global and domestic companies, including Cisco, Lukoil, Microsoft, Nokia, Rosatom and Siemens. Industrial partners plan to open 30 R&D centres in Skolkovo, which would create more than 3 000 jobs.

Source: compiled by authors

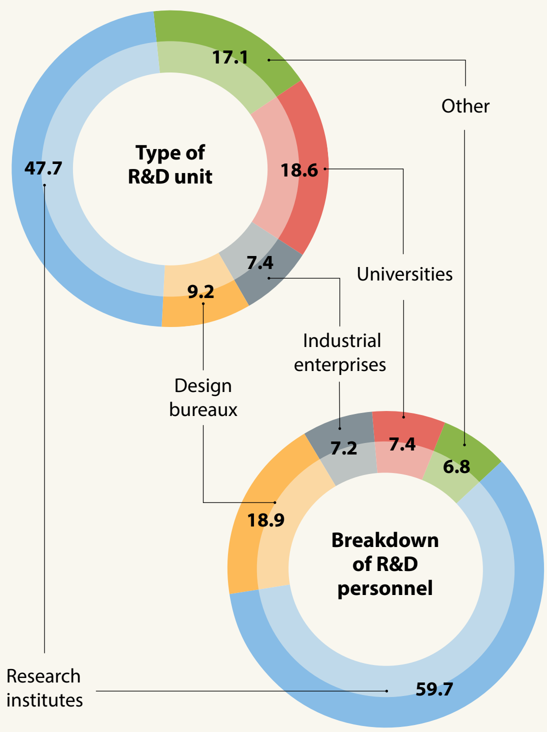
See also: http://economy.gov.ru/minec/press/interview/20141224

Restructuring to reinvigorate research

The institutional structure of the Russian R&D sector is not yet fully adapted to the market economy. As described in *The UNESCO Science Report 2010*, in the Soviet era, basic research was conducted predominantly by the research institutes of the state academies of science and major universities, whereas applied research and experimental development were concentrated mostly in branch institutions, design bureaux and specialized units of industrial enterprises. All R&D organizations were state-owned. Nowadays, most of the so-called industrial R&D in Russia is performed by large companies or legally independent research institutes. Industrial enterprises and design bureaux are mostly privately owned or semi-private organizations. This said, seven out of ten R&D-performing institutions are still state-owned, including universities and enterprises in which the government has a share of the capital. As already noted, small companies in the R&D sector are underrepresented, especially in comparison with other industrial nations (HSE, 2015a).

Unaffiliated research institutes and design bureaux tend to dominate institutions of higher education and enterprises when it comes to R&D: they represented 48% and 9% of all R&D units respectively and employed three-quarters of all R&D personnel in 2013 (Figure 13.4). Industrial enterprises account for just 7.4% of all R&D units, compared to 18% for institutions offering higher education (HSE, 2015a). The government's desire to optimize the institutional structure of research triggered a long-awaited reform of the state academies of science[14] in 2013 that will have far-reaching consequences for Russian science (Box 13.2).

Figure 13.4: **Breakdown of R&D units in the Russian Federation by type and personnel, 2013 (%)**



Source: HSE (2015a)

In parallel, the government is pursuing its plans to expand the network of state research centres (they now number 48) and to create a new network of large-scale national research centres. The first of these national research centres resulted, in 2009, from the subordination of three R&D institutes to the Kurchatov Research Centre, which specializes in nuclear energy and a broader spectrum of convergent[15] technologies. The second centre on a similar scale was established in the aircraft sector in 2014 by attaching several R&D institutes to the Central Aero-hydrodynamic Institute, renowned for aeronautic research. The Krylov Research Centre for Shipbuilding and the Research Institute for Aviation Materials are the next candidates on the list. To monitor the efficiency of national research infrastructure and identify avenues for targeted support, new arrangements were introduced in 2014 to assess the performance of public research institutions in the civil sector regularly.

Eight priority areas and critical technologies identified

The Russian Federation has an established system for identifying priorities so that resources can be distributed effectively to a limited number of fields, taking into account national objectives and both internal and external challenges. The current list encompasses eight priority areas and 27 critical technologies based on the results of a foresight exercise conducted in 2007–2010. This list was approved by the president in 2011. These research priorities have been chosen to address global challenges, ensure national competitiveness and promote innovation in key areas; they are being used to design governmental programmes for R&D and to streamline funding for other policy initiatives. Two of the eight priority areas concern defence and national security. The remaining six focus on civil-purpose science and technology; their share of total funding is broken down as follows:

- Transport systems and space (37.7%);
- Safe and efficient energy systems (15.6%);
- ICTs (12.2%);
- Environmental management (6.8%);
- Life sciences (6.0%); and
- Nanotechnology (3.8%).

