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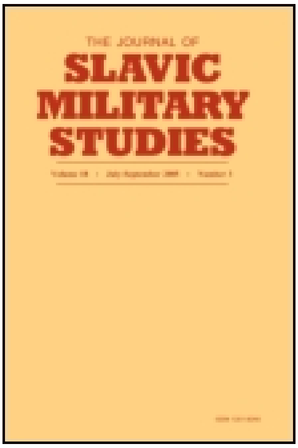

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Russian Science and Technology is Still Having Problems—Implications for Defense Research

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Russian Science and Technology is Still Having Problems—Implications for Defense Research

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Science and technology can play a crucial role in the long-term for the modernization of Russia and the armed forces, and many government initiatives have been approved but their implementation can be questioned. Russia has a strong science base into which it invests substantial funds, but that only to a limited extent generates competitive innovative products and services. The government still hopes the defense sector can be the driving force for innovation that is questioned in this article. The civilian research and development could be the driving force needed for promoting innovations but the problems that remain for the civilian science and technology sector are significant. The reform of the defense industry has been a long-time priority but very slow progress is being made due to difficulties to control it and because the problems facing the defense industries and research and development are even more serious in this sector in spite of large funding increases.

INTRODUCTION

Science and technology (S&T) and especially innovation are high on the policy agenda in Russia. The aim of this article is to discuss the principal

I thank Bengt-Göran Bergstrand of the Swedish Defence Research Agency, Stockholm for preparing Figure 1. This research was carried out in the framework of a project dealing with Russian security policy at the Swedish Defence Research Agency FOI financed by the Swedish Ministry of Defence.

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problems facing Russian S&T and discuss its significance as a contributing factor for the declared policy objectives to develop an innovation-driven economy and modernize the armed forces. Innovation refers to the ability to develop new, commercially viable products on the basis of research and development (R&D). Innovation is closely related to, but not synonymous with, R&D. The approach to design a successful innovation system will depend on the prevailing historical, economic, and technological conditions in a state. The Russian innovation system is characterized by the following features:

- R&D is dominated by government funding and government organizations to a greater extent than in other countries;
- the high proportion of military research is a legacy of the former Soviet R&D system;
- R&D activities are controlled from the top down and have not to large extent been reformed;
- research is fragmented and poorly linked to the education system and market needs.

Privatization of large sectors of Russian industry in the 1990s had grave repercussions for the country's total R&D capability, from which it has not yet recovered. R&D funding from state sources, fell by 75 percent.[1] Disruption of established ties between research institutes, former construction bureaus, and production facilities made it more difficult to convert R&D results into commercial products.[2] Defense-related R&D experienced corresponding reductions in funding by 40 percent.[3] In Russia there was a reorientation of R&D away from military towards civilian goals but analysis shows that this attempt was not particularly successful. The government could not even preserve a critical mass of scientific activities in order to remain internationally competitive in areas of strong scientific achievements, one example being biotechnology.[4]

The situation led to a brain drain where the number of researchers fell from 1,225,000 in 1999 to 376,000 in 2008.[5] Around 10 percent of these went

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1 D. Y. Ball and T. P. Gerber, 'Russian Scientists and Rogue States', *International Security* 29 (2005) pp. 50–77; and Igor Yegerov, 'Post-Soviet Science: Difficulties in the Transformation of the R&D Systems in Russia and Ukraine', *Research Policy* 38 (2009) pp. 600–609.

2 R. Roffey, *Biotechnology in Russia: Why is it not a Success Story?*, Report FOI-R–2986–SE, FOI 2010, Stockholm, pp. 27–28.

3 J. Cooper, 'Military Procurement in Russia', in R. McDermott, B. Nygren, and C. Vendil Pallin (Eds.), *The Russian Armed Forces in Transition: Economic, Geopolitical, and Institutional Uncertainties*, Routledge, London, 2011, Table 9.3, p. 170.

4 I. Yegorov, 'Post-Soviet Science: Difficulties in the Transformation of the R&D Systems in Russia and Ukraine', *Research Policy* 38 (2009) pp. 600–609.

5 J. Cooper, 'The Innovative Potential of the Russian Economy', *Russia Analytical Digest* 88 (2010) pp. 8–12.

abroad, while the remaining 90 percent sought other jobs in Russia.[6] The continuing brain drain of young scientist has effected the average age of researchers and around 50 percent of researchers are over the age of 50, many past retirement age.[7] The problems were similar in civil and military research.[8] Different estimates show that around 25,000–100,000 highly qualified professionals have left the country since 1991.[9] Despite attempts to step-up recruitment of young researchers, the number of research workers was still declining in 2010, mainly as a result of emigration.[10] The World Economic Forum indicates that brain drain was extensive for Russia, ranking 111 out of 144 countries in 2012–2013, falling from a ranking of 98 for 2011–2012. For the quality of research institutes, the ranking was 70 out of 144 countries for 2012–2013 falling from 60 in 2011–2012.[11] It has been assessed that brain drain continues to be one of the main problems for the S&T area.[12] The state is still the dominant actor in Russian R&D, where 73 percent of R&D bodies were state-owned and 77 percent of researchers worked for state organizations.[13] Research fields, such as basic sciences (mathematics, physics, biology, and chemistry), accounted for 77 percent of those who went abroad, and for some research centers, this caused serious problems.[14]

The theoretical base for this study is the knowledge that there is a direct link between S&T development and economic growth. It is probably true that countries that do not innovate fast enough will usually have to continue to rely on exporting raw materials.[15] According to Romer,[16] economic growth for a country will be dependent on education, research, and innovation policies. Edquist[17] and others have further developed a framework generally

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6 I. Yegorov, 'Post-Soviet Science: Difficulties in the Transformation of the R&D Systems in Russia and Ukraine', pp. 600–609.

7 J. Cooper, 'The Innovative Potential of the Russian Economy', pp. 8–12.

8 M. Rabinovich, 'Editorial: Biotech in Russia–Phoenix Reborn from the Ashes', *Journal of Biotechnology* 2 (2007) p. 771; and R. Roffey, *Biotechnology in Russia: Why is it not a Success Story?*, p. 28.

9 L. R. Graham and I. Dezhina, *Science in the New Russia: Crisis, Aid, Reform* Indiana University Press, Bloomington, IN, 2008.

10 E. A. Klochikhin, 'Russia's Innovation Policy: Stubborn Path-dependencies and New Approaches', *Research Policy* 41 (2012) pp. 1620–1630.

11 K. Schwab, *The Global Competitiveness Report 2011–2012* (Geneva: World Economics Forum. 2011), p. 307 and K. Schwab, *The Global Competitiveness Report 2012–2013* (Geneva: World Economic Forum, 2012), p. 305.

12 E. A. Klochikhin, 'The Challenges of Fostering Innovation: Russia's Unstable Progress', *International Journal of Economics and Business Research* 4 (2012) pp. 659–678.

13 OECD, *OECD Reviews of Innovation Policy*: *Russian Federation 2011, Organsation for Economic Co-operation and Development*, Paris, (2011) p. 115–117.

14 A. V. Korobkov and Z. A. Zaionchkovskaia, 'Russian Brain Drain: Myths v. reality', *Communist and Post-Communist Studies* 45 (2012) pp. 327–341.

15 E. A. Klochikhin, 'Russia's Innovation Policy: Stubborn Path-dependencies and New Approaches', pp. 1620–1630.

16 P. M. Romer, 'Increasing Returns and Long-run Growth', *Journal of Political Economy* 94 (1986) pp.1002–1037.

17 C. Edquist (Ed.), *Systems of Innovation: Technologies, Institutions, and Organizations*, Pinter, London, 1997.

used by Organisation for Economic Co-operation and Development (OECD) for national innovation system analysis. This model emphasizes three actors promoting innovation: the production structure (companies), the knowledge infrastructure (universities), and the support structure (public sector).

Russia is an example of a country that specifically targets technologies, such as nanotechnology and biotechnology, to concentrate resources where breakthroughs are hoped, rather than spreading resources in all potential innovation areas. The Russian government is also one of the world's largest investors in nanotechnology R&D and it is hoped that this will push the entire innovation area forward in Russia.[18] One feature of the innovation policies in Russia is the focus on the issues of science and less on innovation, as such. This study focuses on the national dimension of innovation and S&T development in Russia and its potential implications for the defense sector that has not been much discussed in Western publications.

R&D policies are shaped and implemented predominantly at the national federal level, by the government. Modernization and innovation has been given high priority by the Russian government and it has established the Government Military-Industrial Commission[19] and the Presidential Council for Economic Modernization and Innovative Development[20], and the Council for Science and Education to coordinate, prioritize, and frame future research and innovation policy at the national level.[21] In November 2008, the government adopted the concept for long-term socioeconomic development of the Russian Federation, which explicitly set the goal of modernizing the country and achieving the technological edge.[22] The regions have limited tasks and resources for R&D available, but their relevance is increasing.[23] More than 30 regions have, in the past few years, established their own S&T support programs focusing on applied research and innovation (e.g., in Moscow, St. Petersburg, Nizhny Novgorod, Novosibirsk, Tomsk and Tatarstan).