14. Prior to the reform of 2013, there were six Russian academies: the Academies of Sciences; Medical Sciences; Agricultural Sciences; Education; the Arts; and Architecture and Construction Services.

15. such as bionanotechnology, neurobiology, bioinformatics, etc.

Chapter 13

Box 13.2: **Reform of the Academy of Sciences**

The reform of the Russian Academy of Sciences had been debated for over a decade. Since the late 1990s, the academy had functioned as a quasi-ministry, managing federal property and overseeing the network of institutions which carried out the bulk of basic research in Russia. In 2013, the six academies comprising this sector accounted for 24% of the Russian Federation's research institutions, about one-fifth of R&D personnel, 36% of researchers and 43% of all researchers with Candidate and Doctor of Science degrees. They thus grouped a highly qualified labour force.

However, many of the institutions attached to the academy had developed a top-heavy age pyramid, with about one-third of researchers being over the age of 60 (34% in 2013), including about 14% over 70. The academies were also accused of low productivity – they received 20–25% of government research funding –and a lack of transparency. There was certainly a conflict of interest, in so far as some of those in charge of the academy and the distribution of resources among subsidiary institutes also happened to head these same institutes. Critics also reproached the academies for a lack of prioritization and weak ties to universities and industry.

The Russian Academies of Sciences, Agricultural Sciences and Medical Sciences attracted the most criticism, as they grouped about 96% of the research institutes placed under the academies, 99% of the academies' funding and 98% of their researchers in 2013. A series of 'soft' reforms in recent years had ironed out some problems, such as the introduction of rotation for managerial posts, greater internal mobility, a mandatory retirement age and teaching requirements and the expansion of competitive grants.

In September 2013, the government's long-awaited reform got under way with the adoption of a law stipulating the merger of the Russian Academy of Sciences with the two smaller academies for medical and agricultural sciences. The Russian Academy of Sciences was entitled to keep its name. A month later, the government passed a law establishing the Federal Agency for Research Organizations, with direct reporting lines to the government.

These two laws served the immediate objective of establishing a system with two nodes of power divided between the Russian Academy of Sciences, on the one hand, and the Federal Agency for Research Organizations, on the other. The functions of co-ordinating basic research, evaluating research results across the entire public research sector and providing expert advice remain the preserve of the Russian Academy of Sciences, whereas the management of the academy's finances, property and infrastructure now falls to the Federal Agency for Research Organizations.

The more than 800 institutes that used to belong to the three academies of sciences are now formally the property of the Federal Agency for Research Organizations, even though they may still bear the label of one of the academies. This network remains extensive: the 800 institutes employ about 17% of researchers and produce nearly half of the country's international scientific publications.

Source: Gokhberg *et al.* (2011), HSE (2015a), Stone (2014)

In 2014, work began on updating this list, once the government had approved the findings of the most recent foresight exercise, *Foresight – 2030,* conducted between 2012 and 2014 (HSE, 2014c). The report's recommendations are intended to serve as early-warning signals for the strategic planning of enterprises, universities, research institutes and government agencies.

Growing exports of nanoproducts

The *UNESCO Science Report 2010* underscored the significance of the Russian *Strategy for Nano-industry Development* (2007) and predicted that 'by 2015, all the necessary conditions will be in place for large-scale manufacturing of new nanotechnology-related products and for Russian nanotech companies to enter global markets'. It also predicted that the sales of nanotechnology-related products would grow by seven or eight times between 2009 and 2015. According to the state corporation Rusnano, as of 2013, over 500 companies were engaged in manufacturing nanotech products, the sales from which exceeded RUB 416 billion (more than US$ 15 billion). This is 11% over the target fixed in 2007 and means that the industry has grown 2.6 times since 2011. Almost one-quarter of nanotech products are exported. Moreover, export earnings doubled between 2011 and 2014 to RUB 130 billion.

By the end of 2013, Rusnano was supporting 98 projects and had established 11 centres for technological development and transfer (nanocentres) and four engineering companies in different regions. These specialize in composite materials, power engineering, radiation technologies, nano-electronics, biotechnology, optics and plasma technologies, ICTs and so on. Substantial achievements have been made in such areas as nanoceramics, nanotubes, composites and both hybrid and medical materials. Since its inception in 2011, the Centre for Nanotechnology and Nanomaterials in Saransk (Republic of Mordovia) has begun manufacturing unique nanopincers for microscopes that allow particles on a scale of 30 nanometers to be captured; this is a real breakthrough, with a multitude of potential applications in electronics and medicine (Rusnano, 2013, 2014). The centre has also patented special anticorrosion coatings, among other inventions.

Although the production of nanomaterials has grown considerably, Russian scientific output in nanotechnologies does not seem to be progressing as quickly as in a number of other economies (see Figure 15.5); nor does Russian scientific activity seem to have translated, as yet, into a significant amount of patented inventions (Figure 13.5).

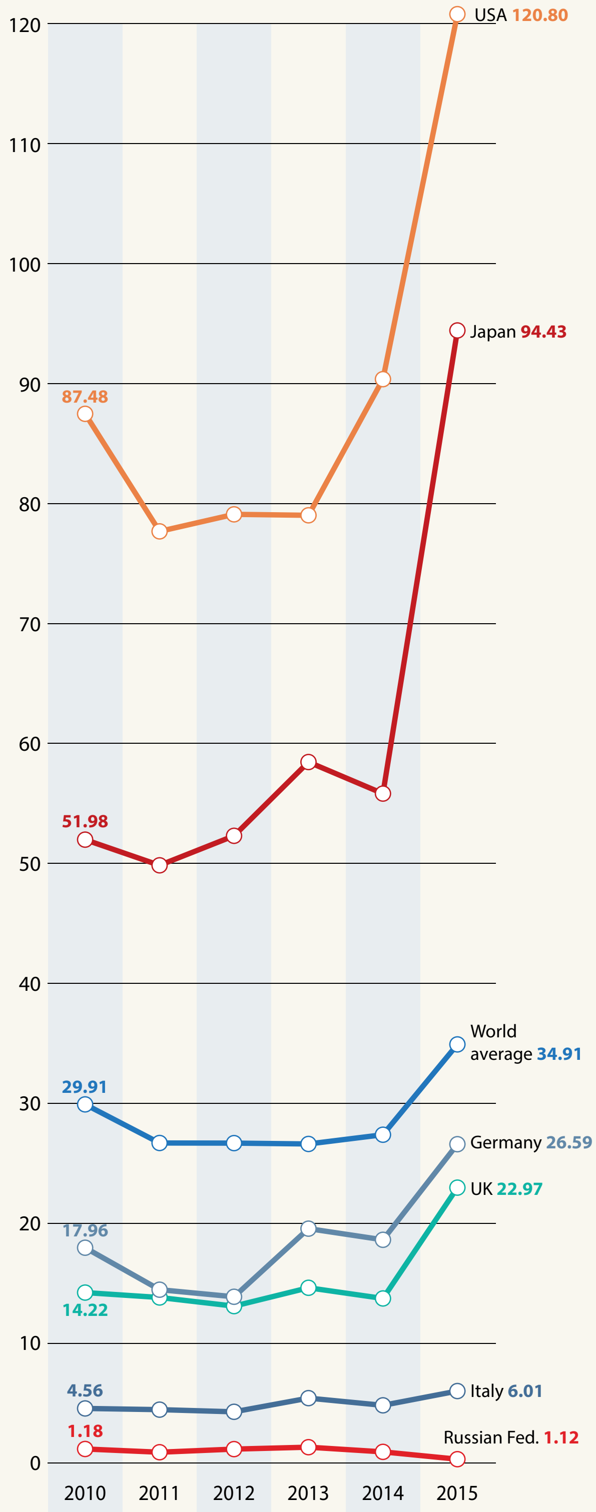
The advent of the State Roscosmos Corporation

The space industry has traditionally been considered a national priority. In terms of funding, the Russian space industry is the third-biggest after those of the USA and EU. The Russian Federation retains technological advantages in cosmonautics, rocket engines and carrier rockets. Prospective areas for R&D identified by *Foresight – 2030* include: carrier rocket technologies and acceleration block structural components, such as composite nanomaterials; spacecraft onboard engines, drives and energy storage systems; digital electronics and satellite navigation systems; new-generation environmentally friendly engines and safe fuels; clusters of small-format spacecraft for remote exploration of the Earth; and the deployment of broadband telecommunication systems (HSE, 2014c). These orientations are being taken into account in the design of a new Federal Space Programme covering the period to 2025; the new programme's priorities refer to 'social space' (the space industry as an engine of socio-economic development), basic space research and piloted cosmonautics (a new generation of space stations). It is also envisaged to complete the deployment of the International Space Station.