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18 F. Westerlund, *Russian Nanotechnology R&D: Thinking Big About Small Scale Science*, FOI—3197-SE, Stockholm, FOI.

19 Russian Government, 'Government Military-Industrial Commission', http://government.ru/eng/gov/agencies/134/ (assessed 10 January 2013).

20 President of Russia, 'Executive Order on Council for Economic Modernisation and Innovative Development', 18 June 2012, http://eng.state.kremlin.ru/council/30/news/4043 (assessed 20 January 2013).

21 President of Russia, 'Executive Order on the Presidential Council for Science and Education Signed', 30 July 2012, at http://eng.kremlin.ru/news/4240 (assessed 20 January 2013).

22 Russian Government, *The Concept for Long-term Socioeconomic Development of Russia till 2020*, Approved 17 November, 2008, Decree No. 1662-p.

23 EraWatch, 'Russian Federation, Regional Research Policies', European Commission, Brussels, 2012, http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/ru/country?section=RegionalResearchPolicies&subsection=Overview (accessed 20 December 2012).

R&D—INSTITUTIONAL REFORMS

In Russia, the top universities are Lomonosov Moscow State University, St. Petersburg State University, Moscow State Engineering Physics Institute, National Research University Higher School of Economics, and Novosibirsk State University. In the international ranking systems, Russian universities are not scoring well. Lomonosov Moscow State University ranked 116 and St. Petersburg State University ranked 253 out of 600 in the Quacquarelli Symonds World University Rankings (QS) list of world-leading universities in 2012.[24] Similar rankings are found according to the Times Higher Education World University Rankings 2012–2013.[25] Russian authority response was that they were working with international specialists to create their own 'international and universal' university rating.[26] In 2010, Russian researchers had concluded that the state of Russian research was in such a serious state that 185 leading foreign-based Russian scientists sent an open letter to, at the time, President Dmitri Medvedev and Prime Minister Vladimir Putin, warning of a total collapse of Russian research unless something was done to improve the situation.[27]

Russian research is not, in general, very competitive in an international comparison, accounting for only 1.5 percent of all published papers in 2008. The corresponding figures for Sweden, the United States, and China were 0.8, 16.3, and 12.3 percent, respectively. In that same year, 174 scientific publications per million inhabitants were published in Russia. The corresponding figure for Sweden was 1,570. Frequency of publication in Russia, unlike China, has remained largely unchanged since 1981.[28] The number of researchers per million people had fallen to 2,602 in 2009 from 7,266 in 1991 (Rosstat, 2010)[29]. In 2003, there were 26,200 publications in the Web of Science that increased to 29,800 publications in 2009, and decreased to 28,900 in 2010. A further decrease of the number of Russian publications

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24 QS Top University Ranking 2012, http://www.topuniversities.com/institution/saint-petersburg-state-university/wur (accessed 22 December 2012); and K. Novikova and M. Kuiri, 'Russian Higher Education Reform–Designed to Approach World Top Universities', Expert article 1177, 19 December, *Baltic Rim Economies Quarterly Review* 6 (2012) p. 53.

25 The Times Higher Education World University Rankings 2012–2013, http://www.timeshighereducation.co.uk/world-university-rankings/2012-13/world-ranking/range/001-200 (accessed 22 December 2012).

26 S. Kishovsky 'Russia Moves to Improve Its University Rankings' *The New York Times*, 25 March 2012, http://www.nytimes.com/2012/03/26/world/europe/russia-moves-to-improve-its-university-rankings.html?pagewanted=all&_r=0 (accessed 11 December 2012).

27 'Editorial: Scientific Glasnost', *Nature* 464 (2010) pp. 141–142.

28 Ibid., Figure 1.35, p. 112.

29 Rosstat, 'Russian Statistical Yearbook. 2010' *Statistics Digest*, Moscow, 2010, http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/en/figures/education/ (accessed 10 December 2011).

is forecast by some analysts as much as 10 percent from the 2009 level.[30] In comparison, China had 31,048 publications in 2000, which has increased to 131,545 publications by 2009.[31] Russia has not been very successful in improving the number of patent applications, which was 23,377 in 2000, and not many more in 2009 with 25,598. China, in comparison, has shown a large increase in patent applications.[32]

Four bodies dispose of a major share of the state civil R&D budget: the Russian Academy of Sciences (RAS) with 50,000 scientists, around 400 institutes[33] and spending a third of the civil research budget, the Federal Space Agency (Roscosmos) is responsible for Russia's space program,[34] the State Corporation for Atomic Energy (Rosatom), and the Ministry of Industry and Trade. A further three bodies, the Russian Foundation for Basic Research (RFBR), the Russian Foundation for Humanities (RFH), and the Foundation for Promotion of Small Enterprises and Technology (FASIE) share a smaller portion of the R&D budget through a competitive procedure.[35] In addition, certain ministries, including the Ministry of Defense, have their own R&D budgets. There are also around nine venture funds, including Russian Venture Company (RVC) and Russian Corporation of Nanotechnologies (RUSNANO) for investing in innovations.[36]

The strength of Russian research lies traditionally in basic research, while applied research is lagging behind in comparison to OECD countries. The RAS was responsible for 45 percent of all publications in state research institutes from 1996–2007, and carried out 50 percent of all basic research in Russia. An analysis of research production at the RAS, however, showed that 50 percent of researchers were unproductive and that only 25 percent were engaged in competitive research in 2007.[37] The Russian government is attempting, in various ways, to diminish RAS influence by reducing its funding and investing in other government initiatives, such as research foundations and federal target programs.[38]

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30 E. Onishchenko, 'The Number of Russian Publications Will Decrease by Around 10%', 2011 (in Russian), http://www.gazeta.ru/science/2011/11/17 a 3837722.shtml (accessed 18 August 2012).

31 E.A. Klochikhin, *Mutual Learning in the Global Innovation System: A Comparison of S&T Transitions in Russia and China*, Manchester Institute of Innovation Research, Manchester Business School, University of Manchester, Manchester UK, 2012, Table 1, pp. 9–10.

32 Ibid., p. 15.

33 Q. Schiermeier, 'Putin Promises Science Boost, but Russian Researchers are Sceptical of Ambitious Schemes', *Nature* 483 (2012) pp. 253–254.

34 EraWatch, 'Russian Federation: Research Performers, Public Research Organisations', European Commission, Brussels, 30 April 2010, http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&topicID=67&parentID=65&countryCode=RU (accessed 26 August 2010).

35 Ibid., p. 193.

36 I. Dezhina, 'Policy Framework to Stimulate Technological Innovations in Russia', *Journal of East-West Business* 17 (2011) pp. 90–100.

37 Q. Schiermeier and K. Severinov, 'Russia Woos Lost Scientists: Minister of Education and Science Discusses Plans for Rebuilding the Country's Research Base', *Nature* 465 (2010) p. 858.

38 OECD, *OECD Reviews of Innovation Policy . . .*, p. 214.

There was a strategy from 2006 and a comprehensive program from 2007 for the development of science and innovation in Russia up to the year 2015.[39] Detailed priorities are specified in the List of Critical Technologies set by the President in 2005. The first list, containing 70 critical technologies, was drawn up in 1996, and by 2011 the numbers had been reduced to 27.[40] The priority areas of S&T in 2011 were:[41]

- security and antiterrorism;
- life sciences;
- industry of nano-systems and materials;
- information and telecommunication systems;
- advanced weapons, military and special technologies;
- sustainable use of environment;
- transport, aviation and space systems; and
- energy and energy saving.

A series of measures have been taken to restructure the university and R&D system. Funds have been allocated to certain universities and institutes in view of their special status.[42] These include:

- the Kurchatov Institute, a national research centre with special responsibility for innovation and coordinating R&D in nanotechnology;
- two national universities: Moscow State University and St. Petersburg State University;
- twenty-seven national research institutes, for integration of research into relevant university courses;
- fifty-nine state-run research centres, many undertake defense-related research;
- seven regional federal universities, by merging several universities and leading educational establishments;
- fifty-seven so-called innovative universities have been supported with modern equipment, new technologies and personnel;[43]

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[39] Russian Ministry of Education and Science, 'Strategy for the Development of Science and Innovation in the Russian Federation up to the Year 2015', 2006, http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/ru/policydocument/policydoc_mig_0001 (accessed 22 December 2012); and Russian Ministry of Education and Science, 'Comprehensive Programme for the Scientific-Technological Development and Technological Modernisation of the Economy of the Russian Federation up to the year 2015', 2007, http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/ru/policydocument/policydoc_mig_0004 (accessed 22 December 2012).

[40] OECD, *OECD Reviews of Innovation Policy. . .*, p. 204; and President of Russia, 'Development Priorities in Science, Technology, and Engineering in the Russian Federation Have Been Approved', 7 July 2011, http://eng.state.kremlin.ru/face/2530 (accessed 4 August 2011).

[41] Ibid.

[42] OECD, *OECD Reviews of Innovation Policy. . .*, pp. 212, 220, 231–232.

[43] A. Fursenko, 'Speech of the Minister of Education and Science of the Russian Federation Andrei Fursenko at the Meeting of the "Government hour" in the Federation Council of Russia', on March

- thirty federal research and production centers (FRPC);
- twenty-four special economic zones, of which four will concentrate on innovative production;
- there are around 100 Technology Transfer Centers (TTC) at higher-education institutions to support partners search for technology development and implementation;[44]
- fourteen science cities; at the end of the Soviet era there were 60 science cities;[45]
- technoparks (around 80) are operational, but few of them develop new technologies, to attract companies to settle next to research institutes and establish high tech start-up companies, 11 of which are included in a federal program.[46]

There are funding programs targeted at young scientists—so-called Presidential Grants. In an initiative aimed at persuading Russian researchers based abroad to return home, RUB 12 billion were appropriated for research grants of RUB 150 million each, to be applied for on a competitive basis. This has, so far, not been very successful.[47] Postgraduate students continue, however, to leave Russia, partly to avoid military service but also due to unsatisfactory working conditions.[48] In 2010, the government allocated RUB 19 billion to promote industrial enterprises to place orders in educational institutions and contribute to funding for these projects so as to change companies' attitudes to institutions of higher education.[49] To facilitate innovative activities at universities, a law regulating spin-offs or partnerships at research institutes and intellectual property rights came into force in 2009.[50]

The Skolkovo initiative, implemented by former President Dmitri Medvedev, aims to stimulate innovation by attracting leading researchers, universities, and foreign high-tech companies (e.g., Microsoft, Cisco, Nokia, and Siemens) and is intended to serve as a model for the promotion of innovative activities in Russia.[51] By 2011, 83 companies from various regions in Russia had joined.[52] Skoltech, the science and technology institute,

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25, 2009', Federation Council of Russia, Moscow, 2009, http://eng.mon.gov.ru/ruk/ministr/dok/4199/ (accessed 22 December 2012).

44 FinNode, 'Russian Innovations Strategy 2020 in Brief', *FinNode Network*, 8 February 2012.

45 OECD, *OECD Reviews of Innovation Policy*. . ., p. 234.

46 Ibid., p. 232.

47 Schiermeier, 'Russia Woos Lost Scientists: Minister of Education and Science Discusses Plans for Rebuilding the Country's Research base', p. 858.

48 'Russian Science: What the Scientists Say', *Nature* 449 (2007) pp. 528–530.

49 Russian Government, 'Prime Minister Vladimir Putin meets with Minister of Education and Science Andrei Fursenko', Events, Russian Government home page, 2010, http://government.ru/eng/docs/11241/ (accessed 12 December 2011).

50 EraWatch, 'Russian Federation, Research Performers, Higher Education Institutions', European Commission, Brussels, 2012.

51 'On the Skolkovo Innovation Center', Federal Law No. 244-FZ of September 28, 2010.

52 OECD, *OECD Reviews of Innovation Policy*. . ., based on Table 3–5, p. 236.

established the biggest development fund in Russia: approximately $570 million in 2012 and part of this comes from state companies that transfer 1 percent of the budget to the Skolkovo Scientific Fund. Around 15 percent of the funds will be provided as grants each year.[53]

Skolkovo focuses on activities in energy efficiency and energy-saving, nuclear energy technology, space technology, health technology, strategic computer technology, and software. Although Skolkovo could have an important role to play in the Russian innovation system, it can mainly be seen as a symbol of innovation, elite research, and an instrument for marketing Russia as an innovative, investor-friendly economy.[54] The government will open more high-tech research centers across Russia and 25 pilot innovative territorial clusters have been selected in 2012 that can receive benefits of the Skolkovo Center residents. The clusters will stimulate cooperation among companies, research, higher-education institutions, and support the development of small and medium enterprises (SME).[55]

It should be noted that Russia is regarded as successful in a number of areas, including aviation, nuclear technology, and information technology. Russia is also still relatively successful in regard to space exploration, although there have been problems lately with a number of space launches. In the nuclear field, Russia occupies a strong position in uranium enrichment technology, new types of fast neutron reactor, and breeder reactors. Russia has enjoyed a strong position in the information technology (IT) sector, particularly in the software field, as shown by its rapidly growing exports.[56] Russia is hoping to promote innovation growth by supporting and consolidating important research intensive industrial sectors in recent years into huge state corporations like Rosatom (200 enterprises, 70 R&D institutes, and 300,000 employees), United Aircraft Corporation, and Russian Technologies State Corporation (RTSC) (Rostechnologii) for automobile and military technologies. It is well-known, though, that state-owned companies in Russia have been ineffective with low-level productivity and widespread corruption.[57] Additionally in 2009, only 8 percent of companies in Russia were conducting technological innovations, in comparison to Germany's 64 percent.[58]

During the past few years, Russia has spent slightly above 1 percent of gross domestic product (GDP) on R&D, for example in 2010, it spent 1.11

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53 RT, 'Skolkovo to Get Russia's Biggest Development Fund', *Russia Today*, 21 March 2012.
54 OECD, *OECD Reviews of Innovation Policy*. . ., p. 236.
55 EraWatch, 'Innovative Territorial Clusters Selected', European Commission, Brussels, 2012.
56 OECD, *OECD Reviews of Innovation Policy*. . ., Table 3.2, p. 227.
57 E. A. Klochikhin, *Mutual Learning in the Global Innovation System: A Comparison of S&T Transitions in Russia and China*, Manchester Institute of Innovation Research, Manchester Business School, University of Manchester, Manchester, UK, 2012, p. 14.
58 I. Dezhina, 'Policy Framework to Stimulate Technological Innovations in Russia', *Journal of East-West Business* 17 (2011) pp. 90–100.

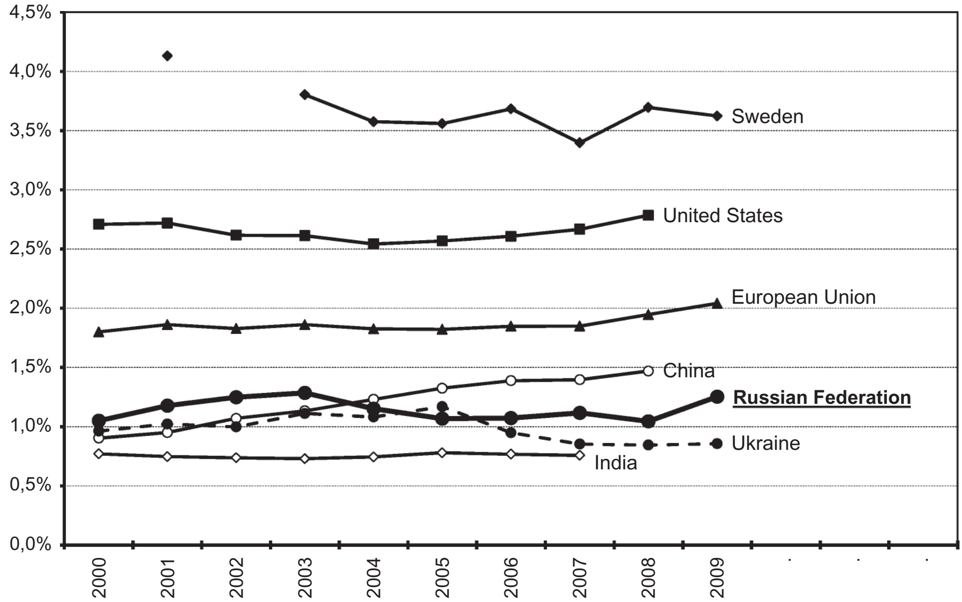

FIGURE 1 Comparison of costs for R&D in Sweden, United States, UK, EU 27, China, Russia, Ukraine, and India as percentages of GDP. Source: Figure based on calculations by multiplying World Bank Indicator R&D shares of GDP with indicator GDP amounts: at, http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS and http://data.worldbank.org/indicator/NY.GDP.MKTP.CD (accessed 10 January 2013).

percent of GDP on R&D as compared to Sweden spending 3.6 percent of GDP. As the GDP strongly expanded up to 2008 at growth levels of around 7 percent, funding inflows in R&D have in absolute figures grown substantially from RUB 46 billion in 1999 to RUB 485.8 billion in 2009; despite this, Russian science does not show signs of rapid recovery.[59] Figure 1 compares R&D expenditure as a percentage of GDP for the EU and a number of other countries. Russia, which ranks near the bottom,[60] has ambitious plans to increase expenditure on R&D to 2.5–3 percent of GDP over the next ten years.