In recent years, the Russian space industry has faced growing global competition. At the same time, the industry's structure and organization have become outdated and inefficient, a verdict confirmed by several failed launches. This state of affairs led the government to launch a reform in 2013 to integrate more than 90 state-owned industrial enterprises and R&D centres into a single United Rocket and Space Corporation. The next stage of this ongoing reform got under way in 2015 with the merger of this corporation with the Federal Space Agency. The aim is to concentrate R&D, manufacturing and land infrastructure in the newly established State Roscosmos Corporation, which is to become a hub for the strategic planning and decision-making needed to overcome existing problems. There are strong hopes that this move will enhance horizontal linkages to avoid a dispersion of the procurement, performance and regulatory functions and 'reinforce competition'. A similar approach was successfully tried earlier by the nuclear energy corporation Rosatom.

Figure 13.5: **Nanotechnology patents in the Russian Federation, 2011–2015**

Number of patents per 100 nano-articles



Note: Data concern the ratio of nanotechnology patents to nano-articles (USPTO patents per 100 articles). The data for 2015 cover the period to the end of March.

Source: Thomson Reuters' Web of Science; USPTO

Along with this reform of the public space sector, new players are gradually changing the traditional centralized landscape. These are several private start-up companies based at Skolkovo (Box 13.1), including Dauria Aerospace, Lepton Company (St Petersburg) and Sputniks. These start-ups are targeting the production of microsatellites and space instruments, as well as the commercialization of remote sensing technologies for weather forecasting, environmental monitoring and exploration of natural resources.

Developing technologies to 'shrink' distances

The development of transport systems has two key motivations: to strengthen the global reach of domestic technologies and ensure continuity across the Russian Federation's vast territory through the development of regional aviation hubs and high-speed railways.

Foresight – 2030 suggests some orientations for specific transport sectors. It recommends that the aircraft industry focus its technological portfolio on reducing the weight of planes, on the use of alternative fuels (biofuel, condensed and cryogenic fuel), the development of 'smart' cabins for pilots with front windshield-based information panels and new composite (non-metal) materials, coatings and constructions (HSE, 2014c). The Sukhoi Superjet 100 (SSJ) is one example of recent technological progress; this new-generation regional aircraft is equipped with advanced technologies and meets the demand of both domestic and global civil aviation markets. A novel integrated power system for regional and long-haul aircraft is also being developed by Snecma (the French Safran Group) and Saturn (Russian Federation).

The state programme for the shipbuilding industry was adopted in 2013. This sector is experiencing a renaissance. More than 200 enterprises are engaged in manufacturing vehicles for maritime and inland cargo shipping, equipment for exploiting oil and gas reserves on the continental shelf, commercial and scientific shipping. The United Shipbuilding Corporation (est. 2007) is the largest company in this sector; this fully state-owned company encompasses 60 enterprises and accounts for about 80% of the domestic shipbuilding industry's turnover, with exports to 20 countries.

According to *Foresight – 2030* and a special report on *Foresight for Shipbuilding* (Dekhtyaruk *et al.,* 2014), research objectives for this industry principally concern the following areas: the development of composite materials based on nanotechnologies, organic and non-organic synthesis, metallurgy and thermal treatment; construction using novel materials and coatings; techniques to maximize the economic performance of vehicles; the construction of high-performance propulsion systems for small vessels based on the novel principles of energy generation, storage and conversion; high-performance tools and systems for ensuring the safety and durability of ships and vessels, including modern radio-electronic equipment based on nanotechnologies; and the design of highly automated smart adjustable systems for industrial production.

A stronger focus on alternative energy and energy efficiency

Given the energy sector's key contribution to GDP and exports, any changes have an immediate impact on national competitiveness. You could say that, when the energy sector sneezes, the Russian economy catches a cold. In 2014, the government launched the Energy Efficiency and Development programme to tackle the challenges facing the sector, including low energy efficiency, high extraction costs for fuel and the predominant orientation towards traditional sources of energy. Within this programme, funds have been earmarked for the development of electric power engineering and the oil, gas and coal industries – but also alternative energy sources. Since 2010, four technological platforms have been put in place for an Intellectual Energy System (smart system), Environmentally Neutral and Efficient Heat and Power Engineering, Advanced Technologies for Renewable Energy and Small Distributed Generation Systems.