Block funding to public R&D institutions and publicly owned companies is still the most important allocation pattern, but the amount allocated through competition is increasing and in 2012 is around 50 percent.[61] In a study that evaluated 82 countries by merging indicators, such as technology, number of researchers, research investment, and innovation, into a global

59 O. V. Fomichev (Ed.), Strategy *for Innovation-Driven Development of the Russian Federation for the Period Ending in 2020*, Ministry of Economic Development of the Russian Federation, Ministry of Education and Science of Russian Federation, National Research University Higher School of Economics, HSE Publishing House, Moscow, 2012, p. 19.

60 OECD, *Main Science and Technology Indicators*, vol. 1, OECD, Paris, 2009, Table 2, p. 25.

61 OECD, *OECD Reviews of Innovation Policy*. . ., p. 198–200.

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creativity index, Sweden was at the top of the list while Russia ranked thirty-third.[62] Competitive scientific research is an important source of innovation potential in the long-term and the World Economic Forum (WEF) indicates that the 2012–2013 Global Competitiveness Index for Russia was 67 out of 144 countries—the same as the previous year. Sweden ranked number 4 in 2012–2013. For the innovation and sophistication factor, Russia ranked 108 for 2012–2013, while Sweden ranked number 5 out of 144 countries.[63]

FEDERAL TARGET PROGRAMS

Fifty-one Federal Target Programs (FTP), inspired by the EU Framework Programs for R&D, have been introduced in order to speed up Russia's modernization. Twelve of these target programs are concerned with science, technology, and innovation. These programs mark a shift from block funding toward more competitive allocation of funds and to enhance public private collaboration in funded projects.[64]

The purpose of FTP are to speed up technological and scientific development in priority areas appearing on a list of critical technologies.[65] Initial funding for FTP, prioritizing R&D, was RUB 195 billion, including RUB 61 billion from the business sector.[66] The budget for the program was reduced by 30 percent in 2009 due to the economic crisis, and further reductions were made in 2010; the program has consequently been extended.[67] One of its aims was to bridge the gap between research and development of commercially viable products. An anti-crisis program was adopted in 2010 that included special funds for stimulation of innovation activities.[68]

Technology platforms have been stimulated by cooperation in the EU seventh Framework Program (FP7), for example, for agriculture and the life sciences, which brings research institutes and companies together. A competition in April 2011 resulted in the selection of 27 Russian technology

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62 R. Florida, C. Mellander and K. Stolarick, *Creativity and Prosperity: The Global Creativity Index,* Martin Prosperity Institute, Toronto, 2011.

63 Schwab, *The Global Competiveness Report 2012–2013*, Table 3, p. 13.

64 EraWatch, *Research Inventory Report for: Russian Federation*, European Commission, Brussels, 2010, http://erawatch.jrc.ec.europa.eu/erawatch/export/sites/default/search/countryprofiles/country_profile_RU.pdf (accessed 20 November 2011), p. 5.

65 EraWatch, *R&D in the Priority Directions for the Development of the Scientific-Technological Complex of Russia 2007–2012*, *Erawatch*, European Commission, Brussels, 2010, http://cordis.europa.eu/erawatch/index.cfm?fuseaction=prog.document&uuid=E1AE722E-0754-2D00-2686B1B398A86814 (accessed 20 July 2011).

66 EraWatch, *R&D in the Priority Directions for the Development of the Scientific-Technological Complex of Russia 2007–2012*, *Erawatch*, Appenix 3, och 6.

67 OECD, *OECD Reviews of Innovation Policy. . .*, p. 198–200.

68 EraWatch, *Research Inventory Report for: Russian Federation*, European Commission, Brussels, 2010, http://erawatch.jrc.ec.europa.eu/erawatch/export/sites/default/search/countryprofiles/country_profile_RU.pdf (accessed 20 November 2011).

platforms, which will be supported with public funds. Technology platforms have been set-up, for example, in the energy, life sciences, and agriculture fields.[69]

Putin promised before the presidential election in 2012 to substantially increase the public funding for basic and applied research. In addition, he indicated that the criticized lack of fair grant assessment procedures must become more transparent and open to genuine competition.[70] Recently, a strategy for innovation policy Innovative Russia 2020 was created, prepared by the Ministry of Economic Development, and approved at the end of 2011.

NEW STRATEGY FOR INNOVATION POLICY

An innovation strategy was developed based on the concept of long-term socio-economic development of the Russian Federation up to the year 2020.[71] The Russian policy for innovation, entitled 'Innovative Russia 2020', was approved in December 2011 with the following aims:[72]

- increase the share of Russia's exports of high-tech goods in the total global high-tech exports to 2 percent by 2020 (from 0.25 per cent in 2008);
- increase the share of innovation-based products in the overall industrial output to 25–35 percent by 2020 (from 4.9 percent in 2010);
- increase the domestic R&D expenses to 2.5–3 percent of the GDP by 2020 (from 1.3 percent in 2010), including over half at the expense of the private sector;
- the share of university research to reach 30 percent in overall research funding provided by the state;
- increase the share of papers published by Russian researchers in the total number of papers published in global scientific magazines to 3 percent by 2020 (from 2.08 percent in 2010);
- increase the number of references per publication by Russian researchers in scholarly journals indexed in the Web of Science database to 4 references by 2020 (from 2.4 references per article in 2010);
- increase the number of Russian higher education establishments ranked in the top 200 global universities according to QS World University Rankings to 4 by 2020 (1 in 2010);

69 OECD, *OECD Reviews of Innovation Policy. . .*, p. 220.

70 'Putin Promises Science Boost', *Nature* 483 (2012) p. 253.

71 EraWatch, *Concept of Long-term Socio-Economic Development of the Russian Federation for the Period up to the Year 2020*, The Ministry for Economic Development of the Russian Federation, 1 November, 2008, European Commission, Brussels, 2010, http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/ru/policydocument/policydoc_mig_0005 (accessed 23 September 2011).

72 O. V. Fomichev (Ed.), *Strategy for Innovation-Driven Development of the Russian Federation for the Period Ending in 2020*, p. 134.

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- increase the number of patents annually registered by Russian natural and legal persons with the patent offices of the EU, United States„ and Japan to 2,500–3,000 patents by 2020 (63 patents in 2009);
- the level of the economy's spending on scientific research, education, and support for innovation should reach that of the OECD countries by 2020;
- achieve a leading position in fundamental and applied research, plus associated technologies, including information technology, nanotechnology, and biotechnology.[73]
- Russia's share in the global market of high-tech goods and services is hoped to reach 5–10 percent by 2020 in such areas as:[74]
  - nuclear technology,
  - aircraft manufacturing,
  - shipbuilding,
  - software,
  - arms and military equipment,
  - educational services, and
  - outer space services manufacture of rockets and space equipment.

Special care will be taken to ensure that the innovation strategy is implemented in the defense industry, in areas where Russia has performed well. Defense-related R&D will, according to the innovation strategy, be a decisive factor for national security, as well economically, and will help advance other sectors of the economy.[75]

INTERNATIONAL COOPERATION AND INDUSTRIAL ESPIONAGE

The government is promoting greater engagement of Russian research organizations and companies in international S&T cooperation, and participating in research projects for the purposes of integration into the European research space.[76] The 2003 EU–Russia agreement on common spaces made provisions for research and education/training. Russia's cooperation priorities are:[77]

- information, telecommunications, and electronics;
- nanotechnology and materials;
- life sciences;

[73] Ibid., p. 86.
[74] Ibid., p. 26.
[75] Ibid., p. 111.
[76] Ibid., p. 123.
[77] *Russian National Contact Point (RNCP) on Biotechnology, Food and Agriculture (2009) BILAT-RUS Project*, http://www.fp7-bio.ru/en/fp7-projects-of-russia/bilat-rus/ (accessed 20 October 2009).

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- environmental protection and management;
- energy and energy saving;
- security and counter-terrorism; and
- advanced machinery and equipment.

Scientific cooperation is viewed as successful and as one of the few areas where EU–Russian cooperation worked reasonably well.[78] The EU-Russian Partnership for Modernization, adopted in 2010, has not made much progress, though.[79] Many EU member states have also entered into bilateral cooperation agreements with Russia, including Germany, France, the UK, and the Netherlands.[80] European and Russian researchers and research bodies have worked together in various programs funded by the EU and international organizations, such as the International Science and Technology Center (ISTC). Russia, however, has decided to leave the ISTC in 2015.[81] In addition, Russia maintains its cooperation with countries in the Commonwealth of Independent States (CIS) and with the United States in specific areas. There is a U.S.–Russia Innovation Council on High Technology, as well as the India–Russia Joint Science and Technology Centers that assist in the development and commercialization of technologies, including nanotechnology, bio-medicine, and super-computing.[82]

Another priority is Russian participation in multilateral mega-scientific research projects, such as the Large Hadron Collider (LHC), the world's largest and most powerful particle accelerator at the European Organization for Nuclear Research (CERN). Russia will be taking part in four foreign mega-projects, in cooperation with the EU. These are intended to reverse the exodus of Russian researchers and attract foreign researchers.[83] How successful the strategy will prove remains to be seen.

However, it has become more difficult for researchers in Russia to cooperate with foreign researchers due to the risk of being accused of working as

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[78] European Commission, *Compendium on Science & Research Cooperation between the European Union and the Russian Federation,* European Commission, Brussels, 2009; and EraWatch, *Research Inventory Report for: Russian Federation' (Brussels: European Commission*, 2010, p. 10, http://cordis.europa.eu/erawatch (accessed 20 November 2011).

[79] European Union, 'Joint Statement on the Partnership for Modernisation EU-Russia Summit 31 May–1 June 2010', Presse 154, 10546/10, Rostov (1 June 2010).

[80] European Commission, *Compendium on Science & Research Cooperation between the European Union and the Russian Federation*.

[81] G. E. Schweitzer, 'The Life and Legacy of Moscow's Science Center', *Bulletin of the Atomic Scientists*, (2012), http://www.thebulletin.org/web-edition/op-eds/the-life-and-legacy-of-moscow%E2%80%99s-science-center (accessed 11 September 2012).

[82] 'Russia–India Sign Defence Deals Worth $4 billion', *Daily News and Analysis*, 24 December, 2012, http://www.dnaindia.com/india/report_russia-india-sign-defense-deals-worth-4-billion_1781337 (accessed 15 January 2013).

[83] 'Prime Minister Vladimir Putin Holds a Session of the Government Commission on High Technology and Innovation in Dubna', Government of the Russian Federation, 5 July 2011, http://government.ru/eng/gov/priorities/docs/15785/ (accessed 18 July 2011).

a spy by the Russian Federal Security Service (FSB). A law has been passed broadening the definition of treason to include 'providing financial, technical, advisory, or other assistance to a foreign state or international organization'.[84]

Russia's aspiration to become a leading actor in highly competitive R&D areas makes industrial espionage a tempting proposition. The Russian FSB is required by federal law to gather intelligence information 'to assist the country's economic development and scientific and technical progress and ensuring the Russian Federation's military-technical security'. Russia is often accused of committing industrial espionage on a large scale, specifically involving high-tech operations in both military and civil R&D.[85] Industrial espionage can do more harm than good; when discovered, it can damage the country's reputation as well as its prospects of cooperation with foreign researchers and businessman. Deriving prompt benefit from acquired R&D intelligence information requires considerable scientific and industrial resources to be useful.[86]

R&D PERFORMANCE IN THE BIOTECHNOLOGY AREA

In order to study how well Russia's R&D system functions, biotechnology was used as a case study.[87] The reason for this was that Russia inherited a solid R&D foundation in biotechnology from the extensive Soviet-era military biological weapons program.[88] In 1991, there was a well-established R&D sector in Russia and many highly qualified researchers and research institutes. Around 50 institutes and 60,000 persons were involved that could be a good base to develop advanced R&D and a competitive biotechnology industry. Despite this, efforts to maintain and develop this area as a basis for an internationally competitive biotechnology and pharmaceutical industry have not been very successful so far. There have been several governmental programs to develop this research area; inadequate funding led many leading researchers to move abroad or seek other forms of employment. Poor working conditions, limited research funding, unwelcome government control over scientific activities, and lack of international cooperation have hampered efforts to induce researchers to return.[89]

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84 'Will Russian Science be Stunted by Putin's fear of Espionage?' *Time*, (2012), http://world.time.com/2012/12/13/will-russian-science-be-stunted-by-putins-fear-of-espionage/ (accessed 22 December 2012).

85 F. Westerlund, *Russian Intelligence Gathering for Domestic R&D—Shortcut or Dead End for Modernization?* FOI Memo 3126, FOI, Stockholm, 2010.

86 Roffey, *Biotechnology in Russia. . .*, p. 70–73.

87 Ibid.

88 M. Leitenberg and R. A. Zilinskas, *The Soviet Biological Weapons Program: A History*, Harvard University Press, London, 2012.

89 Roffey, *Biotechnology in Russia. . . .*, p. 112–119; and Q. Schiermeier, 'Russia's International Research Ties under Threat', *Nature* 455 (2008) p. 6.

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Russia's biotechnology industry has suffered from structural defects and ageing equipment since 1990. Products do not meet high international standards and marketing experience and leadership are lacking. The breakdown in many cases of good working relations between research and production units has widened the gap between researchers' ideas and those who turn these into commercially viable products. The explanation for this may be that much of the work in the biotechnology field was defense-oriented and so-called civil research was merely a cover for secret military research. In 2005, the Russian government began to talk of prioritizing biotechnology and to recognize that the economic and legal framework would have to be improved if the industry was to develop. Support was forthcoming both from stakeholders and the Duma.[90] According to the Russian Federation Ministry of Education and Science, RUB 27.3 billion were spent from 2007–2011 on research projects in the life sciences.[91] A total of 1,000 institutes were engaged in biotechnology-related work in Russia in 2009.[92] Russia ranked 17th in terms of citations in international biotech journals, and 18th in terms of the number of patents taken-out in the countries studied. It may be noted that here, Sweden ranked 12th and 20th, respectively.[93] Using another ranking system for biotechnology Russia ranked as 16 in 2005, which had decreased to 25 in 2011—a clear negative trend.[94]

Although Russia has long prioritized a competitive biotechnology and pharmaceutical industry, this has been difficult to achieve. There has been no lack of government programs aimed at promoting the development of the biotechnology and pharmaceutical industries. Former President Medvedev in 2009 declared that modernization was of the highest importance in the medical technology and pharmaceutical industries.[95] As early as 2008, a strategy was launched for the pharmaceutical industry to re-establish domestic pharmaceutical production by 2020.[96]

The year 2006 saw the launching of a national program entitled, Biotechnological Development in Russia in 2006–2015. The program was further elaborated into a strategy for the biotech industry.[97] The Ministry of

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90 Roffey, *Biotechnology in Russia. . .*, p. 75–79; and Russian Society of Biotechnologists, 'National Program: Biotechnology in the Russian Federation, 2006–2015, Based on Public-Private Partnership', *Russian Society of Biotechnologists*, 2005, http://bioros.tmweb.ru/papers-society/programma_razvitia.doc (accessed 24 February 2009).

91 State Coordination Program for the Development of Biotechnology in the Russian Federation until 2020 Moscow, 2012, Approved by Prime Minister of the Russian Federation V. Putin, 24 April 2012.

92 Rabinovich, 'Editorial: Biotech in Russia—Phoenix Reborn from the Ashes', p. 771.

93 Roffey, *Biotechnology in Russia. . ..*, Table 4, p. 56.

94 Ranking system, number of publications PubMed, number of patents EspaceNet and number of biotechnology companies, as described in BWPP*, BioWeapons Monitor 2011*, Table, BioWeapons Prevention Project, Geneva.

95 Ibid., pp. 107–108.

96 Ibid., pp. 108–110.

97 Roffey, *Biotechnology in Russia. . ..*, pp. 79–85; and 'Putin Orders Russian Biotech Plan by May', *UPI World News*, 1 April 2011, http://www.upi.com/Top_News/World-News/2011/04/01/Putin-orders-Russian-biotech-plan-by-May/UPI-82221301673754/ (accessed 20 September 2011).

Defense took part in drawing up the national program but kept its own investment in R&D in biotechnology and protection against biological and chemical weapons under strict control. Biotechnology was included in the so-called military critical technologies. An explicit policy ambition in 2011 was to invest in biotechnology R&D and industrial applications for the civil and military sectors.[98]

The State Coordination Program for the Development of Biotechnology was approved 2012.[99] The fist stage of the program is from 2011–2015, and the second stage is 2016–2020.[100] Russia is to achieve a leading position in the development of biotechnology, including certain areas of biomedicine, agro-biotechnology, industrial biotechnology, and bio-energy, and the creation of the globally competitive sector of bio-economy, which along with nano-industry and information technology, should become the basis for modernization and creation of post-industrial economy. The aim of the program to 2020 is to:

- increase consumption of biotechnology products in Russia by a factor of 8.3;
- increase production of biotechnology products in Russia by a factor of 33;
- reduce import share in consumption of biotechnology products by 50 percent;
- increase export share in the production of biotechnology products by a factor of more than 25;
- increase level of biotechnological production in Russia to 1 percent of global GDP by 2020 and further to at least 3 percent of GDP by 2030; and
- increase the number of approved original biopharmaceuticals to 19 by 2015 and up to 50 by 2020.[101]