There have been some noteworthy achievements in the field of alternative energy in recent years. High-performance separators, turbines and allied equipment are being used in the construction of new geothermal power stations in Kamchatka and Kurils, for instance. Mini-power plants using biogas generated from waste have also been built in many regions. Engines are also being produced for wind farms and small hydropower plants. In 2013, a complex engineering project got under way to develop the Prirazlomnaya ice-strengthened platform, offering a strong impetus for the exploitation of the Arctic shelf.

A cluster of projects are developing energy-efficient technologies at Skolkovo (Box 13.2). These focus on reducing energy consumption in industry, housing and municipal infrastructure. For example, the New Energy Technologies company is developing efficient thermos-electric generators for the direct conversion of thermal energy into electricity, based on nanostructured membranes and highly efficient solar converters derived from organic polymers. Meanwhile, the Wormholes Implementation company is creating intelligent systems for the monitoring and optimal exploitation of wells, in order to increase the efficiency of oil extraction and oil field development.

Foresight – 2030 identifies 14 thematic areas for highly-promising applied R&D related to energy. These include specific technologies for the efficient prospecting and extraction of fossil fuels, effective energy consumption, bio-energy, storage of electric and thermal energy, hydrogen-based power generation, deep processing of organic fuels, smart energy systems, high-power fourth-generation water-cooled nuclear reactors and optimizing energy and fuel transportation (HSE, 2014c).

A series of pilot innovative territorial clusters

In the past five years, the government has taken steps to strengthen institutional infrastructure for the commercialization and transfer of technology. In 2012, it launched a series of pilot innovative territorial clusters to promote value-added production chains and drive growth in the regions. Initially, 25 clusters were selected on a competitive basis out of nearly a hundred applications. The applicants were cluster consortia grouping industry, research institutes and universities supported by local administrations. The clusters represent a variety of regions stretching from Moscow to the Far East; they specialize in areas ranging from high-tech (ICTs, biotechnology, nuclear energy, etc.) to the more traditional manufacturing sectors of the automotive, shipbuilding, aircraft and chemical industries.

In 2013, the 14 best-prepared clusters received funding from federal and regional authorities on a 50:50 basis (matching principle); in 2014, a further 11 clusters were earmarked for support. The next stage of the national cluster policy will involve creating broader regional cluster programmes and cluster development centres to ensure co-ordination and networking.

Technology platforms to support industry

The first technology platforms were set up in Russia in 2010. They serve as a communication tool to unite the efforts by the state, businesses and the scientific communities to identify challenges, develop strategic research programmes and implementation mechanisms and encourage promising commercial technologies, new goods and services in specific economic sectors. There are currently 34 technology platforms across the country involving over 3 000 organizations: 38% concern businesses, 18% universities, 21% research institutes and the remainder NGOs, business associations and so on. In many cases, the platforms' strategic research programmes have been inspired by the recommendations of *Foresight – 2030* (HSE, 2014c).

Two key tools used to regulate the activity of these platforms are the co-ordination with government technology-oriented programmes and the provision of interest-free loans for innovative projects from the Russian Technology Development Fund, which was renamed the Foundation for Industrial Development in 2014.

Among the best-performing platforms are Medicine of the Future; Bio-industry and Bioresources – BioTech2030; Bio-energy; Environmentally Neutral and Efficient Heat and Power Engineering; Advanced Technologies for Renewable Energy; Technologies for Hydrocarbon Extraction and Use; Hydrocarbon Deep Processing; Photonics; and Aviation Mobility.

All 34 platforms will be evaluated to assess their level of support for industry; the list of platforms will then be adjusted accordingly. State support will only be renewed for those platforms that have demonstrated a high potential and tangible results.

Engineering centres being created at leading universities

Research and federal universities, state research centres and academic institutes form the core of the country's federal centres for collaborative use of scientific equipment, the first of which appeared in the mid-1990s. Since 2013, these centres have been brought together in a network of 357 entities to improve their effectiveness. Their funding comes from the Federal Goal-oriented Programme for Research and Development in Priority Areas. Centres can obtain annual subsidies of up to RUB 100 million (*circa* US$ 1.8 million) for a maximum of three years for a specific project.

Since 2013, a related pilot project to create engineering centres at leading technological universities has got under way. Its objective is to advance university-led development and the provision of engineering and training services. Support comes from budgetary subsidies that offset some of the expenses incurred in carrying out projects in engineering and industrial design: in 2013, each centre received RUB 40–50 million, for a total of RUB 500 million in subsidies.