A five-fold increase in the number of biotechnology research groups between 2010 and 2020 would entail considerable investment. Increasing the number of domestically produced pharmaceutical products for clinical testing from 5 in 2010 to 30 in 2020 is seen as unrealistic, as is the objective of reducing the share of imported pharmaceuticals from 90 to 70 percent.[102] The fast development of biotechnology will be promoted by the implementation of measures according to the Strategy of the Innovative Development of the Russian Federation until 2020.[103] Experience gained from the implementation

98 Roffey, *Biotechnology in Russia. . .*, s. 112–119.
99 State Coordination Program for the Development of Biotechnology in the Russian Federation until 2020 Moscow.
100 Ibid.
101 Ibid.
102 Ibid., Table 7, pp. 84–85.
103 Fomichev, *Strategy for Innovation-Driven Development of the Russian Federation for the Period Ending in 2020.*

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of previous programs has not been particularly encouraging as these were either not implemented in full or were unrealistic. Regional initiatives will be promoted as well as international cooperation including in the EU Framework Programs.[104] Foreign biotechnology companies have not shown an interest so far to move production to Russia.[105]

However, R&D funding is still low by international standards, despite the government's initiatives. The global biotechnology market share of Russia is currently less than 0.1 percent.[106] In 2009, Russia was only ranked as 70 in the global biotechnology rankings, and accounted for 0.25 percent of the world's biotech products, compared to 42, 22, 10, and 2 percent for the United States, the EU, China, and India, respectively.[107] In 1984, by contrast, Russia's share was 5 percent. The value of the Russian biotechnology market in 2010 was $4.4 billion. Approximately three-quarters of the market is supplied by imported goods.[108]

Russia had a strong base in biotechnology but has not succeeded in developing it despite a series of programs and initiatives. It is unlikely that the problems in the biotech sector can be remedied within a ten-year period and that Russia will become a leading country in certain areas, or that the industry will become internationally competitive. In a similar study of Russian nanotechnology, similar conclusions were drawn concerning that area.[109]

ANALYSIS OF THE CIVIL R&D SYSTEM

Positive Aspects

Russia has a number of strengths, in particular high education standards and long-standing, cutting-edge expertise in several important areas of S&T. Technical and natural science education in Russia has traditionally been placed among the world's strongest. However, the quality of higher education has been decreasing in recent years, caused by low funding levels.[110] The number of political policy initiatives launched in order to build on these strengths can be seen as a sign that the government is serious about making innovation a national priority. The higher education system has been strengthened and research has been linked to many universities. Efforts have been made to recruit young new researchers. A growing number of technology-based companies have been established and the innovation

104 State Coordination Program for the Development of Biotechnology in the Russian Federation until 2020.

105 Ibid.

106 State Coordination Program for the Development of Biotechnology in the Russian Federation until 2020.

107 Roffey, *Biotechnology in Russia. . ..*, pp. 61–65.

108 Ibid.; and Rabinovich, 'Editorial: Biotech in Russia—Phoenix Reborn from the Ashes', pp. 775–777.

109 Westerlund, *Russian Nanotechnology R&D: Thinking Big About Small Scale Science.*

110 FinNode, 'Russian Innovations Strategy 2020 in Brief'.

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infrastructure has been improved. A law on intellectual property rights has been in place since 2008. The R&D system has been reformed to make it more dynamic and receptive to innovation. The share of R&D open to competition is growing and in 2011 it was approximately 50 percent. Some regions have made considerable progress with well-developed innovation strategies. Russian researchers working abroad can be a positive driving force in reforming the R&D system.[111] Venture capital companies and investment funds have also been set-up to finance high-technology risk projects.[112] Russian research policy is increasingly fostering wider and closer international cooperation. Vladimir Putin has indicated that the aim is to achieve several 'world-class' research universities by 2020.[113]

Weaknesses

A number of weaknesses serve to reduce the effectiveness of the innovation system. There is a low efficiency of public R&D, low effectiveness of infrastructure for commercialization, and low level of entrepreneurial activity. There is a limited absorption capacity for innovations, a lack of linkages between companies and R&D performers, a low level of foreign investments in Russian R&D, and a low efficiency of innovation policies.[114] There is also a very small proportion of R&D activity and innovation undertaken by companies, and poor conditions for innovation, in particular weak competition, extensive regulations, widespread corruption, and inadequate infrastructure.[115] There is a need to develop an innovation system that spans the entire chain from research to finished product. Procedures for follow-up and evaluation of innovation system performance are still unsatisfactory as of 2011. A number of special economic zones have been established but with mixed success. The technology transfer mechanisms are still fairly ineffective and in need of improvements.[116]

Research funding has increasingly been directed toward applied research, which will mean fewer resources for basic research. A similar tendency was noted as early as 2009; there is still no satisfactory mechanism for prioritizing the distribution of government research funding. Allocation of funding is determined more by institutional affiliation and personal contacts than by the quality and results of the research being undertaken.[117]

111 OECD, *OECD Reviews of Innovation Policy . . .*, p. 16.
112 Ibid., pp. 223–224.
113 Schiermeier, 'Putin Promises Science Boost, but Russian Researchers are Sceptical of Ambitious Schemes, pp. 235–254.
114 World Economic Forum, *The Global Competitiveness Report 2011–2012,* World Economic Forum, Geneva, 2011, p. 71.
115 Ibid., pp. 16–17.
116 Klochikhin, *Mutual Learning in the Global Innovation System: A Comparison of S&T Transitions in Russia and China*, p. 11.
117 M. Feigelman, 'What the Scientists Say', *Nature* 449 (2007) p. 529.

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One aspect is that most initiatives to establish new innovative enterprises come from the political leadership and that the leaders for these are selected according to their support of the current political leadership, thus many talented young people avoid such initiatives.[118]

Moreover, it is doubtful that Russia will be able to provide a competitive R&D environment capable of retaining senior researchers while recruiting able, young research workers. It is not only funding that is required as policy makers must take into account many of the problems in the S&T area stemming from the structural rigidity of the science sector still remaining from the Soviet era.[119] It has also been noted that the engineering programs in higher education are in a bad state and are not generating creative engineers. This will also negatively effect R&D organizations innovative capacity in the defense industry.[120] The problems in the area of S&T in Russia have developed over a number of years and have reached such proportions that there are no easy or cheap ways to reform it for Russia to again regain its former position in S&T areas.[121] The transformation of Russia's innovation system will not take place overnight. Many initiatives take time to implement and imbalances in the innovation systems must be rectified as indicated in the Russia 2020 strategy.[122]

The Minister of Science and Education Andrei Fursenko claimed in 2008 that there were about a thousand universities in Russia but only 150 of them were really competitive. He also stated that on a national scale there should remain only 50 universities or 150–200 as a maximum.[123] Russian universities will now face massive cuts in funding in 2013 after a government performance audit and review. The aim will now be to concentrate funding to higher performing universities. Out of the total number of 600 institutions reviewed 102 universities and 374 local branches did not meet the criteria set.[124]

Russia still believes in supporting specific technologies (e.g., nanotechnology or biotechnology) as a way to concentrate resources in selected areas in the hope of achieving breakthroughs, rather than spreading them wider. These areas can be further used for international

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118 Klochikhin, 'The Challenges of Fostering Innovation: Russia's Unstable Progress', pp. 459–678.

119 E. A. Klochikhin, 'Russian Science Must Learn to Live with its History', *Research Europe* (25 October 2012), http://www.researchresearch.com/index.php?articleId=1260711&option=com_news&template=rr_2col&view=article (accessed 20 January 2013).

120 S. Kukushkin and N. Churlyaeva, 'The Problem of Engineering Creativity in Russia: A Critical Review', *European Journal of Engineering Education* 37 (2012) pp. 500–507.

121 Yegorov, 'Post-Soviet science: Difficulties in the transformation of the R&D systems in Russia and Ukraine', pp. 600–609.

122 OECD, *OECD Reviews of Innovation Policy*. . ., p. 184.

123 'Andrew Fusenko Believes That There Should be Only 200 Universities Left in Russia', *Tatar Information Agency* (24 July 2008), http://eng.tatar-inform.ru/news/2008/07/24/18234/ (accessed 20 January 2011).

124 Q. Schiermeier, 'Russia Shakes Up its Universities: Government Plans to Close Struggling Institutions and Increase Funding to the Best', *Nature* 492 (2012) p. 320.

specialization and provide important competitive advantages in the world market. Technological development has been the driving force, strongly influencing Russia's innovation policies. Greater consideration should be given to market and customer needs when developing innovations.

CONSEQUENCES FOR MILITARY R&D, DEPENDENCE ON THE CIVIL SECTOR

Civilian science and technology as a sector will also provide skilled personnel and new technological solutions to the defense industry and to the further development of new defense material. It also helps to facilitate the increased need to engage in international high-tech cooperation for Russian companies producing defense materials on a basis of equality and mutual benefits as well as ensuring that the costs of developing increasingly expensive, advanced defense materials are reduced by sharing costs. The reform of the armed forces with a requirement of 70 percent of new defense equipment by 2020 implies that S&T must be improved and reach international standards due to an ever increasingly competitive international market. From a socio-economic point of view, defense related spending in Russia is important, with around 35–40 percent of governmental R&D spending.[125]

A key mechanism of coordination between the innovation system's civilian and defense sectors would be the Government Military-Industrial Commission chaired by Dmitry Rogozin, Deputy Prime Minister, which organizes and coordinates the operations of the defense-industrial complex, S&T in the interest of national defenses, law-enforcement activities, and national security.[126] The Government's Military Industrial Commision was to implement the innovation strategy for the defense sectors development.

An estimated 35–40 percent of total funding of R&D in Russia goes to the defense sector, which employs 50 percent of all researchers. Thus, the sector continues to play a dominant role in the Russian R&D system.[127] The defense sector has skilled personnel and uses advanced technologies for both military and civilian production and accounted for 70 percent of all high technology products in Russia. Around 42 percent of the defense sectors production was for the civilian market. The defense sector has been characterized by a high level of innovation.[128] This is why the defense industries and their innovation capacity is to be integrated and used for promoting the civilian production

[125] Cooper, 'The Innovative Potential of the Russian Economy', p. 9.

[126] Official Website of the Russian Government, 'Russian Government Commissions', Government Military-Industrial Commission, http://government.ru/eng/gov/agencies/134/ (accessed 15 November 2012).

[127] Cooper, 'The Innovative Potential of the Russian Economy', p. 9.

[128] Iu. V. Erygin and A. M. Saakian, 'Russia's Defense-Industrial Complex', *Problems of Economic Transition* 54 (2011) pp. 3–12.

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and innovation. At the same time, Russia has a very low share of high-tech products on the global market.[129] In 1990, Russia's share in the world's exports of high-tech equipment was 6 percent in 1990, decreasing to 0.5 percent in 2007, and decreasing further to 0.2 percent in 2008—a significant decrease. This is also why in the strategy for innovation, the defense sector has been given a key role, but it can be questioned if it could be a driving force for national innovation.[130]

The Ministry of Defense's total R&D budget amounted to RUB 152 250 million in 2010, with a planned increase to RUB 198 346 million.[131] There are also programs aimed at developing the defense industry and implementing the State Armament Programs supported by special FTP.[132] However, parts of the 2020 State Armament Program appear difficult to achieve due to limits to the defense industry's production capacity.[133] The rearmament programs covers all R&D for development of new material and modernization of existing material for the Ministry of Defense and other ministries and services that have armed forces at their disposal. For the 2020 State Armament Program, 80 percent of the total budget will be spent on arms procurement, while 10 percent will be spent for R&D, repair, and upgrading of older material.[134] RTSC (Rostechnologii) is an important player in the military-industrial sector and controls more than 500 companies most dealing with military equipment. It is charged with implementation of the policy of the military-technical cooperation between Russia and foreign countries as well as assigned a significant role in mutual exchanges of technologies between the civilian and defense sectors.[135]

Russia's defense industry consists of 1,353 organizations and companies in 64 regions of the country, and employs more than 2 million people.[136] There are defense research institutes, design bureaus, as well as two military universities, 11 military academies, and three officer training and science centers in Russia in 2011.[137]

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129 Ibid.

130 Ibid., p. 8.

131 J. Cooper, 'Military Expenditure in the Russian Federation during the Years 2012 to 2015', Tables 1 and 2, pp. 3–4, Research note, Presented at SIPRI, Stockholm, 9 October, 2012. http://www.sipri.org/research/armaments/milex/publications/unpubl_milex/military-expenditure-in-the-russian-federation-2012-2015 (assessed 30 April 2013).

132 F. Westerlund, 'Chapter 4: The Defence Industry' in C. V. Pallin (Ed.), *Russian Military Capability in a Ten-Year Perspective—2011*, p. 71.

133 Ibid., p. 92.

134 Ibid., p. 67.

135 Fomichev, *Strategy for Innovation-Driven Development of the Russian Federation for the Period Ending in 2020*, p. 48; and OECD, *OECD Reviews of Innovation Policy. . .*, p. 192.

136 'Putin Demands New Plan for Defense Industry Overhaul', *Ria Novosti*, 24 September 2012, http://en.rian.ru/military_news/20120924/176199693.html (accessed 11 December 2012).

137 J. Nichol, *Russian Military Reform and Defense Policy, Congressional Research Service R42006*, 24 August 2011, s. 18, http://www.fas.org/sgp/crs/row/R42006.pdf (accessed 4 October 2011).

The Council on Scientific and Technical Policy (SNTP) created in 2011 is chaired by the Minister of Defense and vice-chaired by the Chief of General Staff, and is responsible for drafting and implementing decisions on R&D with a view to developing new material based on proposals from institutes and defense services. It controls 5 new military scientific research institutes, formed from 19 military science committees and 38 scientific research organizations.[138] In a speech to the Academy of Military Sciences 2012 by Army-General Nikolai Makarov, the then Chief of the General Staff highlighted the degradation of military science in Russia, which had resulted in a lag of twenty years behind the leading foreign militaries. The SNTP will promote cooperation between the defense ministry and Russian scientists from the RAS and other organizations.[139]

Former Defense Minister Serdyukov regretted that a large proportion of the R&D appropriation has failed to produce results, while Putin has estimated that 40 percent of military R&D has been unnecessary.[140] An advisory body to the government claims that the state of Russia's scientific institutions was 'catastrophic', with the worst problems facing the most sensitive fields: defense and space technology. Instead of investigating new developments, more time is spent to justify the technology that is already being used.[141] Together, these findings point to serious problems in the defense research sphere.

Defense industries still carry a stronger legacy from the Soviet system than other industrial sectors in Russia. The defense industry was one of the most centralized, geographically isolated, with high levels of corruption and not prepared for the requirements of market system.[142] On the whole, the defense industry is not in a good state and, for example, is no longer able to produce a range of conventional weapons systems why Russia has to buy foreign armament equipment, ships, and drones. With this, the problems with the Bulava missile system can be mentioned.[143] According to the Russian president the defense-industrial complex must be integrated in a unified national innovation system. In spite of all efforts it has been assessed that 75 percent of production assets are obsolete and 50 percent worn-out.[144] The

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138 Ibid., p. 20.

139 R. McDermott, 'Russian Defense Ministry Creates New Military Science Council', *Eurasia Daily Monitor* 8 (95) (17 May 2011), http://www.jamestown.org/single/?no_cache=1&tx_ttnews%5Btt_news%5D=37936 (accessed 17 September 2011); and Russian Ministry of Defense, at, http://eng.mil.ru/en/science/committee.htm (accessed 15 November 2012).

140 R. McDermott, 'Russian Defense Ministry Creates New Military Science Council', *Eurasia Daily Monitor*, volume 8, (95) (17 May 2011).

141 'Will Russian Science be Stunted by Putin's Fear of Espionage?'.

142 L. Kosals and A. Izyumov, 'The Russian Defense Industry Confronts the Market: Findings of a Longitudial Study', *Europe-Asia Studies* 63 (2011) pp. 731–736.

143 D. Trenin, 'Russia Reborn' *Foreign Affairs*, November/December, 2009, http://www.foreignaffairs.com/articles/65498/dmitri-trenin/russia-reborn (accessed 15 December 2011).

144 N. Kalinina and V. Kozyulin, 'Russia's Defense Industry: Feet of Clay' *Security Index: A Russian Journal on International Security* 16 (2010) pp. 31–46.

gap between the scientific developments of the defense sector and civilian sectors continue to grow instead of decreasing.

The Russian government's 2009–2020 development plan prioritizes the defense-industrial complex in civil high-tech R&D program and technological development.[145] Priority will be given to exchange of knowledge and technology between the defense and civil sectors, development of dual-use technology, weapons development, modernization of military material, and improving methods to fight terrorism.[146]

Russian President Putin has indicated that the entire arms industry needs a major modernization. During the past 30 years, the Russian defense industry has missed several opportunities for modernization. Concerning international cooperation it was unacceptable for Russia to manufacture arms from foreign-made parts.[147] The Russian State Armament Program (GPV) has as a primary goal to achieve 70 percent new weapons and equipment in the military inventory by 2020.[148] Russia will invest RUB 3 trillion ($100 billion) in the development of the country's defense industry in the next decade.[149]

In discussions of the sixth-generation warfare, where new generations of technologies will effect how wars will be fought, including breakthroughs in bio-, nano-, and information technology according to Putin in 2012.[150] Weapons were to be developed based on new principles (i.e., radiation, geophysical, wave, genetic, and psycho-physical) providing entirely new means for achieving political and strategic goals.[151] Former Defense Minister Anatoly Serdyukov claimed that these kinds of weapons would be developed by 2020.[152] This gives a vision of what new technologies will be developed within the defense sector, though it is doubtful that the Russian defense industry had the knowledge and production resources needed to even develop nano-based military material. Nor can the armed forces rely on spin-off effects from civil product development taking place in the West so long as the Russian civil nano-industry remains poorly developed.