Red tape holding back technopark development

There are currently 88 technoparks. The main tools of public support for these are the programme for The Creation of High-Tech Technoparks in the Russian Federation (2006) and, since 2009, an annual competitive programme for SMEs. Technoparks mostly specialize in ICTs, medicine, biotechnology, instrument-making and mechanical engineering but one-third (36%) exhibit a cross-sectorial specialization.

Technopark policies are fraught with problems, owing to some 'grey areas' in legislation and organizational procedures. According to the Russian Association of Technoparks in High-Tech Sectors, only 15 technoparks are actually effective.[16] The remainder are in the planning, construction or winding-up stages. The main reason for this is the excessive length of time taken by regional authorities to establish the titles to plots of land and to give town-planning permission, or to render decisions on funding.

16. Some technoparks have failed to achieve prescribed objectives related to the creation of highly skilled jobs, turnover in goods manufacturing, services rendered to resident businesses, etc. See: http://nptechnopark.ru/upload/spravka.pdf

More bridges needed between special zones and the exterior

Special economic zones date back to 2005, when the government decided to instigate a favourable regime for innovative entrepreneurship at the local level. Certain locations were identified specifically to encourage the development of new high-tech businesses and high-tech exports.

By 2014, five such zones were in operation in St Petersburg, Dubna, Zelenograd, Tomsk and the Republic of Tatarstan. These five zones host a total of 214 organizations. Each one benefits from a preferential regulatory environment, such as a zero property tax for the first ten years or other tax benefits, free customs regimes, preferential leasing terms, the opportunity to buy plots of land and state investment in the development of innovation, engineering, transport and social infrastructure. In order to increase the efficiency of these policy instruments, particular attention should be paid to arriving at a critical mass of organizations and to strengthening linkages between residents and the external environment.

TRENDS IN INTERNATIONAL SCIENTIFIC CO-OPERATION

Towards a Common Space for Research and Education with the EU

In recent years, the Russian Federation has made a concerted effort to integrate the international scientific community and develop international co-operation in science and technology. A crucial aspect of this co-operation lies in its ties with the EU, international organizations and regional economic associations.

There has been fruitful scientific collaboration with the EU over the past decade, as confirmed by the extension for another five years of the Agreement on Co-operation in Science and Technology between the European Community and the Russian government in 2014. A roadmap for establishing a Common Space for Reasearch and Education is currently being implemented, involving, *inter alia*, the stepping up of collaboration in space research and technologies. The Agreement for Co-operation between the European Atomic Energy Community and the Russian government in the field of controlled nuclear safety (2001) is currently in force. A joint declaration on the Partnership for Modernization was signed at the Russian Federation–EU summit in 2010.

The Russian Federation also participates in a number of European research centres, including the European Organization for Nuclear Research (CERN) in Switzerland, the European Synchrotron Radiation Facility in France and European X-ray Free Electron Laser in Germany. It is a major stakeholder in several international megascience projects, including the ongoing construction of both the International Thermonuclear Experimental Reactor in France and the Facility for Antiproton and Ion Research in Germany. The Russian Federation also hosts the Joint Institute for Nuclear Research in Dubna, which employs over 1 000 researchers from the Russian Federation and further afield and receives nearly the same number of temporary foreign visitors each year.

Following fairly active participation in the EU framework programmes for research and innovation in the past, Russian research centres and universities are liable to participate in the EU's current Horizon 2020 programme (2014–2020), as members of international consortia. This co-operation is being co-ordinated by a joint committee; in parallel, joint working groups have been set up to manage field-specific joint research calls that are cofinanced by the allied EU and Russian programmes.

The Russian Federation is also developing bilateral ties with European countries through international organizations and projects, such as the UK Science and Innovation Network or the Russian–French collaboration on climate change.

In 2014, a wide array of activities were set in motion as part of the Russian–EU Year of Science. These include the launch of joint projects such as Interact (Arctic research), Supra (next-generation pilot simulators), Diabimmune (diabetic and auto-immune illness prophylactics) and Hopsa/Apos (efficient supercomputing for science and industry) [Ministry of Education and Science, 2014].