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145 'Government Approves 2020 Development Plan' *BOFIT Weekly* 4 (23 January 2009) p. 20.

146 Roffey, *Biotechnology in Russia: Why is it not a success story?*, p. 49.

147 'Russia to Invest $100 bln in Defense Industry until 2020', *Ria Novosti*, 21 March 2011, http://en.rian.ru/military_news/20110321/163131244.html (accessed 10 December 2012).

148 R. McDermott, 'The Generational Crisis In Russia's Defense Industry', *Eurasia Daily Monitor* 8 (100) (2011), http://www.jamestown.org/search/searchresults/?no_cache=1&tx_ttnews%5Bswords%5D=8fd5893941d69d0be3f378576261ae3e&tx_ttnews%5Bany_of_the_words%5D=McDermott&tx_ttnews%5Bpointer%5D=3&cHash=baf417519b713c14d24b26c42a314aa8 (accessed 10 September 2011).

149 'Russia to Invest $100 bln in Defense Industry until 2020'.

150 R. McDermott, 'Putin's Presidential Re-election and Future Warfare Capabilities', *Eurasia Daily Monitor* 9 (28 February 2012) (41), http://www.jamestown.org/single/?no_cache=1&tx_ttnews%5Btt_news%5D=39064&tx_ttnews%5BbackPid%5D=587 (accessed 10 April 2012).

151 D. E. Hoffman, 'Genetic Weapons, You, Say?', *Foreign Policy* (27 March 2012), http://hoffman.foreignpolicy.com/posts/2012/03/27/genetic_weapons_you_say (accessed 10 June 2012).

152 'Is Moscow Developing Super Duper Secret Mega Weapons'? *Time*, 19 April 2012, http://www.time.com/time/world/article/0,8599,2112637,00.html (accessed 11 December 2012).

Dmitri Medvedev took the view in 2011 that Russia needed an equivalent to the U.S. Defense Advanced Research Projects Agency (DARPA) and not just continuing to upgrade Soviet-developed material and procure new material. Russia should develop its own high-tech base. A DARPA-like organization in Russia could strengthen its defense industry.[153] The Russian Foundation for Advanced Research (FAR) in the defense industry will finance high-risk and fundamental research projects like DARPA.[154] The foundation has been approved by the Duma and President Vladimir Putin, who signed the bill into law in October 2012 for the new agency.[155] It will initially employ 100–150 experts to handle some 150 research efforts, and will be tasked with informing the country's leadership on projects that can ensure Russian superiority in defense technology. It will also analyze the risks of any Russian technological backwardness and technological dependence on other powers.[156]

It will be important to close the gap in advanced research with Western partners after 20 years of stagnation in Russian military science and defense industry according to Deputy Prime Minister Dmitry Rogozin. If new technologies are adopted first by other countries, this could shift the existing strategic military balance. Unmanned aerial vehicles (UAVs), advanced technologies, automated systems, and new materials are some examples of the main defense research areas. Funding will come from the budget of the state arms procurement program but the budget of the Fund has not been disclosed, however, some reports indicate a possible budget of RUB 100 billion ($32.8 billion) through to 2020. This would achieve an annual budget greater than DARPA; if true it may reflect the requirement to fast-track projects to close the technological gap with the West.[157] There is also competition from China, which is boosting its defense budget and has its own DARPA-like organization.[158]

The aim is that S&T achievements generated in the area of defense and security can be used more efficiently in the context of promoting the national innovation system. The Ministry of Defense is the principal coordinator of fundamental research and S&T development in the area of defense and security.

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153 'Russian DARPA to Advance Military Technologies', *Armed Forces International News* (23 September 2010), http://www.armedforces-int.com/news/russian-darpa-to-advance-military-technologies.html (accessed 12 September 2011).

154 'Russia to take on High Risk Defense Research Projects', *Ria Novosti* (21 June 2012), http://en.rian.ru/military_news/20120621/174160894.html (accessed 10 September 2012).

155 'Putin Signs 'DARPA' Future Research Fund Bill', *Ria Novosti* (17 October 2012), http://en.rian.ru/military_news/20121017/176692006.html (accessed 14 December 2012).

156 'Russian lawmakers Approve Defense Research Agency', *Ria Novosti* (4 July 2012), http://en.rian.ru/military_news/20120704/174404371.html (accessed 16 December 2012).

157 Nordic Intelligence, Security, Risk, and Investment support, 'Russian Future Research Fund', 30 October 2012, http://nordicintel.com/russian-future-research-fund/ (accessed 15 November 2012).

158 'Russian lawmakers Approve Defense Research Agency'.

CONCLUSIONS, R&D IN A LONG-TERM PERSPECTIVE

In conclusion, Russian R&D is only slowly recovering from the 1990s research crisis thanks to a number of major government initiatives. It will probably take around 10 years with current investment levels to reverse this trend for the civilian sector. The main problem is an ageing research corps that, with some exceptions, is not internationally competitive in many areas. The emergence of a new generation of high-performing researchers is slow and many talented young scientists prefer going abroad for a research carrier. The target levels for the development of science and innovation in Russia up to the year 2015 were for several innovation indicators not achieved. Efforts made failed to overcome a number of negative trends for innovative-driven development. A key problem is the overall low demand for innovations in Russia.[159] There have been many initiatives to strengthen R&D and innovation for example in biotechnology or nanotechnology, but so far these have not reached the aims set up for them.

It will be a challenge to turn the traditional universities that only focused on education into research institutes and to prevent further brain drain of young scientists when they acquire their doctorial degrees. It can be questioned whether the civilian S&T sector can show greater progress in promoting science and innovation; it will then be even less chance that this will be possible for the defense sector. The national innovation system suffers from the same problems as private enterprise generally, namely corruption, lack of legal security, and low levels of innovation. In short, it is difficult to turn good ideas into good, new products.

The defense industry and research is probably not a first choice for young talented scientists in Russia today. These basic problems in the R&D sector will also have an adverse effect on quality and the ability to supply with highly qualified specialists and develop new, high-tech, advanced, innovative weapon systems, or strengthening its prospects of cooperating internationally within a 10-year time frame. While it is estimated that more than half of all researchers employed in the defense industry and around 35–40 percent of R&D costs are defense-oriented, the question is whether the industry will be able to produce internationally sought-after defense material over a long-time perspective.

It will be a challenge to change the current imbalance between the amounts of resources devoted to knowledge creation and the limited outputs in terms of innovation. These issues constitute some of the major challenges for Russian innovation policy. Knowledge creation in the business sector

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[159] Fomichev, *Strategy for Innovation-Driven Development of the Russian Federation for the Period Ending in 2020,* p. 15.

is still very limited.[160] Russian S&T will be unable to meet international competitiveness except in certain limited areas. The innovation system remains undeveloped and the institutional structure is poorly adapted to market demand. Funding is being increasingly directed towards applied research at the expense of essential basic research. The government has thus far failed in its attempt to modernize the research sector throughout the chain from research to finished product and for the defense sector even less progress has been made.

Russia's vision is a modern nation capable of becoming a world leader in high-tech industries. However, Russian high-tech products accounted for only 0.3 percent of the world market in 2010. There was no lack of ambitious programs designed to encourage high-tech research and innovation, such as the Skolkovo initiative, which aimed to attract researchers and foreign high-tech enterprises. Major efforts are being made to reform and enhance the effectiveness of research with a view to making it more dynamic and receptive to innovation. It plans to double R&D investment over the next 10 years to achieve its stated target of 2.5–3 percent of GDP. Although expectations are high, the prospects of achieving these ambitious targets must be considered slim.

The future prospects for research and development in the defense sector are difficult to assess in the long-term due to lack of data. With the exception of a few specific products, Russian defense material will have difficulty competing in the international market unless vigorous measures are taken to reform the entire defense industry of which there are no signs so far. The increasing defense allocation will benefit defense-related R&D that will be successful in certain areas. In the future, however, it will—as in the West—become increasingly dependent on progress and innovation in the civil research sector. At present, a coherent, systematic connection between civil and military research is largely lacking in Russia. Even if such a connection could be achieved, the challenges facing civil S&T are formidable why the sector would have difficulty ensuring that the armed forces are supplied with competitive high-tech material in sufficient quantities envisaged in the ongoing reform program. Knowledge and technology transfer from other countries will become increasingly important here and Russia could resort to legal—and possibly other—avenues to acquire the information they need. While the growing research allocations will benefit defense research they will ultimately be unable to remedy existing structural problems and lack of scientific excellence in many areas within the next 10 years.

[160] A. Gerasimova and I. Khasuntsev, 'Institutional Characteristic Features of Innovation Systems Development of BRICS Countries', 2011 International Conference on Management Science & Engineering (18th), Rome, Italy, September 13–15, 2011.

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