Political tensions are affecting some areas of co-operation

Economic sanctions imposed on the Russian Federation by the EU in 2014 are limiting co-operation in certain areas, such as dual-use military technologies, energy-related equipment and technologies, services related to deep-water exploration and Arctic or shale oil exploration. The sanctions may ultimately affect broader scientific co-operation.[17]

Over the past 20–25 years, there has also been significant co-operation with the USA in key areas such as space research, nuclear energy, ICTs, controlled thermonuclear fusion, plasma physics and the fundamental properties of matter. This co-operation has involved leading universities and research organizations on both sides, including Moscow State University and Saint Petersburg University, Brookhaven and Fermi national laboratories and Stanford University. The level of mutual trust was such that the USA even relied on Russian spacecraft to transport its astronauts to the International Space Station after its own space shuttle programme was wound up in 2011.

17. See: http://europa.eu/newsroom/highlights/special-coverage/eu_sanctions/index_en.htm#5

However, these contacts with the USA are now being affected by the recent political tensions over Ukraine. For example, joint efforts to secure nuclear materials actually ceased when the US Department of Energy announced the termination of co-operation in April 2014. For the time being, co-operation between the Russian Federation and the USA is being maintained at the level of particular research centres and universities. This approach was approved, for example, by a meeting of the Skolkovo Scientific Advisory Council in November 2014 in Stanford (USA). At this meeting, several areas were selected for joint activities, namely brain and other bioscience research, molecular diagnostics, environmental monitoring and the forecasting of natural and technogenic emergencies.

Growing collaboration with Asia

Collaboration with the Association of Southeast Asian Nations currently targets joint activities in such high-tech sectors as the commercial development of space (space tourism), prospecting and extraction of minerals (including the use of space technology), materials engineering, medicine, computing and telecommunications. Collaborative projects are also being carried out in the field of renewable energy, biotechnology, atomic energy and education. In 2014, Viet Nam hosted a large-scale presentation of export-oriented Russian technologies. This resulted in a series of concrete agreements to initiate projects in the field of navigation technologies, agricultural biotechnology, energy and pharmaceuticals. An agreement was also reached in 2011 for the development of nuclear energy in Viet Nam using Russian technologies and equipment.

The Republic of Korea is co-operating with the Russian Federation in Antarctic exploration. This joint activity got under way in 2012; it includes the construction of a second Korean science station, assistance with the training of professionals in ice navigation, accompanying the Korean ice-breaker Araon, information exchange and joint research on living organisms found in low-temperature environments. The two countries have also been deepening their co-operation in the pharmaceutical sector since 2013; Russia's Chemical Diversity Research Institute and SK Biopharmaceuticals, on the one hand, and the Korean Pasteur Institute, on the other, have been collaborating on pre-clinical research, clinical trials, new drugs to treat tuberculosis, etc. Moreover, the Russian High-tech Centre ChimRar is currently setting up a joint biotechnology business to engage in research and develop innovative preparations to treat diseases which attack the central nervous system, together with the Korean firm Dong-A Pharmaceutical Co. Ltd.

Dynamic bilateral collaboration with China stems from the Treaty on Good Neighbourliness, Friendship and Co-operation signed by the two countries in 2001, which has given rise to regular four-year plans for its implementation. The treaty provides the basis for about 40 collaborative projects, as well as student exchanges at the secondary and tertiary levels and the joint organization of conferences and symposia, among other forms of co-operation. Dozens of joint large-scale projects are being carried out. They concern the construction of the first super-high-voltage electricity transmission line in China; the development of an experimental fast neutron reactor; geological prospecting in the Russian Federation and China; and joint research in optics, metal processing, hydraulics, aerodynamics and solid fuel cells. Other priority areas for co-operation include industrial and medical lasers, computer technology, energy, the environment and chemistry, geochemistry, catalytic processes, new materials, including polymers, pigments, etc. One new priority theme for high-tech co-operation concerns the joint development of a new long-range civil aircraft. To date, the aircraft's basic parameters have been elaborated, as well as a list of key technologies and a business plan which has been submitted for approval.

The Russian Federation and China are also co-operating in the field of satellite navigation, through a project involving Glonass (the Russian equivalent of GPS) and Beidou (the regional Chinese satellite navigation system). They have also embarked on a joint study of the planets of our Solar System. A resident company of Skolkovo, Optogard Nanotech (Russian) and the Chinese Shandong Trustpipe Industry Group signed a long-term deal in 2014 to promote Russian technologies in China. In 2014, Moscow State University, the Russian Venture Company and the China Construction Investment Corporation (Chzhoda) also signed an agreement to upscale co-operation in developing technologies for 'smart homes' and 'smart' cities' (see also Box 23.1).

We are seeing a shift in Russo–Chinese collaboration from knowledge and project exchanges to joint work. Since 2003, joint technoparks have been operating in the Chinese cities of Harbin, Changchun and Yantai, among others. Within these technoparks, there are plans to manufacture civilian and military aircraft, space vehicles, gas turbines and other large equipment using cutting-edge innovation, as well as to mass-produce Russian technologies developed by the Siberian Branch of the Russian Academy of Sciences.

In the past few years, the government has removed a number of administrative barriers to closer international co-operation with its partners. For example, the visa application process has been simplified, along with labour and customs regulations, to promote academic mobility and flows of research equipment and materials related to collaborative projects.

CONCLUSION

A need for longer-term horizons in policy-making

Despite the current complex economic and geopolitical situation, the Russian Federation has the firm intention of consolidating its national innovation system and pursuing international co-operation. In January 2015, the Minister of Education and Science, Dmitry Livanov, told *Nature* magazine as much. 'There will be no substantial reductions in the level of science funding caused by the current economic situation', he said. 'I strongly believe that scientific co-operation should not depend on temporary changes in the economic and political situation. After all, the generation of new knowledge and technologies is a mutually beneficial process' (Schiermeier, 2015).

The rapidly changing landscape of science and technology – with supply and demand for innovation shifting incessantly – is obliging policy-makers to address longer-term horizons and tackle emerging challenges. In a context of rapidly evolving global economic and geopolitical climates, coupled with growing international competition, both the government and public and private companies need to adopt more active investment strategies. To this end, future policy reforms in the Russian Federation should incorporate:

- preferential support for competitive centres of excellence, taking into account international quality standards for research and the centres' potential for involvement in global networks; research priorities should be influenced by the recommendations of *Foresight – 2030*;
- better strategic planning and long-term technology foresight exercises; an important task for the near future will be to ensure the consistency of foresight studies, strategic planning and policy-making at the national, regional and sectorial levels and that national priorities are translated into targeted action plans;
- greater financial support for the research of leading universities and research institutes, together with incentives for them to collaborate with businesses and investment bodies;
- further development of competitive research funding, coupled with a regular assessment of the effectiveness of budget spending in this area;
- stimuli for technological and organizational innovation in industry and the services sector, including subsidies for innovative companies – particularly those engaged in import substitution – tax deductions for companies investing in high-tech companies, a wider range of incentives for companies to invest in R&D, such as tax rebates and corporate venture funds; and
- regular appraisals of specific institutional mechanisms to support innovation, such as the technology platforms, and monitoring of their funding levels and performance.

STI will obviously develop most intensively in those sectors where resources are concentrated, such as in fuel and energy, traditional high-tech manufacturing and so on. At the same time, we expect to see future STI intensity around newly emerging competitive industries where the conditions for global competition have already been met, such as in advanced manufacturing, nanotechnology, software engineering and neurotechnology.

In order to strengthen domestic STI in a globally competitive environment, Russia needs to establish a climate conducive to investment, innovation, trade and business, including through the introduction of tax incentives and lighter customs regulations. The National Technology Initiative adopted in 2015 has been devised to ensure that Russian companies capture their share of future emerging markets.

It is of vital importance that administrative barriers blocking the entry to markets and the development of start-ups be removed; the intellectual property market must also be further liberalized by gradually reducing the role of the state in managing intellectual property and enlarging the class of owners, with the introduction of support measures to raise demand for innovation. Some of these issues have been addressed in the action plan adopted in 2015 to implement *The Russian Federation's Strategy for Innovative Development to 2020* – the impact of which will be discussed in the next edition of the *UNESCO Science Report*.

KEY TARGETS FOR THE RUSSIAN FEDERATION

- Raise labour productivity by 150% by 2018;
- Increase the share of high-tech industries in GDP by 130% between 2011 and 2018;
- Raise export revenue from nanotech products to RUB 300 billion by 2020;
- Raise GERD from 1.12% of GDP in 2012 to 1.77% by 2018;
- Raise the average salary of researchers to 200% of the average salary in the region where the researcher is based by 2018;
- Raise the share of GERD performed by universities from 9% in 2013 to 11.4% by 2015 and 13.5% by 2018;
- Increase total funding of public scientific foundations to RUB 25 billion by 2018;
- Boost Russia's world share of publications in the Web of Science from 1.92% in 2013 to 2.44% by 2015.

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